

CAVRN Syllabus

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Heemsbergen

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Contents



Introduction	5
We should be regulating the metaverse now	Joanne Gray 8
MIFF70 - Extended reality and storytelling	Kate Euphemia Clark 11
Avoiding the (virtual) hype	Maxwell Foxman 14
Is the metaverse really the future of work?	Ben Egliston, Kate Euphemia Clark & Luke Heemsbergen 17
Facing the socialisation of augmented reality	Luke Heemsbergen 19
Defining (x) realities	Tony Liao 21
On media genealogy and forecasting	Dooley Murphy 26
Learning from VR Motion Sickness	Paul Roquet 30
Expectations of privacy in public space	Marcus Carter, Ben Egliston & Kate Euphemia Clark 34
Getting our VR legs: Who is using VR?	Daniel Harley 38
How Augmented Reality Comes to Be	Luke Heemsbergen & Andrew Iliadis 41
Sexual assault in the metaverse isn't a glitch that can be fixed	Kate Euphemia Clark & Trang Le 46
The death of the metaverse	Leighton Evans 49
From calming spaces to superpowered avatars	Panote Siriaraya 52
The reemergence of the metaverse: An interview with Leighton Evans	Marcus Carter & Leighton Evans 60
The identity, emotion and gaze behind Apple's Vision Pro	Chris Chesher 64

Abstract

In this inaugural volume, we introduce CAVRN and set out an agenda for a Critical Augmented and Virtual Reality research Network. Through what we refer to as 'critical AR and VR studies', we argue there is urgent need for research that takes stock of rapid developments in the AR and VR space – accounting for the ethical, social, political, and economic implications of these technologies.

This volume of CAVRN presents 16 contributions offering critical perspectives on AR and VR, encompassing diverse domains, united in their call for a deeper exploration of the complexities of virtual interaction, advocating for an approach to the critique of VR that accounts for both its material-technical affordances and its socio-cultural dimensions.

The contributions in this volume cover four main areas – 1) the policy, regulatory, and legal implications of AR and VR, 2) media theoretical approaches to studying VR, 3) responses to the emerging 'metaverse', and 4) VR experiences and storytelling.

CAVRN: An Agenda for Critical Augmented and Virtual Reality studies

By Ben Egliston / University of Sydney,
Kate Euphemia Clark / Monash University,
Luke Heemsbergen / Deakin University &
Marcus Carter / University of Sydney

We established CAVRN in December 2022 as an academic network for studying the unique cultural, ethical, and critical challenges posed by Virtual and Augmented Reality. Across fields in interaction design and Human-Computer Interaction, and humanities and social sciences disciplines like media and communication and cultural studies, researchers have long brought to bear critical perspectives in thinking about the use and production of AR and VR technology.

The shift in attention towards AR and VR was magnified in 2021, when Mark Zuckerberg unveiled his company's Metaverse vision. For Zuckerberg, the metaverse is a technological stack reliant on AR and VR (in what was seemingly a desire to jettison the company's toxic social media offerings). Perhaps due to the high-profile nature of Meta's 'metaverse' rebrand, consternation about the data-rich nature of XR is increasingly prevalent amongst academics and policymakers. As we write this introduction, Apple is entering into the AR and VR space with its own novel product category – which it refuses to brand within the metaverse and instead suggests its innovation is, finally, offering a spatial computing platform that will define the digital future. The increasing interest in AR and VR by the technology sector is somewhat of

Introduction

a mixed blessing – as these are now no longer niche subsets of technology research and policy.

Yet we found that there was little community around this work. Despite being driven by common topical interests and political or normative commitments, due to the interdisciplinary nature of this research, there was a palpable lack of interconnectedness among researchers. Many were working in silos, often unaware of the parallel efforts being made in adjacent disciplines or regions. The pandemic, with its stringent travel restrictions and cancellation of in-person conferences, further exacerbated this isolation, making traditional methods of networking and knowledge sharing challenging.

But beyond a community-building project, CAVRN is an intellectual one. We envisage CAVRN as an effort to formalise a loose knit group of research – driven by similar questions and normative outlooks – seeking to understand the implications of VR and AR on society and economy across material-technical, discursive, and political economic registers.

Much of this work – echoing a rich and prescient tradition of work in feminist science and technology studies – offers rich resource for pushing back against the notion of virtuality and VR's disembodied or incorporeal nature, arguing that the virtual can never be disentangled from the politics of the social. As Nicola Green adroitly puts it, to “become virtual” is “not simply to use a computing system as a tool, nor is it to access a wholly ‘other’ space and become digital. Rather, it is a process of making connections between programmed and nonprogrammed spaces in specific locales, and power-laden social, cultural, and economic relationships”.

CAVRN: Volume 1

This inaugural issue of CAVRN features 16 contributions. Each of these articles share core concerns that we view as important to critical VR and AR studies. Articles by Joanne Gray, Marcus Carter, Ben Eglis-

ton, and Kate Euphemia Clark and another by Clark and Trang Le focus on the policy, regulatory and legal implications of VR and AR. Gray's article examines the web of policy, regulatory, and legal implications surrounding the burgeoning digital realm of the metaverse. Gray particularly underscores the urgency of establishing regulations in this new frontier, arguing that proactive measures are crucial. Carter, Egliston, and Clark examine shifting paradigms of privacy in augmented reality, emphasizing the evolving expectations of privacy even within seemingly public virtual spaces. Meanwhile, Clark and Le spotlight a highly troubling area of virtual interaction: issues of sexual assault in the metaverse. They contend that these aren't mere technical problems but represent profound challenges requiring thorough legal and societal examination.

Contributions by Tony Liao, Dooley Murphy, Paul Roquet, Chris Chesher, and Luke Heemsbergen offer media theoretical analyses of AR and VR. These articles attempt to theorise the experiences and affordances of VR and AR, while also thinking how the medium's unique affordances complicate and provide new directions for media theoretical analysis. Liao's article explores definitional questions surrounding AR and VR – examining the epistemic and normative implications of 'defining' technology.

Murphy's article offers a review of Jay David Bolter, Maria Engberg, and Blair MacIntyre's *Reality Media* and Grant Tavinor's *Aesthetics of Virtual Reality*, focusing on the urgent need to take seriously VR's media-specificity along with its sociocultural affordances in analysis. Roquet's article develops the concept of nauseogenic media to think VR as actively engaged in inventing new forms of bodily discomfort. Heemsbergen's article revisits danah boyd's early research on how teens use digital media to shape their identities and social interactions, drawing a parallel with an idea of emerging augmented publics.

The piece underscores the transformative power of AR in redefining social interactions, identity, and public spaces, while noting how the concept of "bi-spatial surveillance" reflects the extensive biometric

and environmental data capture required for AR to function as it forms these emerging cultural practices. Focusing on the recent Apple Vision Pro, Chesher focuses on the role of eyes and gaze in communicating emotions and identity – something that has historically lacked attention in the design of VR and AR interfaces to date.

Articles by Maxwell Foxman, Leighton Evans, Ben Egliston, Kate Euphemia Clark and Marcus Carter focus on the emergence of the concept of the metaverse – one that acts as something of a floating signifier, taking on different meaning in different contexts. Foxman's contribution enjoins journalists and other commentators (including academics) writing about VR to avoid the cycle of constant hardware anticipation and the hype of new terminologies in the XR sector, emphasizing the need for a grounded approach to journalism that focuses on the experiences of communities already engaged with existing virtual platforms. Egliston, Clark, and Carter query whether booster visions of the metaverse as bringing about transformative changes to our work lives really hold truth.

Drawing from phenomenology, Evans examines the rapid deflation of Meta's metaverse hype – not really representing a rich virtual world, but a "spatial container for a poorly realised vision that cannot yet be done". This section also features an interview with Evans by Marcus Carter, covering territory ranging from the metaverse, embodiment, and the politics of who imagines VR.

Finally, articles by Kate Euphemia Clark, Daniel Harley, Luke Heemsbergen and Andrew Iliadis, and Panote Siriaraya focus on experience and storytelling. Clark offers a review of the Melbourne International Film Festival AR and VR content – offering new ways to tell stories, but also crucially listen and respond to stories. Harley's contribution focuses on the short-sightedness of diagnosing the issues inherent in social VR as technical – rather, they are social, stemming from social harms often directed at women and other marginalised gender identities (who are – as a result – often absent or underrepresented in these spaces). In an interesting meta commentary on the state of VR research, for Harley this underrepresentation pres-

ents a problem for researchers, who are often unable to easily access these diverse cohorts.

Siriaraya's article turns to VR's application to supporting physical health and enhancing well-being, exploring the potential of VR in enhancing the life quality for individuals with dementia through the creation of serene and engaging environments, fostering self-worth and reducing biases through the utilization of varied avatars in virtual spaces, and augmenting physical exercise experiences with virtual feedback, while identifying existing opportunities, issues, and critical challenges in these domains.

Heemsbergen and Illiadis discuss the evolution of Augmented Reality (AR) technology through the dynamic lens of Geels' "multi-level perspective" Technology Transitions. They delve into how AR is conceptualized, concretized, and (re)contextualized to highlight how these technologies are imagined, solidified in society, and then used in ways that might differ from their original intent via pressures of the market, user preferences, and cultural. ■■■■■

We should be regulating the metaverse now

By Joanne Gray / The University of Sydney

We have no way of knowing exactly what form the metaverse will eventually take but that doesn't mean we can't start regulating it.

What we know about the metaverse

The term metaverse might invoke visions of gaming platforms and virtual worlds in which people socialise in real time as unique digital avatars. Platforms such as Fortnite, Roblox, Second Life and Minecraft, or even Decentraland, may come to mind.

But a fully immersive virtual world is just one potential manifestation of the metaverse. As scholars and industry have argued, the metaverse is "primarily a trend, rather than a specific space, item, or even concrete formulation" (Qadir, 2022). It is a technological and industrial trend towards increasing convergence between the physical and the digital, or a more "spatial web" (De Filippi, 2022).

In practice, this convergence involves the combination of elements of virtual worlds, the internet of things and augmented reality to create new three-dimensional digital spaces (including everything from portable virtual assistants to entire new digital cities).

In theory, these new systems have the potential to be applied across domains from work and education to commerce, healthcare, manufacturing, media, arts and entertainment (Ball, 2022).

Joanne Gray



Woman in VR surrounded by code

While the metaverse is in an early stage of development and there is a lot we can't really predict in terms of adoption and application, what we do know is significant.

We know that metaverse systems generally combine features of existing digital platforms with elements of immersive gaming.

And we know a lot about digital platforms and gaming.

For decades now researchers have studied digital platforms, how they operate, their users and their governance. We have extensive scholarship on issues of surveillance, targeted advertising, participation, creativity, hate speech, harm, abuse, misinformation, data monopolies, competition, inequality and intellectual property.

At the same time, gaming scholars have also studied at length issues of privacy, safety, identity, equality, participation, creativity, harassment, monetisation and community in immersive spaces.

We do not have to start from scratch when seeking to regulate the metaverse. Drawing on this rich scholarship, we can envision future metaverse problems and solutions.

The big tech factor

The Silicon Valley tech giants—including Google, Apple, Meta, Microsoft and Amazon—are, to varying degrees, spending millions of dollars developing new tracking and data extraction methods, cloud computing and storage, consumer and industrial hardware, AI-enabled mapping and ‘digital twin’ systems, connectivity networks, and 3D software. All of which are likely to be the tools and infrastructure of the metaverse.

Effectively, as the metaverse evolves, these digital platform companies could reach more deeply into our society—generating data, curating content and determining access to resources in a range of new ways and contexts. If these companies are permitted to do so without proper public oversight, problems of online surveillance, targeted advertising, harmful speech, data monopolies and information gatekeeping are likely to intensify.

Alert and only mildly alarmed

Make no mistake, the metaverse is exciting. It potentially offers a range of productivity, social, economic, creativity and even environmental benefits across a broad range of industries and practices.

It’s also likely to be a lot of fun. Who doesn’t want to visit Peru without taking a long-haul flight?

But if the metaverse connects more people online in more all-encompassing ways, it has the potential to worsen existing digital platform problems that harm societies and individuals.

We need to work out now what regulatory agencies and legislatures need to set the standards for how and on what terms metaverse systems are made available to the public.

The time to regulate is now

As the metaverse is still on the horizon, we have a critical window of opportunity to anticipate and act to prevent problems before they occur.

In Australia and around the world there is currently the political will to regulate the big tech platforms. Regulators have learned from what has happened with social media and they are willing to take action to curb their activities and reach.

We must capitalise on this issue salience. Self-regulation must not be the model for governing the metaverse.

Over the years, the tech giants have sought to fend off external governance by self-regulating: from automated content moderation systems on YouTube, to Facebook’s quasi-judicial body, the Oversight Board. But self-regulation consolidates platform power: platforms are free to devise rules and governance models that prioritise their own interests.

Public regulation by democratic governments is most capable of protecting and advancing the public interest.

As the dominant platform forge ahead with new metaverse technologies, we need a regulatory agenda that focuses attention towards the trajectory of the dominant platform companies. We need stakeholders to come together now – including government, industry and civil society – to lay the foundations for public interest metaverse governance. ■■■■■



Digital platforms have been well-researched by scholars in the digital humanities

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MIFF70: Extended reality and storytelling

By Kate Euphemia Clark / Monash University

The Melbourne International Film Festival (MIFF) celebrated its 70th year of operation this year. In recent years, the festival has been expanding to include extended reality (XR) content. This year marked MIFF's most ambitious XR offering to date, with twelve XR pieces presented both in-person and in a digital recreation of Melbourne's iconic art-deco Capitol theatre. The virtual gallery experience provides a sense of place to MIFF's digital offerings by situating the Capitol on a Melbourne street, complete with trams and cyclists, with the Melbourne Arts Centre spire visible in the distance.



Night Creatures

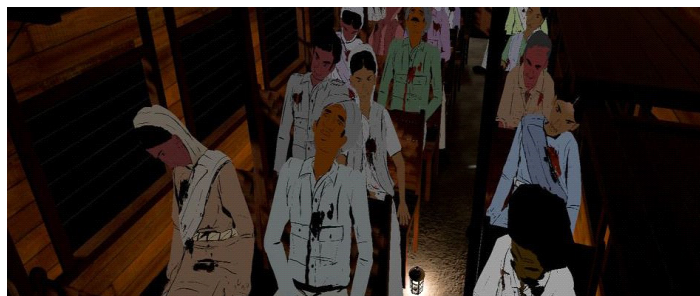
To help integrate the XR offerings into the wider festival, MIFF (with the help of Linh Ang) commissioned **Night Creatures** (dirs. Isobel Knowles, Van Sowerwine): a series of augmented reality stop-motion animated bats that are both scattered throughout the MIFFXR digital gallery, and available throughout MIFF's more traditional event spaces via a QR code. Each of the bats tell a short anecdote about the experience of going to see a film at a festival.

Night Creatures provides a charming point of connection to the broader film festival, which helps to

Kate Euphemia Clark

centre MIFFXR as an integral part of the festival.

In its XR selections, MIFF aims to “rewrite the frontiers of storytelling through audio-visual immersion” and MIFF70's offerings certainly achieved this. For example, in *Child of Empire* (dirs. Erfan Saadati, Omi Zola Gupta and Sparsh Ahuja) unpacks the aftermath of colonial rule, and the British colony's brutal and senseless drawing of borders between India and Pakistan.



Child of Empire at MIFF70

Child of Empire takes the form of a conversation between a Muslim Pakistani man and a Hindu Indian man, where they share stories about how they became displaced overnight, how they felt about the drawing of the border, and the horrific journey to make it back to their own country – a journey in which more than two million people died. *Child of Empire* gives the user a seat at the table for this conversation, while also casting them as a silent ob-



Still from Speak of Country

server to a conversation between two viewpoints that have historically been talked about, but not allowed to speak for themselves, particularly in majority white spaces.

Speak of Country (dir. Katrina Channels) tasks users with finding seven different objects as they fly over Yuin country (the south coast of NSW) in a Kombi van. Each object marks the sharing of a particular

story from fifteen Yuin Nation community members. Many of the stories provide a unique insight into an intimate cultural moment (for example, Basket graciously shares the experience of making a possum skin cloak and the power that this has for community belonging, connection to ancestors, and spiritual healing for Yuin people). Each of the seven stories



Gondwana at MIFF70

also demonstrates an important connection to land (for example, Postcard tells the story of traditional dancing rings and the resonances they have with land and ancestors).

Speak of Country poignantly connects these intimate moments with the vast landscapes of Yuin country, by moving between sweeping 360-degree views of country and closely shot footage of cultural business that extends the expression of connectedness to country.

Project Zero (dir. FabLab Dynamic) utilises the capacity for VR to tell a more experimental, sensory story. The user begins the experience in darkness. Dots and lines emerge, at first seemingly randomly, then they fly together in a manner reminiscent of starlings. Geometric lines appear to create an arresting cityscape that the user travels through to their destination: a reimagining of a dance performance by Xiao He-Wen, that could not be had outside the medium of VR. He-Wen's movements are reimagined as a series of moving lines, with smaller dots around her that pulsate with her movements to the music. The movement of the environment in time to the performance invites the user to reimagine the power of movement and its affective potential.

By far MIFF70's most ambitious VR work was **Gondwana (dir. Ben Joseph Andrews)**. Gondwana was a 48-hour procedurally generated experience – the first of its kind anywhere in the world. Gondwana was exhibited in-person, at the Australian Centre for the Moving Image (ACMI), where visitors could use a headset at any time during the 48-hour run-time. Gondwana asked users to 'bear witness' to 100 years of far-north Queensland's Daintree forest – from 1990 to a speculative 2090.

Gondwana seeks to show possible futures of global warming – the procedurally generated rainforest goes through a process of degradation that was based on a number of global warming predictions. However, the greater amount of time the audiences spent in the simulation, the more resilient the Daintree became to the effects of global warming. Every fourteen minutes of real-time, the simulation jumped forward ten years. Audiences were encouraged to attend multiple times to witness how the Daintree changed over time.

My first visit to Gondwana was early in the 48-hour period and the end of 1991. The 'forest vitality' meter was at 99 per cent. I spent most of this visit enjoying the lush, green landscape, listening to the sounds of the Daintree, from the wind running through the forest to the animal life, weather events, and music (an impressively procedurally generated soundscape). My second visit was in the future: 26th of January 2049. The Daintree's vitality was at 76 per cent.

The most shocking difference between these two visits was that there were many plants that were bleached white, an image reminiscent of how coral is currently being bleached in the Great Barrier reef. These bleached plants in the Daintree represented the plants that had become extinct since my last visit. In this sense, Gondwana made visible a phenomenon that is normally difficult to see. Currently, we are living through a mass extinction event, something that is surprisingly invisible to many of us, particularly those living in big cities. At the conclusion of the 48-hour period, this iteration of Gondwana retained 25 per cent of the forest, because of the MIFF's audience spectatorship.

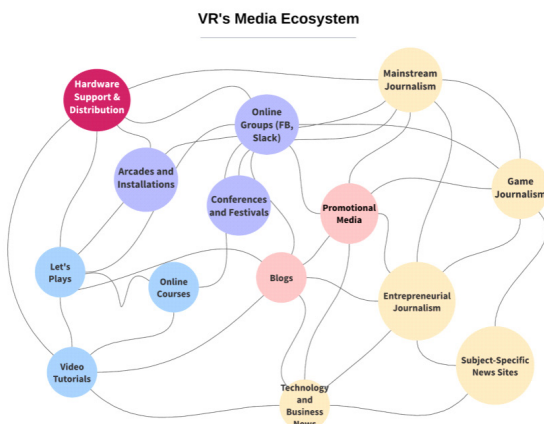
Each of these pieces showed a way that VR, and other XR technology, can produce new assemblages and insights into not only how we tell stories, but also how we listen and respond to stories. The act of telling stories matters, but how we are positioned – and position ourselves – in relation to these stories is also important. MIFF70's XR exhibition invites its audience to ask: how do we listen to the stories that we are told? And, how does the act of listening change these stories? ■■■■■

Avoiding the (Virtual) Hype

Maxwell Foxman

By Maxwell Foxman / University of Oregon

Inevitably, a big 2023 story will be Apple's release of their long-rumored XR headset. For years, news and tech websites have published minutiae of the project, quoting supply chain analysts' claims it will be "the most complicated product Apple has ever designed" as well as "a game-changer for the headset industry."



While fans may be planning to queue up at Apple stores to get their hands on these high-priced HMDs, for industry-followers (e.g., academics, media makers) such stories seem all too common and devoid of key issues like privacy, accessibility, or even practical use-cases of the technology. That is the focus of this post; I suggest that a promotional media ecosystem has long propped up narrow views of VR, its potential and problems. I will then offer some advice garnered from game and tech journalists about how to frame and consume stories about virtual reality.

Virtual Reality's Media Ecosystem

When commercial headsets like the Oculus (now

Meta) Rift and HTC Vive were released, I mapped out a media ecosystem (Foxman, 2018). I was performing participant observation of VR's early adopters in New York City, attending meetups crammed with many people who still post about Apple and other XR products. Those messages were one node in a complex media network for circulating VR information.

This interwoven network of bloggers, newsmakers, influencers, online forums, and physical festivals still exists even if platforms like Facebook groups have shifted to competitors like Discord. Mainstream, games, tech, and subject-specific (e.g., Upload VR, VR Focus) journalists shared information and, more importantly, space with amateur developers, entrepreneurs, and influencers. They were learning from and referencing each other's work at a moment when newsmakers were heavily investing in the technology. Paradoxically, these writers needed to objectively evaluate commercial VR's viability while simultaneously relying on enthusiasts and early adopters to better understand its use and endorse their journalistic content within the ecosystem.

The circulatory nature of this information sharing was promotional and ambitious, typically espousing VR's social and economic aspects (p. 109), while hedging that its main use was for gaming (p. 111). VR was framed as an innovation whose benefits could touch almost any profession (including journalism itself). Its revolutionary potential was on the horizon and required a collective push from those within the media ecosystem to realize. This narrow perspective has consequences: perpetual portraits of VR's state of "newness" (Harley, 2022); assumptions about the appropriate companies to herald the technology (Egliston & Carter, 2020); deep association with gaming culture (and some of its more toxic elements) (Evans, 2018; Golding, 2019); and connection to obscure and culturally problematic (if optimistic) concepts like empathy (Nakamura, 2020).

In fact, I found that journalists writing about VR and empathy similarly defined the latter term aspirationally without a clear understanding of its scientific

underpinnings (Foxman et al., 2021).

In other words, the media ecosystem surrounding VR seems to foster murky coverage rife with hopeful yet unclear expectations (and letdowns) of the technology's promise, while disregarding critical concerns about power, control, data, politics, and demography in its application. Hype and anticipation about VR still grace the pages of many websites even while, for some, everyday use is commonplace.

Advice for Future Coverage

So, what can those (whether academics or journalists) writing about VR do to combat the norms of this promotional media ecosystem? Moving beyond the excitement and lack of clarity regarding VR's future seems like a good start, but for other practical solutions, I want to turn to my recent report on how coverage of virtual worlds (including those facilitated by VR) changed during the COVID-19 pandemic (Foxman, 2022). During the pandemic, VR was framed (again) as a future technology that could help us congregate synchronously, but not quite effective enough compared to apps like Zoom or video games like Animal Crossing. However, when I questioned journalists about this coverage, a few salient pieces of advice emerged:

First, discontinuing reportage of one specific headset, title or experience can break the anticipatory cycle of hardware releases that dogs XR coverage.

Second, avoiding the hype around new terminologies and technologies was encouraged. While interviews occurred before Meta's rebranding, reporters were skeptical about the metaverse and recognized it was already "here. It's just fragmented. So maybe it's not quite as meta as we aspire for it to be for better or worse."

Generally, writers reminded me that news outlets should refrain from the prognostication found in VR's media ecosystem and instead focus on tried and true on-the-ground reporting.

Third, and related, they advocated concentrating on people over platforms as there are already diverse and interesting communities (not to mention sources) embedded with virtual environments. Spending time within them in a social space like VRChat would net meaningful stories from people who consider the medium integral to their lives.

These three key points reflect some of the report's findings, which also take into account massive multiplayer online games, livestreaming, and other forms of virtual meeting spaces. However, at its root, the reporters' counsel serves as useful guard rails for writers and readers of VR coverage: to move beyond hype cycles and think more about the present as well as those in power and empowered by this not-so-novel technology. ■■■■■

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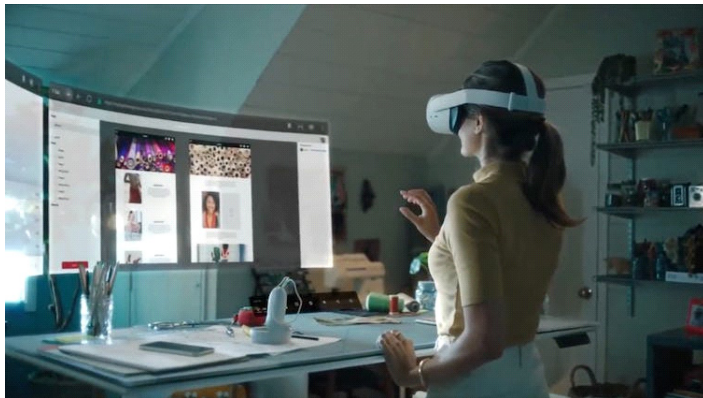
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Is the metaverse really the future of work?

By **Ben Egliston** / University of Sydney,
Kate Euphemia Clark / Monash University &
Luke Heemsbergen / Deakin University

According to Mark Zuckerberg, the “metaverse” – which the Meta founder describes as “an embodied internet, where instead of just viewing content – you are in it” – will radically change our lives.



Meta

So far, Meta’s main metaverse product is a virtual reality playground called Horizon Worlds. When Zuckerberg announced his company’s metaverse push in October 2021, the prevailing sentiment was that it was something nobody had asked for, nor particularly wanted.

Many of us wondered what people would actually do in this new online realm. Last week, amid announcements of new hardware, software, and business deals, Zuckerberg presented an answer: the thing people will do in the metaverse is work.

But who is this for? What are the implications of using these new technologies in the workplace? And will it all be as rosy as Meta promises?

The future of work?

The centrepiece of last week’s Meta Connect event

**Ben Egliston, Kate Euphemia Clark
and Luke Heemsbergen**

was the announcement of the Quest Pro headset for virtual and augmented reality.

Costing US\$1,499 (~A\$2,400), the device has new features including the ability to track the user’s eyes and face. The Quest Pro will also use outward-facing cameras to let users see the real world around them (with digital add-ons).

Meta’s presentation showed this function in use for work. It depicted a user sitting among several large virtual screens – what it has previously dubbed “Infinite Office”. As Meta technical chief Andrew Bosworth put it, “Eventually, we think the Quest could be the only monitor you’ll need.”

Meta also announced it is working with Microsoft to make available virtual versions of business software such as Office and Teams. These will be incorporated into Horizon Workrooms virtual office platform, which has been widely ridiculed for its low-quality graphics and floating, legless avatars.

The Microsoft approach

The partnership may well provide significant benefit for both companies.

Microsoft’s own mixed-reality headset, the HoloLens, has seen limited adoption. Meta dominates the augmented and reality markets, so it makes sense for Microsoft to try to hitch a ride on Meta’s efforts.

For Meta, its project may gain credibility by association with Microsoft’s long history of producing trusted business software. Partnerships with other businesses in the tech sector and beyond are a major way that Meta seeks to materialise its metaverse ambitions.

Microsoft also represents an alternative approach to making a product successful. While several decades of efforts to sell VR technology to consumers have had limited success, Microsoft became a household name by selling to businesses and other enterprises. By focusing on an enterprise market, firms can nor-

malise emerging technologies in society. They might not be things that consumers want to use, but rather things that workers are forced to use.

Recent implementations of Microsoft's Teams software in industry and government across Australia offer models for how the metaverse may arrive in offices.

Enhanced bossware

While proponents of work in the metaverse envisage a future in which technologies like AR and VR are frictionlessly incorporated into our work lives, bringing about prosperity and efficiency, there are a number of areas of concern.

For one, technologies like VR and AR threaten to institute new forms of worker surveillance and control. The rise of remote work throughout the COVID-19 pandemic led to a boom in "bossware" – software for employers to monitor every move of their remote workers.

Technologies like VR and AR – which rely on the capture and processing of vast amounts of data about users and their environments to function – could well



Meta Microsoft Teams in VR

intensify such a dynamic.

Meta says such data will remain "on device". However, recent research shows third-party Quest apps have been able to access and use more data than they strictly need.

Privacy and safety

Developers are learning, and worried, about the privacy and safety implications of virtual and augmented reality devices and platforms.

In experimental settings, VR data are already used to track and measure biometric information about users with a high degree of accuracy. VR data also have been used to measure things like attention.

In a future where work happens in the metaverse, it's not hard to imagine how things like gaze-tracking data might be used to determine the outcome of your next promotion. Or to imagine work spaces where certain activities are "programmed out", such as anything deemed "unproductive", or even things like union organising.

Microsoft's 365 platform already monitors similar metrics about digital work processes – you can view your own here, if your organisation subscribes. Microsoft 365's entrance to VR spaces will offer it plenty of new data to be analysed to describe your work habits.

Moderating content and behaviour in virtual spaces may also be an issue, which could lead to discrimination and inequity. Meta has so far given little in the way of concrete protections for its users amid increasing claims of harassment.

Earlier this year, a report by consumer advocacy group SumOfUs found many users in Horizon Worlds have been encouraged to turn off safety features, such as "personal safety bubbles", by other users.

The use of safety features in workplaces may likewise be seen as antisocial, or as not part of "the team". This could have negative impacts for already marginalised workers. ■■■■■

Facing the socialisation of augmented reality

By Luke Heemsbergen / Deakin University

Fifteen years ago, a grad student named danah doyd was finishing off her dissertation titled *Taken Out of Context: American Teen Sociality in Networked Publics* exploring how teens were leveraging newly forming social media to live their lives in novel ways; **boyd spotted people and publics coming of age in new ways.**

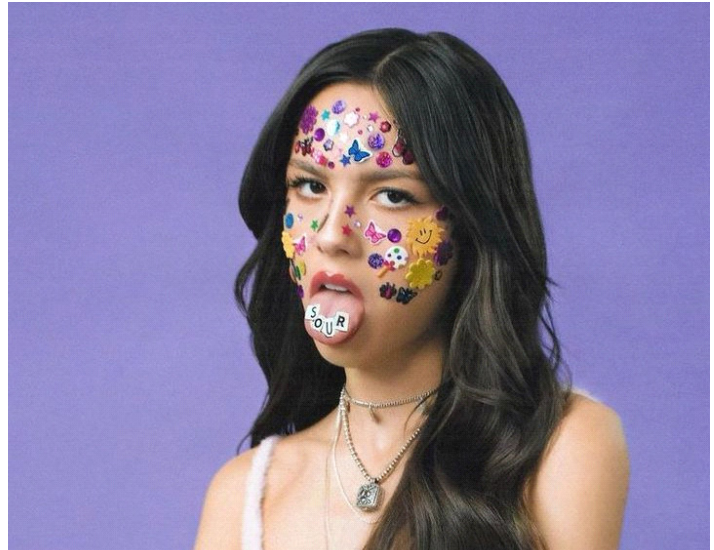
It's useful to return to boyd's early work to start thinking about how novel augmented publics are starting to socialise, including how the properties and dynamics of AR might afford new types of publics. And I'm going to use former Disney channel star Oliva Rodrigo – or more specifically her presentation of face – to do so.

boyd's work argued that social media changed how teens were configuring identity, socialising (with) peers, and interfacing with adult society. Social media were new spaces, where invisible audiences, context collapse, and the blurring of public and private were gathering steam.

Her deeply ethnographic work also pinpointed how the properties and dynamics of the networked media afforded such shifts. Persistence, searchability, replicability, and scalability all afforded these networked publics. For instance, the public articulation of *Friends* online (as opposed to having friends) required evolution of both the concept of friendship and how to manage it.

I note here that AR media do and will have their own

Luke Heemsbergen



Olivia Rodrigo, from her album *SOUR*

properties and dynamics. Some of this has to do with new ways of thinking about surveillance.

Kent Bye (2021) counts 64 different physiological and biometric data streams that are being captured for AR and VR technology designs, while SLAM instantaneously creates an intimate map of your surroundings that can interface with data from the cloud.

Elsewhere I've used the term biospatial surveillance to signal how AR requires incredible amounts of biometric capture and analytics, while also intimately mapping users' immediate environment. For AR to be social, these data won't stay on device.

Which brings us back to boyd, who knew that what networked publics looked like and felt like would continue to evolve. As boyd put it at the time "publics will continue to be transformed [in] the interplay of new technologies and their adoption." (2008; 301). Indeed, she concluded her thesis with a recognition that newly released smart phones were creating social and technical contexts for "mobile networked publics".

In those final pages she experimented with the neologism (dis)locability to describe the network interactions that are "simultaneously independent of and deeply connected to physical location" to consider "how physicality and spatiality will intersect with networked publics." In 2008 this was seeing for the first time the pale blue dot of you on Google's map

of the world. In 2022 features like Snapchat's Snap Map congeal blobs of these locatable networked public interactions, geographically signaling cultural happenings.



Apple's iOS 1.0 Google Map view in 2008 (left) and Snap's Snap Map in 2022 (right) displaying (dis)locality in New York

Faced with spatial contexts: Considering sociality in augmented publics

AR/VR exponentially increases networked '(dis)locability' not in geographic terms but corporeal ones, spatialising body and environment. Biospatial surveillance intimately measures the physical location not only of the immediate surroundings, but of features and gestures of faces. Such mapping makes us reconsider how AR might socialize us, and how we might socialize AR. And here AR's adoption has less to do with the newest enterprise focussed AR/VR solutions from major tech first than you'd think.

Which (finally!) brings us to Oliva Rodrigo's face. While the implementation of biospatial surveillance and their consequences might seem far off, consider that over 250 million of Snapchat's 340 million users use AR functionality daily. A whole generation of social media users are coming of age with their datafied face as a new type of interface to their peers.

Major media are catching on to what the teens are up to. Olvia Rodrigo's break out album and first single Brutal was explicit in how teens just like her could

augment their identities through AR tools provided by her technology partner Apple.

The socialisation of bio-physical surveillance is already here, but as these things go, just not evenly distributed yet – with the fun filters and lenses giving a generation a gateway into what augmented publics will come.

How this socialisation of AR technologies progresses, is not only written on Meta's metaverse wall – teens like Rodrigo and her fans are rewriting what can be written, where, by who, once again. And while I can't speak for boyd, I do get déjà vu, watching people and publics coming of age in new ways. ■■■■■

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Defining (x) Realities

By Tony Liao / University of Houston

Anyone who studies or talks about augmented reality and virtual reality technologies will inevitably get asked the question: but how is that augmented/mixed/virtual reality? Isn't that more AR than VR? How one talks about these technologies is continually evolving.

With every application/device that is released a version of this debate gets kicked up again, whether that's Pokemon GO or Google Glass.

These terms can mean something specific, but often get lumped in with umbrella terms like mixed reality, XR, or extended reality. Even across these terms there is significant variance between how companies/marketers/academics/enthusiasts utilize them, and differences between technical definitions and colloquial usage.

Then there is a long list of enabling technologies and other features that sometimes get associated or conflated with AR/VR, where people may ask whether something is AR or just a heads up display showing holographic content. Perhaps there is some discussion about whether an AR device/application/system

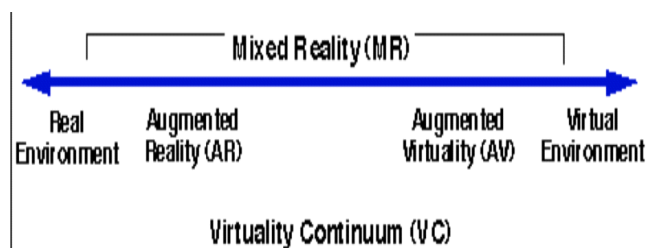


Figure 1: Simplified representation of a "virtuality continuum".

Milgram and Kishino 1994

employs computer vision, simultaneous localization and mapping, and gestural/haptic inputs. Without those inputs, then maybe you will hear someone dis-

Tony Liao

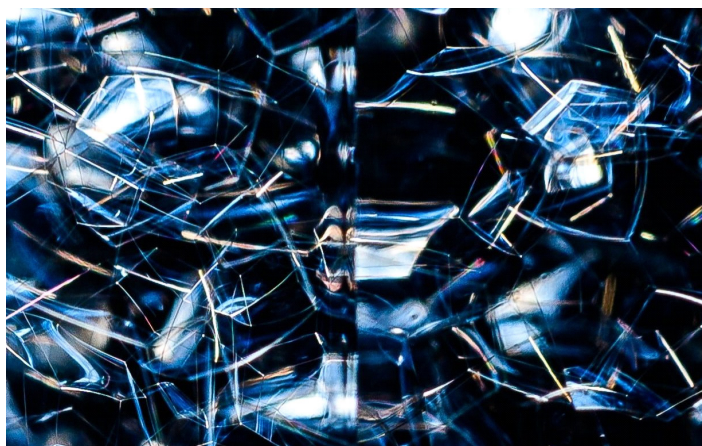


Photo by Ning Shi on Unsplash

miss it as not AR but merely a wearable device with locational tracking.

Depending on who you ask, the definitional question is either absolutely critical or completely meaningless, essential to improving public understanding of these technologies or the primary source of public confusion, philosophically interesting or mindlessly pedantic, highly impactful for technical development or largely irrelevant to actual practice.

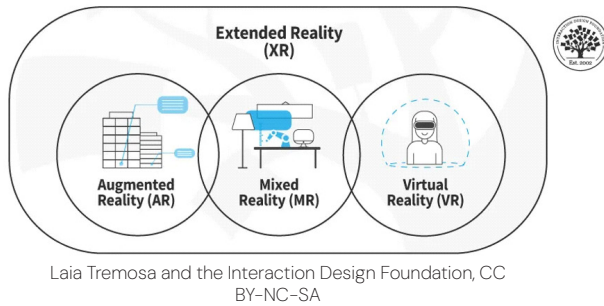
There are no shortage of explainer charts and glossaries out there about AR/VR definitions and technologies, but these are often descriptive and fall into the same trap as others, offering an interpretation of a definition and trying to make that stick. There are also calls to move away from these loaded terms entirely, although these efforts may not resolve any definitional question but instead simply move the debate from 'what is augmented/mixed reality' to 'what is the metaverse.

This post attempts to explain the debate and demystify it for new and old scholars alike, and to explain some of the underlying motivations for why people care about the question and how to talk about it productively.

The Definitions, Taxonomy

At the highest level, there is a class of visual technologies that generate spatial, interactive, and/or digital assets that extend reality (XR). Within this broad categorization these split into augmented or

virtual reality technologies, differentiated by the degree to which the technology interacts with physical space. VR technologies recreate/replace physical



perception of space, while AR technologies exist atop of and interact with physical space. The mixed reality spectrum, coined by Milgram and Kishino (1994), explains how AR/VR technologies are similar based on the degree of virtual interaction/replacement of physical reality, which dictates whether a technology is augmented reality, augmented virtuality, or virtual reality (Milgram & Kishino, 1994).

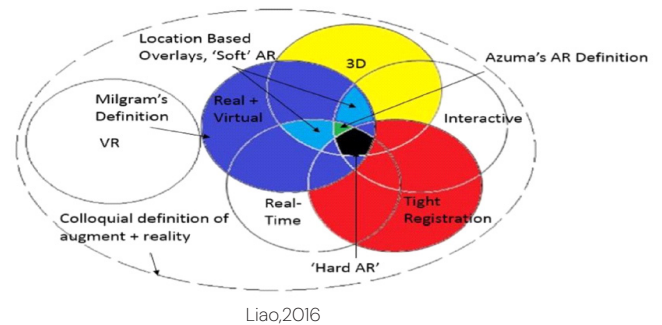
One point of confusion with this graphic is that while VR exists on one end of the pole of the reality-virtuality continuum, it is not technically Mixed Reality (MR) because it does not merge with the real environment.

Milgram's mixed reality spectrum was useful for distinguishing AR from VR, but it is more a definition of exclusion (does not replace reality) and only provides one criteria (integration of virtual graphics with physical space). The Azuma (1997) definition further clarified this to say that AR technologies not only had to 1) combine the real and the virtual but also 2) be registered in 3-Dimensional Space, and 3a) be real-time and 3b) interactive.

This has been the dominant academic definition of AR for decades now, but the interpretations and applications of these criteria have been subject to debate. Take, for example, the famous 1st and Ten line that was first introduced to American Football broadcasts in the late 1990's, which shows several imaginary lines on the field that players move over. One might argue that it is registering the colors of the fields and players in 3-Dimensional space, while others say

that it simply visualizes the line on a 2-D broadcast. Real-time is already a question of degrees, but some would argue that the line is real-time in that it updates and changes without perceptible delay, while others argue that there is still some delay built in where the line gets superimposed on the broadcast to make this system functional. Lastly, the question of interactivity is open to interpretation, in that the system very much interacts with objects in the field of play, but is not something that users can interact with in any way. Based on one's interpretation of Azuma's criteria, then, these graphics on sporting events are either the most successful and mainstream AR applications in the world, or simply a time delayed color sensor/recognition system that displays that animates a televised broadcast (not AR).

This of course is just one system, but every application could run into some ambiguity regarding an interpretation of Azuma's criteria. With some of the earliest 'AR' browsers like Layar and Wikitude, because they overlay visual geolocational data onto a phone, does that meet the 'real-time' if the data



is fairly static and could be weeks or years old, and does that meet the interactive criteria since the assets are just floating in locational space, not necessarily interactive with the events occurring in that space. With the Azuma definition there are different camps in terms of how to apply the criteria, as well as disagreement as to whether technologies need to meet all of the criteria to be called AR by the strict interpretation of it, or if mostly there is close enough (e.g. Mobile AR Browsers, Google Glass, Pokemon Go, etc.).

Some scholars and practitioners of AR have implicitly added criteria to the original Azuma definition, whether by technological proxy or just to distinguish themselves from public applications. Some even

called this 'hard' versus 'soft' augmented reality, with hard AR being characterized by multiple real-time holographic/camera tracking and registration systems, location mapping and computer vision algorithms, and hand/gestural tracking and interactivity with augmented objects. Here is an example where things one level below the stated criteria (e.g. the devices and technologies used to bring about these experiences), get added as necessary components to being 'AR' or 'VR' or used to distinguish between a particular type of AR (hard) versus geolocation-al AR browsers (soft). A graphical representation of this definitional debate is seen here, from one of my research articles about this precise issue and competing interpretations/criteria.

The Politics of Definitions: Who Gets to Say?

Many in the field who have confronted or had to answer these questions many times have opined, is this a productive conversation and why does this matter? Should we continue to enforce the boundaries as defined, however messy, uncomfortable, and unpopular that may be for the technology? Or should we move away from these terms altogether, coalescing around something else or hope that some company comes along to become the de facto lexicon, just as people now say they are 'Googling' something as opposed to 'using a search engine query for information'?

Academics have long understood that definitions matter in ways that go beyond the specifics, more that definitional questions are ones of boundary drawing, consolidating power, and exerting power using that definition (Bowker & Star, 1999). Understanding the definitional question through this lens helps make sense of this conversation beyond the question of interchangeable terminology and specific criteria. First, AR was gaining traction as a defined area of study just as VR technologies in the 1990's had been overhyped and been a commercial failure. For a variety of reasons, materially and discursively distancing the technology from VR became an important motivation for the AR move and the AR criteria, hence the importance of protecting that boundary. Some of

the first workshops and conferences in this area, the International Workshop on Augmented Reality, later the International Symposium on Mixed and Augmented Reality (ISMAR), explicitly adopted the Azuma criteria and made it clear that they were distinct from VR and that VR papers should be presented at other more generalized conferences.

The rise of corporate actors into the AR space often drew the ire of these communities, because they used the term augmented reality/mixed reality more as a marketing and promotion tool rather than a technical term. Posts pointing out how Google/Microsoft/Magic Leap were misusing the terms were part of that boundary work, as were the various primerson these terms to explain/standardize the definition.

The hard/soft distinctions and additional criteria can also be understood as a response to these outside corporate actors trying to reclaim the term, where academics worried that these applications seemed too mundane, unsophisticated, and unappealing to be associated with their work.

While having companies demonstrate successful applications may be beneficial people's general understanding of their academic areas, it could also diminish their importance as authorities and suggest that the technical problems they are working on are already solved (e.g. AR/VR has arrived).

Seen through this lens, then, for many the motivation behind enforcing the strict academic definition is to prevent unpopular/negative associations, show that the problems within the field are still unsolved, and preserve their authority as definitional gatekeepers. The places where academics have authority over these definitions tend to be amongst themselves and through peer review in journals and conferences, but this is enforceable only as long as that power is respected and entities care about their acceptance.

If Microsoft wants to call all of their AR and VR products Mixed Reality™ and try to rebrand it in a way that is not how Milgram and Kishino defined it, there is not so much people can do about it except to write another critique about how the terminology is confusing.

Has Reality been defined for you?

Consider who is asking, why they care, and whether it is important to you.

While definitions are political by nature, not everyone is explicitly being political when they enforce a definition. First, there are many academics who honestly believe that it is necessary to prevent confusion, as they feel the terms would be meaningless without any criteria so you have to draw the line somewhere, otherwise technologies like a Kaleidoscope or Photoshop could 'augment' one's perception. Amongst the academic community, at least internally we need to be able to distinguish between markerless AR and marker-based AR, computer vision algorithms versus geolocational data, etc., so it's not a stretch to then argue whether technologies that employ one or the other meets the criteria of interactivity, real-time, etc. If it is important to people to say present at conferences where these definitions matter and are enforced, then engaging in these debates is important at least to bypass the gatekeeping that enforces these definitions. The degree to which one feels the need to try to extend this definitional battles to private companies trying to utilize these terms and public understanding of AR/VR/MR etc. is up to the individual and if they feel that public understanding needs to line up with agreed upon academic convention.

Then there are individuals who try to enforce certain definitions not just for the sake of clarity and having a clear dividing line, but for the purported 'good of the technology. This is typically a group of self appointed AR/VR promoters/evangelists who are invested in the technology and are working to ensure that it is successful. Some of these people may have overlearned the lessons of the VR experience in the 1990's or simply want to push toward a positive/impactful world of AR/VR, and use the definitional debate as a proxy to weed out applications they see as mundane or harmful. While there is nothing inherently wrong with being a promoter and wanting the technology to

have positive public associations, it is important to note that these are self-appointed arbiters of what is good and bad, which is already subjective, and more so when they are inconsistent in their application/enforcement of criteria. For example, some might want to bend the interactivity criteria to include 1st and Ten and Pokemon GO because they are popular but then wield the same criteria to exclude Google Glass and Magic Leap because they were commercial failures, which can feel arbitrary, opportunistic, and confusing in it's own right.

It probably will not stop people from trying to do the definitional dance, but trying to clarify higher order criteria as a proxy for limiting out specific technologies or uses does not make much sense. If one really does believe that AR is defined by a set of criteria, then it simply is a technology that allows for a range of things such as visually displaying 2D/3D content, interacting with that content, and enhancing/diminishing one's reality. That says nothing about content and what someone does with it, so AR/VR is dual use in the same way the internet is, and people can use AR/VR for all of the same amazing and destructive ways. If this is the motivation for someone to ask about definitions/boundaries, my thought is that the better way to deal with this is simply to call something a bad AR/VR device/application, rather than try to perform definitional gymnastics to define it outside of the technology.

Lastly, there is an element of the definitional debate that serves as a social signifier, a marker that one is part of the in crowd that understands these differences and can call out those who do not. As a practical matter, then, one has to decide whether they want to adopt and use the terminology in the intended way to also reinforce this identity and to increase mutual understanding, or to disregard these conventions and deal with the occasionally obnoxious and self-important correctives and questions about whether you understand that this technology is X, Y, Z.

If one chooses to adopt the Milgram and Kishino Mixed Reality spectrum, the Azuma criteria for AR, and the umbrella terms of XR or Extended Reality, there is nothing wrong with that as long as you understand those terms, the limitations/disputes about

those terms/criteria, and you can discuss your work within and around that system. If one chooses not to use these definitions and instead adopt alternative terms, then as long as they can tolerate and push past the questions of why and can explain exactly what they mean in terms of the technology in productive ways, then that is also an acceptable choice. Lastly, if you find yourself wanting to ask the question 'but is that really mixed reality' at a panel or conference, maybe first ask yourself why it matters and why you are doing it, and whether there is a more interesting question you have about their specific application of the technology. ■■■■■

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On Media Genealogy and Forecasting

By Dooley Murphy / Laerdal Medical

Last year, I wrote reviews of *Reality Media: Augmented and Virtual Reality* by Jay David Bolter, Maria Engberg, and Blair MacIntyre (2021), and *The Aesthetics of Virtual Reality* by Grant Tavinor (2021). While the books aim to do different things, a shared feature is that they each dedicate a chapter to media genealogy. Both delve into immersive technologies' developmental lineages. It's noted how XR headsets are preceded by general-purpose computers, 3D computer-generated imagery, and cinema. Cinema is preceded by photography. Photography follows from developments in linear perspective, and so on. A reasonable assumption made by the books' respective authors is that we can gain insights from retrojecting a medium's family tree. Let's elaborate this idea before playfully underscoring its limitations as a forecasting tool.

Occasionally throughout history, a kind of cross-generational cross-pollination seems to occur among image production and display technologies. Significant leaps forward can happen with little apparent foreshadowing. An example is holographic mixed reality (MR) headsets like the HoloLens or Magic Leap. If we desire, we can frame such present-day innovations as derived from experiments of the distant past, perhaps in an attempt to explain their origins and aetiology. By this I mean, MR may appear to the consumer public as *sui generis*. To non-experts, it can seem as if MR holography defies the kind of slow, incremental evolutionary improvements seen in biology and technology alike. Where did this extraordinary technology come from? It's commercially unprecedented.

Academics, meanwhile, may readily link MR to an



historic imaging experiment. We might note that the very idea of projecting a kind of “spectral” image onto or into a piece of glass positioned in front of the eye is first seen in the work of Filippo Brunelleschi. The Early Renaissance-era architect used a mirror and a painting of one of his buildings (both with peep-holes drilled in them) to superimpose a cathedral over the top of its physical double. And if that ain't augmenting reality, then I don't know what is! Hence given their similitude, it can be tempting to argue, for example, that modern-day AR or MR headsets “remediate” Brunelleschi's mirror, combining his crude but revolutionary imaging device with digital computation, bridging centuries of technological inactivity in terms of projecting things onto or into glass.

It's romantic and seductive to unite past and present by suggesting that when we don XR headsets, we're staring into Brunelleschi's mirror, or that when we gawp at screens, we're gazing through Alberti's window (Friedberg 2006; Grau 2003).

Respectfully, though, I suggest that there's limited mileage in such a media-genealogical method—particularly if the goal is to scaffold predictions about the future. This isn't to be contrarian or to dismiss the productive insights of the above-cited books. I just want to problematise the implicit idea that we can paint a well-rounded picture of a thing by privileging its materiality, form factor, or perceptual-cognitive M.O. over its sociocultural and –political affordances,

which I think are scarcely graspable if we spotlight a medium's formal ontogenic emergence.

I'll first sketch what Bolter et al. and Tavinor mean by "remediate" or "remediation". I'll then suggest that framing XR technologies as fundamentally illusionistic tells us more about how they act upon individuals' sensoria than how they stand to impact the world. I'll end by asserting that if we want to predict what's at stake in the widespread consumer adoption of XR headsets (soon, spectacles; later, contact lenses; ultimately, BCIs or drugs), we might consider downplaying or moving beyond the fact that such media function at the individual level by way of optical, auditory, and kinaesthetic trickery. Rather than comparing XR to *trompe-l'œil* paintings or focusing on how they remediate optics, we might instead emphasise underlying architectures and affordances, comparing the fledgling family of media nodes that is XR most closely to the Internet itself.

So—what is "remediation"? Lead author of *Reality Media*, Jay David Bolter, seems to have coined the term in *Remediation: Understanding New Media* (Bolter & Grusin 1999). Simply put, remediation is when we see traces of older media in newer or nascent media. Bolter and Grusin note how empirically, "at this extended historical moment, all current media function as remediators [of their forebears,] and that remediation offers us a means of interpreting the work of earlier media as well" (p. 55). This isn't an *a priori* truth, they add, but a function of cultural practices and analytic perspectives in tandem. In the West, early cinema re-mediated theatre insofar as cameras were initially static, editing was non-existent, scenes and shots were blocked or staged as if under proscenium, and actors gave wooden yet hammy performances to best address what they felt to be a far-off audience.

Directors didn't know how else to do movies: A bespoke aesthetics of film hadn't yet coalesced. Cinema, a broadly mimetic artform, thus initially remediated the visual perspective of historic theatregoers (Bordwell 1985). And continuing this trend, for Bolter and Grusin, VR "is as a remediation of the subjective style of film" (p. 165). "When we participate in virtual

reality, our digital point of view is understood as a remediation of the point of view that we have occupied for decades in film ... and for centuries in photography and paintings" (p. 232). "Virtual reality [therefore] offers a remediated definition of the self as a new kind of camera" (p. 248).

Bolter et al.'s *Reality Media* (2021) sets out with a slightly different conception of remediation. The term is introduced as "the process of the mutual competition and cooperation among all media at any current cultural moment" (p. xxi), and examples include how VR "easily" remediates the flat-screen genre of first-person shooter games (p. 2). An inevitable observation, maybe. It seems as if for Bolter and co-authors, everything comes back to the eye—and moreover photorealism. Emphasising sensory perception above all else, Bolter, Engberg, and MacIntyre write that "[t]his is how remediation works: a newer medium depends on an older, familiar medium for its definition of reality" (p. 51).

Tavinor's version of remediation in *The Aesthetics of Virtual Reality* (2021) is at once more nuanced and grounded in explicit, stepwise philosophical enquiry. He doesn't cite Bolter and colleagues, instead employing bottom-up conceptual analysis to robustly characterise medium and virtuality—first separately, then jointly—arriving at a unified definition of virtual media, or a virtual medium. Part of what allows him to mount a convincing case is that his understanding of media—and what can be achieved thereby—is broader than that of most media scholars, not limited to communication media *per se*. Take his example of online shopping. A brick-and-mortar shop is like an oil painting: They're both made possible in the first instance by physical media.

Their respective functions—purveying commodities and depicting a subject or object—are not, however, determined by their materiality. An online shop comprised of and enabled by HTML, JavaScript, and PHP "remediates" its Highstreet counterpart in much the same way a JPG encodes bits and bytes to re-present and remediate, say, *The Garden of Earthly Delights*. (This is not to suggest, of course, that computational processes aren't rooted in physical ones.) For Tavinor, VR remediates not photorealism, as Bolter

et al. hold, but visuospatial experience. That is, the way we inhabit and perceive physical reality and the agents it contains. (See also Qvortrup 2002.)

Tavinor's remediation can be seen to focus us not so much on media's material or phenomenal correspondences as advancements in their affordances. His media genealogy does not so much lead us to think ancestor and descendent need be functionally similar, or engaged in a kind of competition. If we expand this approach beyond subjective experiential affordances to additionally encompass interpersonal, communicative, discursive, and rhetorical affordances, we'll get better purchase on what's at stake in XR's eventual mainstream adoption. Indeed, this is what Bolter is hinting at when he and Richard Grusin note in passing that "virtual reality is not only a head-mounted display and computer hardware and software; it is also the sum of the entertainment and training uses to which this hardware and software is put" (Bolter & Grusin 1999, p. 77 – my italics).

The question is, what will those uses transpire to be? How will bad-faith actors leverage XR once we're all sharing the same "consensual hallucination" (Gibson 1984, p. 5)? Or, more worryingly—and perhaps, if we can extrapolate current trends, more probably—when each one of us is living in our own XR private echo-chamber-cum-filter-bubble? Our own private spatial feed? I'm doubtful that media genealogy alone can shed much light on these questions, as the method generally obscures that XR is taking shape as a (family of) network technology/ies, concentrating instead on illusions of presence.

To be clear, XR is undeniably illusionistic. It can be compared to, and seen as descended from, stereoscopes, stereograms, and so on. Backfilling XR's family tree—that is, comparing it to representational media from Pompeian mosaics, through panorama paintings (Grau 2003), to the Lumières' Train Pulling into a Station (Bolter et al. 2021)—is an endlessly fascinating exercise, and I'm guilty of focusing on VR's perceptual and experiential idiosyncrasies in my own work (Murphy 2021). But if we want to predict how XR might affect culture and society; if we want to see the big-

ger picture, we'll do well to prepare for a worst-case scenario by looking at the Internet: Specifically, sites and services like 4chan, Facebook, and Twitter, and the tectonic trouble they've slowly and sometimes subtly but undeniably caused.

Misinformation is rife, exacerbating what can aptly if performatively be called a culture war. Scholars ought therefore to concentrate on how XR may serve as an extension or offshoot of social media and online communication platforms. If you've ever attended a family gathering and been surprised to learn that grandma is now an antivaxxer, convinced that Bill Gates invented COVID-19 because a Twitter user called FreedomEagle88 shared a heavily redacted CIA document "proving" as much, then imagine how intractable the situation will be when agents of chaos can beam a volumetric XR deepfake of George Soros admitting his conspiratorial crimes directly into your media-illiterate relatives' living rooms. I am, of course, being facetious. But this is because the future is hard if not impossible to predict.

The point is that if text and 2D images can distort people's perception of reality, XR will compound societies' tendency to be drawn in and swayed by pseudo-news that's deliberately designed to exploit cognitive biases and unconscious prejudices. If the future is smoke and mirrors, then endless reflections on Brunelleschi's experiment won't even get us half way there. ■■■■■

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Learning from VR Motion Sickness

Paul Roquet

By Paul Roquet / MIT

Most people who spend significant time with virtual reality become familiar with the queasiness that VR experiences can leave you with long after you remove the headset. In my case, I can locate this feeling in a very precise spot in my stomach: a knotted, vaguely poisoned sensation that sometimes takes hours to wear off.

I've always been interested in how media use effects the body, but in my past work on ambient media it had been largely gentle and indirect types of influence—more of a nudge than a wrench to the gut. But in spending long hours in a headset for my recent book on VR, I found myself engaged in research where queasiness was literally the price of admission.

I gradually learned which movement settings and camera motions in a VR experience would trigger this nauseousness, if rarely in time to avoid them the first time around. Simultaneously, however, dealing with routine queasiness as part of my everyday media engagement made me wonder how this came to be considered par for the course. After all, casual dismissals of motion sickness can be found running throughout immersive media history. Motion sickness caused by consumer VR is often positioned as a temporary obstacle, a problem that will gradually evaporate as the technology continues to improve, or as individuals grow accustomed to the interface and develop their “VR legs” (even as major VR companies have struggled to render legs themselves).

But what if we understand motion sickness not as a lingering side effect, but as central to how media technologies like VR remake our relationship with the world? Perhaps the knotted feeling in my stomach is not just the opportunity cost of doing VR research



today, but a clue to a longer history of how media-induced motion sickness came to be rendered socially acceptable.

The relationship between motion sickness and novel technologies has a long history. Paul Virilio famously noted how the invention of the ship also invented the shipwreck. Less considered is how seafaring also inaugurated our current era of techno-nausea: *naus-* being the Greek for ‘ship.’ Ever since, humans have continued inventing new technologies that simultaneously force us to struggle to keep the world from spinning.

Disability media studies scholar Elizabeth Ellcesor notes how media never simply “are” accessible or inaccessible for existing bodies. Rather, in many cases new media technologies create new kinds of impairments that did not previously exist. From this perspective, it isn’t that my stomach is simply ill suited to the forms of virtual movement offered in VR. Rather, VR and other forms of what we might call *nauseogenic media* are actively engaged in inventing new forms of bodily discomfort. Moving image media in particular tend to uncover new forms of image-induced motion sickness as they push towards bigger, more immersive, and more high-definition imagery than before.

A Brief History of Nausogenic Media

There are long-running debates over the precise mechanisms that trigger motion sickness within the human body, alongside a long legacy of funding put towards research trying to prevent it. But media-induced motion sickness is never simply a biological symptom, but also a social one: there is a cultural history to how it is received and discussed once it has surfaced; when it is taken seriously, and when it is dismissed.

Image-induced motion sickness goes by a lot of names. In Japan, where my research focuses, it is most frequently described as *eizō yoi*, something akin to ‘moving image inebriation’ (*yoi* can also refer to drunkenness or intoxication). In the context of 3D interfaces, this term becomes more specifically 3D *yoi*, or more recently, VR *yoi*.

In English, the earliest journalistic mentions I can find dub it “simulator sickness,” in reference to the first place it became an issue: flight simulator training devices used by the United States military. As each branch of the military began adopting simulator training, mainly for fighter jet pilots, simulator sickness quickly emerged as a new kind of liability. The concern here was less about the discomfort of individual soldiers, and more about putting them behind the controls of deadly and highly expensive equipment before the simulator sickness effects had fully worn off.

The Army, Navy, Marine Corps, and Coast Guard all instituted specific protocols for reporting time spent in a simulator, including how many hours post-simulator training someone must wait before getting in a non-simulated cockpit, whether a jet or a car to drive home. The Air Force, in contrast, had no such rule, and the official policy was to refuse to acknowledge simulator sickness even existed. As one Army flight simulator researcher put it in the late 1980s, “pilots do not like to talk about simulator sickness because it creates a perception of weakness” (Fisher, 1989). Here

was an early example of what would be a long-running connection between motion sickness and a kind of rugged masculinity that refused to even acknowledge it, or at best saw it as something to overcome through gritted teeth.

Meanwhile, in the entertainment realm, for much of the twentieth century image-induced motion sickness remained a rather niche, rarely discussed if ever-present affliction. Across the decades a slight but steady trickle of newspaper articles report people getting sick at the movies. The problem does seem to get worse by the later part of the century, however, due to the increasing accessibility of amateur moving image media creation and playback technologies. This is when the production of image-induced motion sickness gets democratized. Handheld video recorders now allowed anyone to easily produce nausea-inducing shaky-cam footage, which became an aesthetic of its own in films like *The Blair Witch Project* (1999).

To give just one example, in 2006 a video shown on a big screen at a Catholic girls’ school gymnasium in Japan caused fifty students to fall ill, with thirteen taken to the hospital by ambulance after they became severely dizzy and nauseous. Investigations pointed to the footage: shaky handheld video of the school’s culture festival taken over the previous few days. But experts noted the screening conditions must also have played a role: the gymnasium windows had been blacked out, and the video was projected onto an especially large screen, four meters by five.

A neurologist interviewed by the *Asahi* newspaper warns that “footage taken by amateurs can be expected to have camera shake, so it’s better not to view it in a dark room” (*Asahi shimbun*, 2006). The arrival of 3D video games at the end of the century also introduced new forms of media-induced nauseousness, as the frequent swerving of the virtual camera could produce similar effects for predisposed players. Andrew Emery of the *Guardian*, for example, describes first experiencing game-based motion sickness on playing *Doom* in 1995 and suffering from it with many games ever since.

VR as a Nauseous Interface

This brings me back to virtual reality, where motion sickness is common enough to make it a more widely discussed problem. During the first 'VR boom' of the 1990s, early attempts at consumer headsets like Sega's Virtua VR were quickly shelved for fear the device would "make kids sick." Here the dark surroundings and big screen that contributed to the school gymnasium sickness was all but assured by placing the screen directly in front of the face and blocking out a user's peripheral vision. At the same time, high latency rates and VR games' invitation for people to swing their heads around lowered the nauseousness threshold that much further.

By the 2010s VR revival, a more sustained discussion finally emerged concerning who exactly was most afflicted by these headsets when it came to their nauseogenic effects. Media scholar danah boyd launched the debate with an opinion piece in Quartz simply titled "Is the Oculus Rift Sexist?," noting how going back to the late twentieth century, VR tended to be engineered by men and based on their own average physical proportions. While women were also involved in VR engineering, boyd notes anecdotally how they were far more likely to have debilitating motion sickness when using the new devices. Subsequent research has identified a similarly gendered design bias across a wide range of consumer headsets.

Game comfort ratings ("comfortable" "moderate" etc.) as seen in Meta's Quest store today provide some general guidance, and individual developers increasingly give a range of movement and vignetting options to try to accommodate different motion tolerances. On the whole, however, the VR industry remains remarkably cavalier when it comes to innovating new forms of impairment. Meta's recently revised 6 core values retains their long-running imperative to "Move Fast"—a principle of sprinting into new unregulated markets, at speeds that might easily make many of those along for the ride motion sick—or worse.

In recent years, funding for motion sickness research has come to be centered on the production of immersive media systems for self-driving cars. From a media industry perspective, the self-driving car promises to open up a new scene of dedicated media consumption for the human passengers now free to ignore the world outside. Systems like Holoride promise to let backseat passengers—and eventually everyone in the car—use virtual reality content while the vehicle is in motion. To prevent the otherwise likely motion sickness, Holoride VR content is timed to the movement of the vehicle itself: when the car makes a turn, the environment inside the VR world will rotate accordingly. Holoride calls these adaptive VR experiences "elastic content."

This scene of being enclosed in a virtual environment, while being simultaneously enclosed in a moving vehicle, brings our history of motion sickness full circle. Much like the way noise-cancelling headphones use inverse waveforms to mask the rumble of the airline cabin, here vehicular nausea and media-induced motion sickness are called on to cancel each other out. In the process, however, passengers become even more dependent on these technologies for their very equilibrium. In the quest for a calmer stomach, the nauseous interface comes to serve as both the poison and the cure. ■■■■■

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Expectations of privacy in public space

By **Marcus Carter** / University of Sydney,
Ben Egliston / University of Sydney &
Kate Euphemia Clark / Monash University

AR and VR intersect (and often conflict) with expectations of privacy in public space in ways that will only become more salient over time. There is a varied and sustained engagement with the topic in the AR literature, which act as sophisticated surveillance systems. As Mark Pesce notes – “[f]ar less a new beginning than an extension and continuation of the existing and ever-deepening techniques of observation, analysis and feedback, AR mirrorshades offer an unprecedented opportunity to scrutinize user interactions in minute detail” (2020, p. 86).

In current research, there is heavy emphasis on pri-



Man wearing Google Glass

vacancy in public, with respect to AR specifically, around wearable and head-mounted technology. Early iterations of wearable head-mounted technology, namely Google Glass, was not adopted by the general public, outside of those already in the tech industry. However, many researchers wrote speculative accounts of Google Glass (Brinkman, 2013; Kostios, 2015; Wolf et al., 2018).

Marcus Carter, Ben Egliston and
Kate Euphemia Clark

Others focused on questions of who and what is surveilled, with specific focus on privacy issues for people other than the users of the technology and things in an environment (see de Guzman et al., 2019; Dainow, 2014). Wolf et al. (2018), for instance, encourage us to move away from a consideration of AR as a visual medium in their discussion of privacy. They suggest we instead focus on other forms of information that are captured by AR devices, such as voice and sound that may be present in an environment, which is currently overlooked in legislation and AR privacy discussions.

These concerns have once again become timely, with the introduction of the Ray-Ban Stories, produced by Meta. Stories are a form of wearable technology that can take photos and record short videos with audio. The glasses have a small red light to indicate that they are taking video or pictures. The release of Ray-Ban Stories was met with serious criticism, around privacy and surveillance, often from groups that Meta had ‘consulted’ with (Egliston and Carter 2022).

It is very easy to conceal the privacy light with a small piece of black tape (Notopoulos 2021). However, this tape is hardly necessary, as Joanna Stern reports from her time using Stories, many people did not know that they were being recorded until she told them, despite the fact that she did nothing to obscure the light that was meant to indicate that the Ray-Ban Stories were in use (Stern 2021). Furthermore, this is just the beginning of what Meta envisages for Ray-Ban Stories – they are reportedly exploring adding facial recognition software (Mac 2021) and image recognition technology (Egliston and Carter 2022) to the glasses.

Other work (Mann, 2013; Mann and Ferenbok, 2013; Denning et al., 2014) touches on the potential for AR to foster an environment where everyone can surveil – terming this ‘sousveillance’. Presenting an optimistic outlook, Mann and Ferenbok (2013) suggest that this sousveillance represents a kind of political challenge to hierarchical, top-down surveillance by the powerful, and facilitating a ‘surveillance from be-

low' (giving the example of recording the police as an accountability measure. 2013, p.20).

The theme of privacy in public spaces with respect to AR was also key in legal perspectives. Wassom (2014) points out gaps in UK based legal regulation around AR – including privacy – and Blodgett-Ford and Supponen (2018) highlight some of the US legal issues present in advertising via AR (and VR), such as in use of biometric and geographic data collection for advertising. Meese (2014) focuses on the legal blind spots in Australian privacy law in regulating widespread AR technologies (noting issues specific to Australia, such as a lack of regulatory or constitutional privacy protections as seen in Europe and the US respectively). Regulatory power is central to privacy in both AR and VR, as there is little input from corporations in this area. Upon the release of Ray-Ban Stories, Meta only has a short list of privacy guidelines for user's to respect bystander privacy, with advice such as: always let people know when you are recording by using obvious gestures; obey the law and do not harass people; take your glasses off in private spaces such as locker rooms; and respect people's preferences for being recorded (Meta 2022). This places the onus on the consumer to uphold the privacy of those around them.

Prior research also has an emphasis on AR, public space and expectations to seclude oneself from others and particular forms of information. Kostios (2015) gives the example of users in public spaces projecting AR images onto private property, also discussed by Blitz (2018) as a form of 'personalisation of space', in the context of US constitutional law. There were also concerns about AR and the projection of harmful material (see Lemley and Volokh, 2018). Pesce (2017) gives the particularly striking example of AR's weaponization as a tool for public hate speech.

He writes:

"What if that blank canvas gets painted with hate speech? What if, perchance, the homes of 'undesirables' are singled out with graffiti that only bad actors can see? What happens when every gathering

place for any oppressed community gets invisibly 'tagged'? In short, what happens when bad actors use Facebook's augmented reality to amplify their own capacity to act badly?" (2017, n.p.).

Robertson (2019) identifies some of these same concerns around the case of Mark AR – a mobile application allowing the creation and placement of persistent digital images in real world environments. She notes that the developers of the application have actively had to incorporate features to minimise the potential for AR's weaponization, such as requiring real names and the need for active human moderation. Further, safety apps, such as Safetipin, use user ratings of the 'safety' of certain locations that then determine how police patrol certain areas, which has some troubling implications for who gets to determine what is 'safe' and what type of areas are deemed 'unsafe' (often those that are poor, majority POC neighbourhoods, sex workers, drug users etc.),



which then creates over-policing of these areas (Le 2022). As AR technology gets more sophisticated, we need to take stock of how we are digitally inscribing physical spaces, and what it means for the communities that gather there.

In contrast, while there is concern around expectations of privacy in public, a number of AR art practitioners have shown the expressive and activist potential of augmented public space. Skwarek, for instance, creates a virtually rendered elimination of the border between Israel and Palestine at the Gaza Strip (see Skwarek, 2018). Others have employed AR for subversive cultural commentary. Katz (2018) discusses the use of AR by artists to overlay artworks at

the New York Museum of Modern Art with images or text (making artworks unrecognisable) – the goal of which being to challenge the authority of high art as something often produced by individuals with certain social and class interests. While these examples do not ‘lessen’ the issues associated with AR as invasive, it does show that this can at least be done for expressive or purposeful ends.

Discussions about the public use of VR – and its intersections with feelings and expectations of privacy – were relatively limited. In an account of the use of VR in art gallery spaces, Parker and Saker (2020) outline the qualitative experience of this increasingly popular ‘public’ use of VR. Inspired by Henri Lefebvre’s account of spatiality, Parker and Saker understand the art museum as both spatial and social – a dynamic that VR-based experiences alters.

As they point out, through interviews with gallery-goers, VR created feelings of ‘freedom’, inasmuch that their view of the virtual space was not visible to others – providing a “mastery of space and autonomy that is rare in a crowded museum” (2020, p.10). Conversely, their participants describe feelings of vulnerability – particularly in being watched using the technology, which we also found in our research into the use of VR videos in the zoo (Carter et al., under review).

As scholars like Golding (2019) discuss elsewhere, VR is a medium that is imagined largely around the performance of an embodied spectacle, through the user making a range of bodily gestures corresponding to movements on the screen. Museums – as social, public spaces – are inherently characterised by a dynamic of watching others, something that Parker and Saker’s (2020) participants also felt to be intensified through VR, where the user’s bodily performance of VR became part of the museum experience. While Parker and Saker do not engage with ethics, what they underline here is the ways ‘private’ VR in public spaces still presents challenges in the context of existing expectations of privacy in public space. ■■■■■

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Getting our VR legs: Who is using VR?

By **Daniel Harley** / University of Waterloo

In October 2022, Forbes reported that 100,000 people had stopped using Meta's social VR app, Horizon Worlds. This wasn't surprising, given that Meta's employees apparently weren't using it either. In internal memos, Vishal Shah, Meta's VP of Metaverse, reprimanded employees for not using (and not 'falling in love' with) the app, arguing that "the aggregate weight of papercuts, stability issues, and bugs is making it too hard for our community to experience the magic of Horizon."

Mark Zuckerberg seemed to think we'd experience that 'magic' if our avatars in VR had legs. After hurrying through "big improvements to [avatar] representation," Zuckerberg showed off his virtual legs by making his avatar jump. "I think everyone's been waiting for this! But seriously, the legs are hard." Later it was revealed that this was a simulation rather than a demonstration. If this was all part of a larger strategy, it didn't seem to be working. Articles around that time calculated that, so far, Meta had spent about US\$36 billion on the metaverse. Less than a month later, Zuckerberg announced that Meta would cut 11,000 jobs, contributing to broader layoffs across the tech sector.

Meta hasn't been the only company struggling with its VR platforms. Microsoft cut 10,000 jobs in the same month that they announced that their own social VR app, Altspace VR, would be shutting down. It was an echo of a similar announcement a few years ago: in 2017, Altspace had run out of money, only to be revived by Microsoft.

Daniel Harley



Now, Microsoft's announcement declared that they would 'sunset' the platform to transition from consumer to business experiences, devoting attention to a "more open, accessible, and secure version of immersive experiences in the metaverse".

Caught between these tumultuous factors and the ongoing hype about the metaverse, we still know very little about who is using VR or why. For VR researchers in the field of human-computer interaction, there is an additional problem. Trying to understand barriers (and opportunities) of VR use are complicated by the difficulty recruiting demographically diverse research participants.

For example, Radiah et al. (2021) and Blackwell et al. (2019) both report difficulty recruiting anyone who does not identify as a cisgender man. In one of their studies, Radiah et al. (2021) note that the sample was so skewed in favour of men that it was impossible to study gender differences as a variable of interest, reporting the challenges they faced attempting to recruit women. Similarly, while Blackwell et al. (2019) report important findings about harassment in VR, the authors acknowledge that their participant pool reveals clear gaps: an absence of demographic data to better account for race and ethnicity; an absence of data on sexual orientation; and an absence of data on women and other marginalised gender identities in VR.

Researchers know this is a problem and still have difficulty avoiding it. In a paper about self-disclosure in social VR software, Sykownik et al. (2022) whittled down 221 survey responses to 126 complete responses—

es that they could use for analysis. From there, 107 participants chose to indicate their gender identity: 77 out of 107 identified as cisgender men. The authors write, “the core limitation of our study is a homogeneous sample in terms of the platforms and demographic groups it represents” (p. 13). In an interview study on mitigating harassment in social VR, Freeman et al. (2022b) write, “we acknowledge that there are not many voices in this study that would be considered most marginalized or most at risk in tech spaces” (p. 26). Of their 30 interviewees, 21 identified as cisgender men.

Although each of these studies gives us more insight into VR use, it can seem like we’re mostly learning about men in VR. Even Zuckerberg is aware that VR use is male-dominated, and he seems to think that’s the reason for the sexual harassment in online VR: “One of the big issues that I think people need to think through is right now there’s a pretty meaningful gender skew, at least in virtual reality, where there’s a lot more men than women. And in some cases that leads to harassment.”

Zuckerberg’s characterisation oversimplifies the issue. It tells us nothing about the problems people face with the software or the hardware, and it tells us nothing about the lack of regulation in these spaces, or the lack of representation and inclusion ranging from production to use. As Clark and Le (2022) argue, evidence of sexual assault in the metaverse should not be misconstrued as an isolated problem detached from its social, cultural, and technological factors.

While there are examples of participant research specifically examining non-dominant experiences in VR (e.g., Freeman and Acena, 2022; Freeman et al. 2022a; Gerling et al. 2020), each of these examples also functions as a call to action for more diverse demographics in participant recruitment. There are also efforts to document and discuss the specific challenges of conducting VR studies (e.g., Radiah et al., 2021), but of course we need much more. As a research community, there’s an opportunity to share

our strategies towards more inclusive participation.

‘Getting your VR legs’ is slang for working through the physical discomfort of dizziness and nausea in VR environments. It almost works as a broader metaphor for the state of VR as we start 2023, with the slow grind through discomfort with the hope that the nausea might go away. But as Meta works to give us virtual legs, I think we already know that Mark Zuckerberg’s jumping avatar won’t solve the problems of VR.

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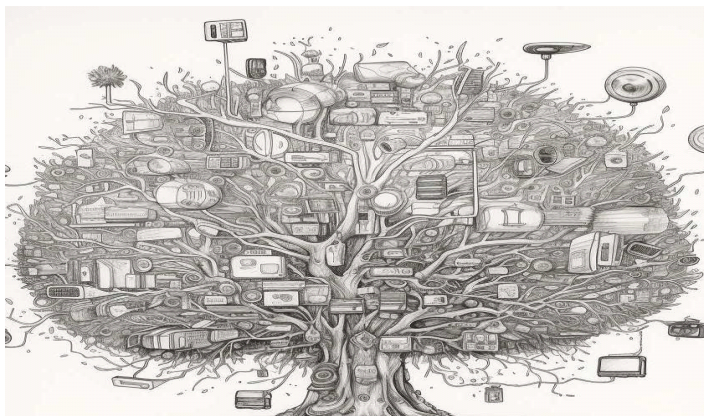
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How Augmented Reality Comes to Be

By Luke Heemsbergen / Deakin University &
Andrew Iliadis / Temple University

There is no shortage of diagrams that purport to explain the evolution of technology in society. One fun diagram in the academic study of emerging technology is Geel's (2002) "dynamic multi-level perspective on [Technology Transitions]." The diagram sure beats popular industry sources like the Gartner Hype Cycle diagram in terms of number of lines and arrows! More seriously, Geels' diagram holds better explanatory power of how technologies are socialised. Schot and Geels (2008) reproduced the diagram with more complexity (and a lot more arrows) in 2008 and this



Evolutionary tree of tech (Authors - Midjourney)

version is the one we've included below (Figure 1) to help think about the socialisation of fields like Augmented Reality (AR).

The image helps us consider three important processes; namely, how the conceptualisation, concretisation, and contextualisation of 'tech' is embodied in forces of markets and user preference, industry, policy, technology, culture, and science that all vie and push into configuring a 'stable regime' of technology use with which people identify.

Luke Heemsbergen and Andrew Iliadis

Identifying tech regimes in society at a certain time and place might bring to mind experiences like 'renting VHS tapes' or 'apps on your smart phone'. Yet products, a tech regime does not make: there was not a 'Google Glass' regime. And there does not yet seem to be an "AR" regime. But how would such a regime emerge?

The post focuses on some of the things that happen when AR moves from niche innovation technologies (the starting point in Geels' diagram) to a technological regime (the end point), and what the consequences are. Rather than try to explain every niche, arrow, and domain within the Schot and Geels diagram, in this post we use the image as inspiration to consider how technologies are conceptualised, concretised, and contextualised. Doing so will help track how sociotechnical imaginaries come to be, are hammered into regimes by market and other forces, and are also reconsidered in everyday use in ways that are often surprising to the makers. That is to say as technologies are 'contextualised' intended uses (and users) can run sideways as people use products in ways that were unintended, despite much work on market research, or regulation, etc.

To be clear, this is about AR. We don't think VR will be the same. VR seems destined to remain a technological niche. Yes, game engines, the metaverse and all that might be here to stay. But pulling users away from their environment segregates cyber-space by definition—AR promises a different regime.

Conceptualisation

How AR is conceptualised matters and here we want to focus on how AR is imagined as a technology. Technological imaginaries function in incredible ways to inform what is coming from what we know and dream about. Jasanoff (2015:3) sees a need for these "conceptual frameworks that situate technologies within the integrated material, moral, and social landscapes." She notes how resources like science fiction offer this up "in such abundance;" it was the science fiction writer William Gibson who coined the

word Cyberspace, Jules Verne who first took us to the moon.

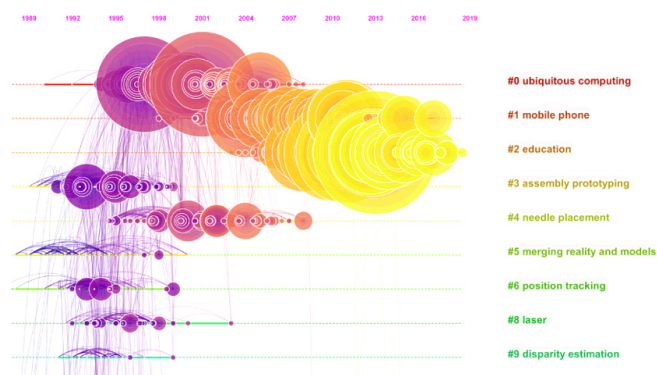
At stake for Jasanoff (2015; 322–323) is how actors' own technological projects are reflected in the design and fulfilment of collectively imagined forms of social life and order. She sees these imaginaries as

- Inviting analysis of the origin of new scientific ideas and technologies and the “social arrangements or rearrangements they help sustain.”

- Allowing us to consider how the “merely imagined is converted into the solidity” of routines, things, and identities; and

- Showing moments of resistance and power when competing imaginaries struggle to establish a “social terrain” and

- Offering ways to consider how unconventional ideas gain traction across time and space.



Right now, in AR, we can see many of these imaginaries and their trajectories play out. One place to do so is FABRIC, a cultural analytics database at Isabel Pedersen's Decimal Lab that catalogues how AR (and other wearable tech) is imagined in products and promos (Iliadis & Pedersen, 2018).

Comparing FABRIC to a decade of Augmented Reality conferences and trade shows, Liao and Iliadis (2021) consider how AR discourses evolve through “Field Configuring Events” that offer the opportunity for numerous actors to come together to create a macro-understandings of how a set of technologies ‘work’: what problems do they solve, how can media tell the story, etc.

Another place to watch imaginaries play out is the AR research space itself. Kim et al. (2018) write the histories of AR technologies as envisioned by the research-engineers designing them. Cipresso et al. (2018) show a different set of imagined futures (and pasts) through bibliometric analysis of how clusters of AR research evolve over time. Their work, covering up to 2015, seems to suggest that as AR hardware commodified, interaction potentials in ‘clinical’ settings became the focus of AR research (in the Web of Science database at least). While the 1990s and early 2000s were about the technology (interoperability, tracking humans and objects, etc.), the cluster analysis suggest more impactful research shifted to applied settings in medical use and lab-based education studies, and by the 2010s started to reflect the shifts that mobile phones made to making AR applicable across whole cities.

Heemsbergen and Cadman's work (2021) borrowed Cipresso et al.'s methodology to see what the picture of AR ideas in research looked like if the next 5 years were included (up to 2020). While we saw similar clusters as citation patterns evolved (Figure 2), what was apparent is that the most recent clustering of research was focussed on AR jumping out of clinical and lab-based applications of the technology, and into peoples' everyday practice.

A significant shift focusing on a cluster that builds from 2015 (yellow), shows AR research considering how humans (would) interact with AR in their everyday lives. This includes imaginaries from marketing to tourism, to hospitality to culture heritage. While it seems that the AR industry pivoted away from failed consumer expectations (see Google Glass and Magic Leap), various non-AR disciplines began to research their own imaginaries of how AR would mediate their industry or discipline.

Concretisation

We think of concretisation as the process of potential imaginaries succumbing to market forces, civic pressure, technological limits, regulation, and other constraints. These pathways of concretisation show how and where ideas that mobilise AR are finding traction and how they run up against one another as

disciplines, industries, and consumers try to claim the experience of the AR media they use, and how they want to do so.

We can think about the varied actors' ideals of AR (de)forming into material systems of media. Jumping to design theory for a moment, Flusser (1999) talked about design as a tragic process that de-forms 'morphe' (form) as it in-forms 'hyle' (matter). Design distorts idea into medium. Media are a working design of an idea that people communicate. Flusser (1999: 24, 28) saw information and communication technologies media as capable of moving "past formalising a world taken for granted" to realise "forms designed to produce alternative worlds." AR and VR offer these worlds, while AR offers it in real time in relation to our own environment.

Yet AR does not claim "unmediated reality" ; it affords certain properties and dynamics just like any other media does. These are 'concretised' by factors that include the technological, but also include the complex dance of actors and ideas that Geels (2002) sketched out across 6 dimensions at play in creating a technological regime. Ideas and constraints vie for attention and solidification into stable regimes.

In many respects, AR is not there yet, as a technological regime. We can look to other media to understand what emerging tech looks like when concretised into a regime. Facebook gives a pretty good example of social media as concretised regime: the economics, uses and users, and political pressures and cultures are widely understood. Likewise, Cable television was a thing that was technical and cultural, with an industry and entire infrastructure built around it.

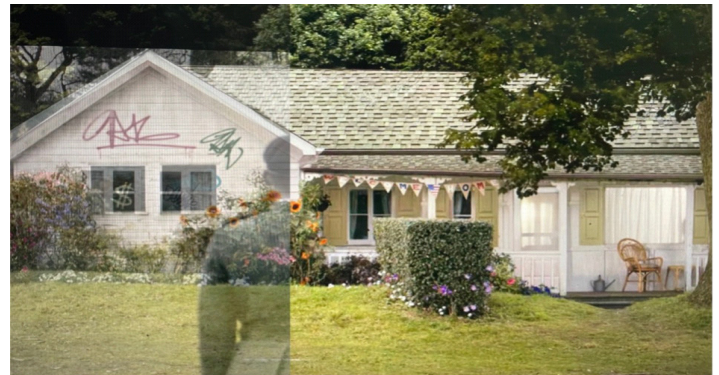
Despite Google's 2013, Magic Leap's 2017, and Apple's 2023(?) efforts at products, there is not yet this sense of formalised form which offers what AR is and is to become. How spatial computing technologies 'extend reality' is still up for grabs. There are imaginaries, but regulators, consumers, and other actors caught up in the socialisation of AR have not yet hardened their minds to the fluid possibilities of what "augmented publics" consist of and how their com-

ponent parts balance into a future trajectory.

That being said, specific properties and dynamics of AR are built from a technical design constraint of invasive surveillance (Heemsbergen et al. 2021). The amount of biometric and physical-environmental surveillance required to make AR 'work' is unprecedented and offers contentious imaginaries that need to be concretised in and across the dimensions Geels sets out. What dimensions come into play here (e.g. regulation or market) is something to think about and shows where to intervene effectively.

Contextualisation

It then seems premature to speak of contextualisation if forms of AR have not yet concretised. Yet, it is important to recognise that new media, despite their intended public debut, suffer continued social and cultural appropriation (Gitelman, 2006, p. 27). Users create and relate diverse experiences to each other that afford evolving forms of mediated socialisation. In other words, how users react, engage, and recon-



Black Mirror's "Men Against Fire" (Netflix)

figure AR as media in novel practices matters and should be a site of research.

Such 'unintended' practices are afforded in context (Costa, 2018; Heemsbergen, 2019) where ideal experiences, users, and other 'imaginaries' give way to experimentation and varied and even subversive use. Future study of these spaces and their communities might help researchers consider how to guide potentially relevant futures of AR publics as they continue to emerge and evolve.

One simple example of this type of contextualisation includes developers experimenting with ARKit's occlusion feature. Apple introduced this functionality

to make AR objects easily 'disappear' or be occluded by human forms that walk in front of the objects. This technical feat requires recognising and manipulating human forms. Some developers contextualised this feature by inverting its intended use – they made people seem to disappear from real life altogether! This was put to the test on cars, and other objects that were no longer desirable.

What is desirable to see or not see in a specific context of mediated reality is up for debate. The political ramifications of such work are (of course) already found in science fiction, like Black Mirror's "Men Against Fire" episode. In this story, not only does AR make enemy combatants look like mutants, once discharged, soldiers can perceive their decrepit home towns through 'rose coloured' lenses.

A real life culturally relevant example of this political in/visibility is explained by Indigital's CEO, Mikaela Jade, whose acts of refusal in AR show how what is taken with us and what is not into AR culture is a political act. For instance, how should we 'witness' the history of massacres of First Peoples in Australian environment? Mikaela's answer is: was living it once not enough? Contextualisation also shows how different media systems can combine in ways that their developers/markets/regulators did not intend or imagine (see Akrich 1992).

Conclusions?

From these examples, we can see that tech like AR being conceptualised, concretised, and contextualised are not always linear or discrete phases (just look at Geels' arrows!) but they do influence how these forms come to inform our lives.

Each phase presents its own things to consider and levers to influence; research through to regulation should be aware of how to exact maximum effectiveness targeted in each phase. How AR will be socialised is complex, but within the complex mix of actors, forces, and structures that bring technological regimes into being, the conceptualisation, concreti-

sation, and contextualisation are all matters worth considering. ■■■■■

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Sexual assault in the metaverse isn't a glitch that can be fixed

By **Kate Euphemia Clark** / Monash University &
Trang Le / Monash University

A growing body of research has documented multiple challenges with commercial content moderation conducted by social media platforms today, from appalling working conditions for moderators who are overwhelmingly located in the Global South, to the issue of biased algorithms, and the lack of transparency and accountability in moderation decisions. Moderation is no doubt an incredibly difficult task. A recent high-profile case of sexual assault in Meta's platform, Horizon World, raises more questions around how virtual reality environments, such as the metaverse, should be moderated.

Despite Facebook's recent rebranding as a "metaverse" company, the metaverse is still a speculative platform.

As Julie Inman Grant, Australia's eSafety Commissioner, speculates, the metaverse could refer to "an extended 3D world", or "a multiverse with a range of 'walled garden' offerings". Even Meta has admitted earlier this year that the implementation of its vision for the metaverse is at least five to 10 years away.

However, this didn't stop CEO Mark Zuckerberg painting a speculative vision of the metaverse in a 2021 keynote – a set of virtual spaces where people from different physical spaces can congregate and seamlessly interact in real time with a sense of presence and total immersion.

Kate Euphemia Clark and Trang Le



For many critics, this real-time multisensory social interaction is what distinguishes itself from traditional "two-dimensional" social media platforms, resulting in a corresponding shift from moderating "content" to moderating "behaviour".

Moderating bodies and movement

The metaverse provides added complexity to content moderation – not only are texts and images needing to be checked for unsavoury content, but also actions, movements, and voices. This amounts to hundreds of thousands of minute movements that would need to be assessed in the course of content moderation.

The gargantuan volume of these materials creates a problem of scale to which, once again, artificial intelligence (AI) seems to be the perfect solution.

Nick Clegg, Meta's head of global affairs, muses that the metaverse might modify existing AI tools that are currently being trialled in online gaming, such as Good Game, Well Played. GGWP is AI software that produces a social score for players, based on a number of anti-social behaviours, such as quitting an online gaming match before it's finished, writing racial slurs in a game's chat feature to other players, or not being a "team player".

GGWP creator Dennis Fong says the chat function in particular pays attention to the context in which potentially hateful speech can be made. If a report is made against a player with a bad social credit score, or by a highly-ranked player in the game, then the

report will be placed at the top of the queue for a human moderator to assess.

There are familiar challenges with adapting this approach to moderation in the metaverse. AI software is only as sensitive as the data being fed into it, which has historically led to serious problems, as demonstrated by Google's autocomplete feature suggesting searches that are racist, sexist, and promote misinformation.

An approach that leans so heavily on AI, with little human involvement, has also led to policies that disproportionately affect minority groups (such as YouTube's demonetisation policy affecting LGBTQIA+ content), and tacitly condones behaviour that excludes many minority groups from these spaces. Further, in order to tackle behaviour moderation in relation to sexual assault, AI software will need to address bodily movements, which begs the question: How do we determine what bodily movements are sexual, given that sexualised violence is highly complex, fluid, context-dependent, and cannot be neatly defined?

And, how might these rules need to be modified in different spaces within the metaverse?



Woman in VR

Patrolling the metaverse?

Traditional moderation software won't be able to cope with moderation in the metaverse.

Matthew Friedman, CEO of The Mekong Club, a non-profit organisation addressing human trafficking and forced labour, takes his cue from how abuses are

dealt with in real life. In a SCMP op-ed, Friedman proposes virtual police might be required to patrol the metaverse to keep everyone safe, particularly vulnerable groups such as women and children.

This proposal isn't surprising, as people have always imagined cyberspace to look like a version of real urban spaces. So, if we expect the police to patrol our cities, we'll similarly expect them to patrol the metaverse.

Clegg also draws real-world parallels to behaviour moderation in the metaverse, by drawing a comparison with how certain behaviours are enforced in public spaces, such as bars and cafes.

But Clegg seems to have accepted this approach wouldn't be enforced:

"We wouldn't hold a bar manager responsible for real-time speech moderation in their bar, as if they should stand over your table, listen intently to your conversation, and silence you if they hear things they don't like." This implies two things: that moderation will be left up to individuals or smaller companies that create virtual spaces within the metaverse, and that Meta assumes behaviour moderation on the scale of the metaverse will ultimately not be possible – both of which absolve Meta from the bulk of responsibility when it comes to moderation of behaviour in the metaverse.

Yet, even if Meta is willing to commit to moderation in a way that no other tech company has previously, the issue of sexualised violence and abuse won't be resolved by simply employing more people to act as virtual police or bar managers.

Similar to the issues with human moderators employed by commercial social media platforms, this raises the question of who will be employed as the police, under which working conditions, and based on standards set by whom.

Further, police forces have historically been ineffective in addressing sexual assault.

More importantly, as one of us has previously argued, this discourse of “police as protectors” and “women as vulnerable” is highly problematic, as this pushes women into the position of victims even before sexual assault occurs, and risks legitimising surveillance as the inevitable solution to address gender-based violence.

While the metaverse remains difficult to define, people are relying on historical solutions to sexualised violence – either through AI on current social media platforms, or police-centred models. Incidents of sexual assault in the metaverse, while troubling, are also unsurprising. While the technology is new, the threats of sexual violence are the continuation of harms we’re familiar with in both the physical and online worlds.

As Meta has historically failed its users on issues of moderation, it’s important to demand clear solutions, as well as more responsibility and accountability from Meta, before the metaverse becomes embedded in our everyday lives.

But we’ll have to come to terms with the fact there’s no magical technological fix to issues of sexual assault in any medium. We’ll have to acknowledge that sexualised violence in the metaverse isn’t simply a “glitch” that can be fixed or tweaked. ■■■■■

The Death of the Metaverse?

Leighton Evans

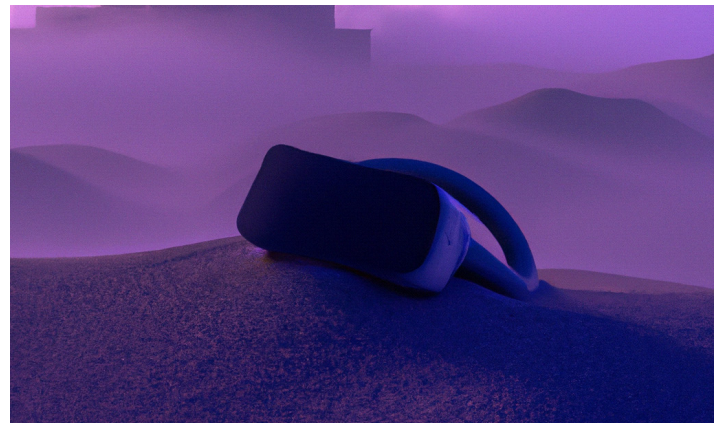
By Leighton Evans / Swansea University

RIP Metaverse. Not my headline, but the leading line of an article in Business Insider in May 2023. As I write this at the end of May, I can look back on a month of relentless articles informing us of the death of the metaverse. Requests for a moment's silence for the death of the metaverse, to exclamations of the metaverse being no more. A vast change from 12 months ago, when Michael Saker, Jordan Frith and I were finishing a book on the metaverse in the wake of hype and hysteria akin to that which accompanied blockchain in the 2010s.

In lieu of a widely accepted definition, in *From Microverse to Metaverse* (2022: 4) we tried to base our conceptualization of the Metaverse in part on how Mark Zuckerberg saw the metaverse:

An all-encompassing virtual world that is persistent and combines virtual spaces for unrelated tasks into the same platform and enables people to perform many of the activities currently performed in the physical world in this interconnected virtual space.

As we interpreted it, Meta's Metaverse is a place where someone could live primarily a digital life (a vision that of course ignores that one cannot leave their body behind (Hayles, 1999)). Consequently, unlike persistent virtual worlds like *Second Life* or *Fortnite*, a full Metaverse would be a world of unrelated activities where people could go to work, exercise, attend live concerts, and on and on using virtual reality (VR). One year on, this vision is apparently dead in the wake of multiple rounds of job losses and stock value declines. Is the 'metaverse', the concept of a virtual world that enables people to perform the functions of everyday life in digitally mediated space, dead? No. If Meta's vision of the metaverse is dead,



VR headset on sand dune

then we might well rejoice. Meta is a company implicated in numerous scandals and nefarious activities in pursuit of their business model. A business model which is predicated on the planetary-level harvesting and processing of personal data to reduce users down to data subjects through blanket surveillance (Zuboff, 2019). This business model incorporates VR and the Metaverse as an extension of the platform economics of the company (Srnicsek, 2017), another way to gain data on users to be sold to advertisers. An intensification of the surveillance capitalism model, capturing biodata and real-time attentional information at a scale not yet possible.

One of the things that the myriad tech articles do not analyse in any depth is why this scant vision has failed. There is a very simple reason for this. Meta's Metaverse is not a place anyone wants to spend any time inside, and there is nobody there to spend time with either. The scaling up of the Metaverse to the kind of environment that Zuckerberg sees as the future is not here now and will not be for a long time. The technological imaginary of the Metaverse is underpinned by the notion of presence. It is a space that supports continuity of identity, objects, history, payments, and achievements over time. It is an environment for socializing, working, playing, exercising, dating and all other interactions. In other words, the metaverse will be a continuous space to dwell in – a world of place attachment perhaps more attractive than the supposed "real", but at least somewhere that I would want to spend time in and somewhere where all this is possible and more. The primary reason why Meta's Metaverse is dead is because this is nowhere close to being built.

If Mark Zuckerberg wants me to live in his metaverse, then the metaverse will have to let me live in a manner where I can have an authentic sense of being. To understand what this looks like, we can turn to Martin Heidegger's phenomenological account of dwelling and being-in-the-world from *Being and Time* (1927).

The challenge for creating the metaverse is to create a world that I want to be in and spend a considerable amount of time in – to dwell in. Proper dwelling in the world, in a phenomenological sense, is critical to our understanding of being and other beings, and that dwelling itself is a relationship to other things. Our understanding of the fundamental questions of being is a function of dwelling in the world, but this dwelling needs to be understood in reference not only to things but also to how we stand in relation to other things.

This derives from Heidegger's notion of Dasein and taking things into 'care' as fundamental to the spatiality of being in a meaningful existential space or world. By taking things into care Dasein stands in relation to that thing and uses the thing in fulfilling a towards-which, and that is part of Dasein's attunement as dwelling.

In the context of digital worlds or the metaverse, it is the manner of orienting and locating oneself in a digital world that is understood as place that will be part of Dasein's attunement or dwelling in place, and as such there will be practices of use that are conducive towards dwelling. Dasein's understanding of the world (which it is thrown into and necessarily is being-in) through taking objects into care (*Sorge*) and being involved with the world through engagement with equipment (*Concern* or *Besorge*) is critical to understanding how Dasein makes sense of place. The kind of understanding of space is an existential nearness or distance to place, is dependent upon the bringing things into care that is realised as a situateness or attunement to things in the world.

In essence, the metaverse will need to be a place where the possibility of bringing things into care is possible and will be done.

As Dasein, we always comport ourselves towards this place called the world; always striving to understand meaning and act accordingly (Dreyfus 1990: 99). The world is then a referential whole, and we understand entities through this referential whole and the references between entities, not through the intentional study of individual actors or objects in the world (Dreyfus 1990:103).

While the universe can be described using the term space (and therefore linked to the material extension of Cartesian dualism) the world for Dasein is a place; somewhere that Dasein resides and lives. Place is not an objective, spatial, geometric phenomenon like the Cartesian explanation – places are existential locales (Blattner 2006: 75), or worlds. Familiarity with such places is a sense of nearness or distance, but this is an existential rather than geometric distance. From Heidegger's phenomenological perspective, we are not located in space-time.

Instead, we are always somewhere more or less familiar. From this perspective, things did look promising for Zuck's metaverse. We could be familiar in a computer-generated world, given the time spent there but also what we do there. The metaverse can easily be closer than the house next door, just as a digital world can be closer than an unfamiliar part of our hometown. I, for example, spend more time in GTA Online than in my office and because of that I am more familiar with San Andreas than some parts of Swansea University (just kidding, boss).



Zuckerberg's metaverse has very little to do

My familiarity with the world of GTA Online comes from my activity there; I do things. I build the world, it is not just given to me. This is the key to the failure of Meta's Metaverse, the reason why it is an existential desert. There is nobody there because we cannot do anything meaningful there. There is nobody there, nothing to build and nothing to do. I do not feel at home there. I don't want to be there because it is boring. Frankly, there is nobody in this world, and no other entities that comport me towards Horizons or any other Meta spaces which will make me want to stay.

Fundamentally, the world made by Meta is not really a world, but a spatial container for a poorly-realised vision that cannot yet be done.

The death of the Metaverse in the hands of a company that established and maintained the surveillance capitalism model of profiting from users' data (Vaidhyanathan, 2018) is no tragedy. In truth, the Metaverse is not here. It is years away from being close to the kind of existential place we can dwell. The technology, the interfaces, the ability to create and change the virtual world that would allow us to dwell are not yet with us. The overreliance on VR in Meta's vision now looks especially simplistic, with the Quest 3 and Apple's Vision Pro being more mixed reality focused devices. The future of the metaverse is not yet written and is not likely to be defined by Meta's early play for dominance of the post-mobile internet. Whatever happens, we will have to do things – we will have to care for objects and others in order to care about the place. That sounds more akin to a mixed reality space than a purely VR based artificial environment Until that happens, there will be no major scale metaverse.

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From Calming Spaces to Superpowered Avatars

By **Panote Siriaraya** / Kyoto Institute of Technology

Exploring How VR and AR could Enhance Health and Well-being by Recreating Spatial, Social, and Feedback Reality

Virtual and Augmented Reality technology has seen rapid advances in the past decade. Previously, entering into a virtual environment often meant that users had to put on a heavy enclosed headset connected to a desktop PC through thick cables or wear 3D glasses and walk into a specially constructed video-theatre like room where the 3D environment is projected onto the surfaces of the room. Nowadays, there are number of affordable lightweight head mounted display devices readily available to teleport users into highly immersive online virtual environments which can be inhabited simultaneously by hundreds of other users in real-time. Even most conventional smart phone devices are now able to extend objects from the virtual space into the physical world with high fidelity. As such, it is not surprising that VR and AR technology has seen increasing use across a wide range of domains such as in education, architecture and engineering, with one of the most prominent fields being healthcare.

In this literature review, we highlight three intriguing ways in which virtual environments have been used to support physical health and enhance mental well-being. We describe 1) how physical and spatial reality could be manipulated through VR to create calm, meaningful or engaging spaces which could help improve the quality of life for people with dementia, 2) how social reality could be recreated through the embodiment of avatars with identities and characteristics that differ from one's own and how this form of virtual embodiment in an online virtual environment

Panote Siriaraya

could improve self-worth for people with physical disabilities or be used to reduce biases as part of cognitive training exercises and 3) how virtual feedback created from real-world exercise interactions could be manipulated to either increase the level of challenge or sense of self-competence for people undergoing physical exercise. In each case, we examine previous work carried out in that specific domain and then highlight the opportunities, issues and critical challenges that still exists. Finally, we discuss a key trend which we believe would have a substantial impact on the future of VR/AR in healthcare: the integration of high performing generative AI models with various components of the virtual world, which would result in them becoming more intelligent and personally meaningful.

Recreating physical reality to create calm and meaningful spaces for people with dementia

People with dementia, especially those at the later stages of their condition, tend to exhibit various Behavioural and Psychological symptoms (BPSD), such as depression, aggressive behaviour and wandering which could substantially reduce their quality of life as well as that of their loved ones. A number of studies have shown that the immersive reality created within a VR headset could have the potential reduce such symptoms (Rose, et al., 2021). Through VR, people with dementia can be teleported to a calm and relaxing environment (peaceful forest, beach etc.), one which does not contain any elements that may trigger their aggressive behaviours (crowds, environments with loud noises etc.). This virtual environment serves as a private space for the individual, one which provides a brief respite from the ambiance of the care home which they are usually limited to. The potential of VR in dementia care is particularly prominent when integrated with Reminiscence therapy (Huang & Yang, 2022). In this therapy, people with dementia are usually presented with various artifacts which relate to a personally meaningful past memory, either news stories of important events which occurred when they were young or photographs and videos that relates to a particularly memorable moment from their past. Using these artifacts as a me-

dium, participants are asked to speak out and reflect on their past experiences, a practice which has been found to help maintain or slow down the loss in their sense of identity due to dementia. The immersive reality recreated through VR, (either through 360 videos or a computer-generated VR space) provides a more salient way for people with dementia to access those memories and also has the added advantage of allowing users to quickly switch between various immersive environments, allowing them to experience and reflect on past experience in different places



Elderly woman in VR headset

without the need to physically travel there.

While VR head mounted displays can be used to create an enclosed virtual space to capture the attention of users, people with dementia are usually only passive viewers of such experiences. AR on the other hand, particularly in the form of a projected virtual environment, has been used to provide an engaging experience that even people with severe levels of dementia could actively participate in.

By using a projector fixed faced-down from the ceiling to project various virtual objects (flowers, fishes etc.) onto a table right in front of people with dementia and using gesture-based sensors to capture their interactions with those objects, developers were able to create simple interactive and playful virtual environments which were able to engage people with dementia for prolonged periods (Anderiesen, 2017).

Such users became captivated by playful activities

such as sweeping through virtual leaves projected onto the table or playing with the projected fish that were swimming around. This in turn helped improve their mood and made it easier for them to build rapport with the care staff who often played alongside them.

Overall, these examples demonstrate the potential of VR and AR technology in creating a virtual space that provides a meaningful experience and calming distraction for people with dementia.

Yet careful consideration needs to be taken when designing such virtual spaces for these users. First, not all people with dementia would enjoy the experience of being enclosed in a head mounted VR display, and in several cases, users were afraid and anxious of the dark space shown in the VR device before the actual video is played (Tabbaa, et al., 2019).

In addition, stereoscopic 3D videos, which generally is more immersive as they provide a sense of depth, was found to be quite disorienting to people with late-stage dementia and normal 360 videos were generally used instead (Tabbaa, et al., 2019).

Careful consideration would also need to be taken when selecting content for people with dementia, as virtual environments showing too many stimuli and events (e.g. people dancing within a music festival or a busy traffic road) were distracting and tend to cause users to become more anxious and frustrated as they were not able to process all of the content.

Finally, there is also the broader question of whether the use of VR/AR as a means of distraction is an ethical and appropriate practice, and whether this could have long-term adverse effects for people with dementia.

Would the immersion in alternative realities through VR complicate the ability of people with dementia to cognitively recognize and process information when they return to the real world, as certain conditions of dementia could cause people to be prone to visual hallucinations? Would the effect on the quality of life of VR be strong enough to justify the cost and effort in training care staff to learn how to use this novel

form of technology as opposed to traditional practices? Several ongoing longitudinal studies are being conducted to address such questions.

Recreating social reality through the embodiment of an avatar with distinct identities and characteristics

In the previous example, we highlighted how the immersive reality provided through VR has the potential to “transport” users from their physical reality to a virtual space, either one which invokes a calm and peaceful experience, or one filled with engaging and meaningful events. In social virtual worlds, multiple people can come together and inhabit these virtual spaces at the same time, therefore providing users with diverse opportunities for social interaction and experiences. Interestingly, similar to how the spatial realities created from VR could be distinct from one’s physical reality, social interaction in a virtual space also offers the opportunity for individuals to embody virtual identities which are distinct from one’s real-life self, opening up new and old possibilities for exploration and self-expression.

Social interaction in virtual environments are often mediated through virtual representations known as avatars. For people with limitations such as physical disabilities, avatars allow users to bypass various physical constraints and interact with others in ways that would otherwise be challenging in real-life. While offline, their social lives could be limited due to the difficulty in traveling to meet new people or to participate in events, within the virtual world however, they were able to connect to people from all over the world and join various online communities.

Some studies even suggest that by embodying an avatar which represents an able-bodied version of themselves, users can experience a greater sense of equivalence as they are able to communicate with others more freely without feeling uncomfortable from displaying their disability (see (Ginsburg, 2020)). Yet studies have also found that despite such affordances, not all users with disabilities wished to be

represented by able-bodied avatars.

Some users preferred to be represented more authentically in the virtual world and purposely chose avatars that manifested symbols of their disabilities such as wheelchairs, canes and guide dogs as they still wish to embrace their real-life identity even in a virtual world (Boellstorff, 2008; Kent, Ellis, Jones, & Bennett, 2015).

The term “proteus effect” was coined to describe the phenomenon, of how the behaviour of a user in the virtual environment could be influenced by the appearance and characteristics of their avatar (e.g. taller avatars behaved more confidently and people with attractive avatars tend to self-disclose more information and had shorter interpersonal distance during social interaction) (Yee & Bailenson, 2007).

This effect might have also been shown by people with disabilities who embodied able-bodied avatars, as such users generally reported feeling more confident in themselves, more willing to self-disclose personal information and more relaxed when socializing through an avatar in past studies (Kleban & Kaye, 2015). This in turn contributed to a general feeling of well-being and self-worth. Overall, participating in such spaces has been shown to significantly lower depression and anxiety and lead to higher life satisfaction and self-esteem for people with disabilities (Gilbert, Murphy, Krueger, Ludwig, & Efron, 2013).

Our own studies also found similar results with older people, who were often homebound through or conditions such as strokes or age-related disabilities. Such users were able to engage satisfactorily in highly immersive social activities, expand their social network, develop deep interpersonal relationships and continue to engage with various social activities which they could no longer do anymore in the real-life in the virtual environment (Siriaraya, Ang, & Bobrowicz, 2014).

In addition, this ability to assume a separate identity in a virtual space may prove advantageous and could be beneficial in the context of cognitive training to improve mental health and well-being. As part of a proof-of-concept therapeutic strategy to treat

people with anorexia, VR was used to “body swap” patients into an avatar with the virtual body of a healthy-weight individual who was then asked to carry out a body-size estimation task within the virtual body. Users became able estimate their body size more accurately in the short term with the VR experience (Serino, Polli, & Riva, 2019). In another example, domestic violence offenders embodied female avatars as they entered the virtual space and experience abusive speech and violent behaviours from a virtual abuser. By experiencing what it was like as a female victim who was abused, participants were able to



better recognize negative emotions from female faces and the exercise helped reduced their cognitive bias in misrecognizing fearful faces as happy faces (Seinfeld & et al, 2018).

In a similar manner, implicit bias against older people were shown to be reduced when young users assumed the virtual identity of an elderly Einstein. Overall, these instances demonstrate how the body ownership illusion afforded by the embodiment of a virtual avatar whose identity and appearance are different from one’s own, has the potential to bring about positive changes in self-perception and reduce maladaptive biases by allowing people to experience another person’s perspective and walk in their (virtual) shoe.

Of course, the use of the avatar to assume a separate identity or body appearance has been a controversial topic, particularly when this could be seen as a form of misrepresentation, or in the extreme case, deception by other users. In our own works for example, several elderly virtual world users who selected

“young” avatars have reported how they were marginalized against when others found out about their real age, either by their conversation partner directly informing them of their unwanted presence or leaving the virtual space abruptly (Siriaraya, Ang, & Bobrowicz, 2014). On the opposite end of this notion, there have also been several reported cases which suggested that adopting a virtual identity could also lead to an open invitation to be marginalized based on that identity. Researchers choosing avatars of young children for example, have report various forms of harassment, insults and threats targeted against them in their assumed identity while in the metaverse (Dwivedi & et al., 2022).

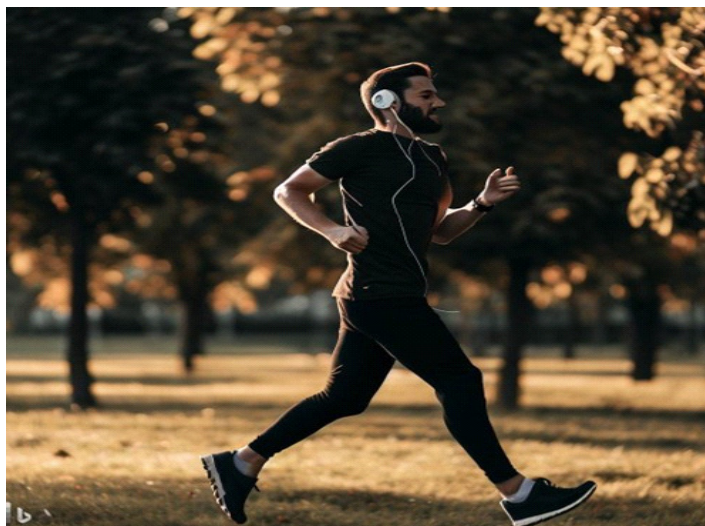
Such forms of “virtual ageism” whether against ones real or virtual identity and other forms of “virtual marginalization”, does highlight several interesting issues that would need to be addressed. In virtual worlds designed mainly for entertainment such as in MMORPGs, such issues could be less prominent as there is often a shared assumption that players who chose to enter such spaces also implicitly choose to adopt the customs and rules of that playful space to immerse themselves and others in their play experience.

Yet, for social virtual worlds whose purpose often goes beyond entertainment, there is an open question of how best we could go about balancing this freedom to choose different identities and what kind of regulation would be needed regarding the selecting of one’s identity, so that users could benefit equally from the ability to embody different identities in a virtual space. Perhaps one solution would be to adopt a similar stance as in online games, with certain areas allowing for roleplaying and others regulating against such practices.

Recreating outcome reality by manipulating interaction and feedback to enhance the physical exercise experience

Another quality of virtual environments, which is beginning to be explored and utilized by VR researchers in healthcare, is the ability for the developer to freely manipulate the interaction and correspond-

ing feedback of each user within the virtual space. Researchers designing virtual spaces to promote physical exercise, in particular, have made use of this mechanism to great effect. While we have seen various examples of VR devices being used in conjunction with exercise equipment (e.g. cycling machines or treadmills) to generate a more engaging virtual environment for users to “run” or “cycle” through while at the gym, recent studies have shown that the exercise performance of the users in the virtual space does not always need to be programmed to match their actual performance with the equipment and the discrepancies between the two could be manipulated to influence the behaviour of users in interesting ways. For instance, by manipulating the numbers on the virtual speedometer when users are riding a VR bicycle that is linked to a real world cycling machine, researchers were able to trick users into cycling 15%



Man running with headphones on

faster without them realizing, highlighting how a form of “performance deception” could be built into their system to frustrate users into putting more effort in their exercise (Löchtefeld, Krüger, Gellersen, 2016). Alternatively, the performance of users in the virtual space could also be exaggerated to create a feeling of having superhuman strength and improve their sense of competence, thus motivating people to exercise more, such as in the case of a VR jumping exercise game (Wolf, Rogers, Kunder, Rukzio, 2020).

The disassociation of one’s physical self while exercising, by projecting the results of their actions

through a virtual avatar, might not only affect the psychological state of users, but could even influence their physiological state as well. In a weightlifting exercise experiment, researchers had found that participants reported less pain intensity and effort when they viewed themselves (i.e. their avatars) lifting weights through a head mounted display VR device, in comparison to a control group, despite lifting the same amount of weights (Matsangidou, et al., 2019). Similarly, in one of our own studies, we had developed an AR running system that allows users to compete against their past records in real-time by projecting them as a “ghost” that would run against them in a spatialized 3D virtual environment.

In this way, users would hear the sound of footsteps and breathing from their ghost opponent grow louder as they catch up or slowly fade further away as they run further past their opponent. A preliminary study showed that participants running against their AR ghost opponent ran at a faster speed and reported higher levels of perceived competence without increasing their average heart rate (Kiriū, Mittal, Siriaraya, Kawai, & Nakajima, 2019). A comparable self-competition mechanism was used in a VR cycling game, which also led to an increase in exercise intensity and perceived competence without any significant effects on perceived exertion, enjoyment and heart rate (Farrow, Lutteroth, Rouse, & Bilzon, 2019).

Despite these promising results, research in this domain is still at the early stages and several questions still remain regarding the practice of manipulating exercise feedback and perceived performance through the use of VR. First and foremost, artificially enhancing or reducing one’s perceived performance could be harmful, as they could result in users overexerting themselves while exercising in VR or could create false confidence when exercising in the real world which could lead to injuries. Whether such incidences would be commonplace and how could they be best prevented are still unknown questions that would need to be addressed.

In addition, one of the joys of engaging in a prolonged exercise regime is the ability for the individual to gradually build up a sense of self-efficacy (i.e. the confidence and self-belief of being able to accom-

plish increasingly challenging goals) and mastery over the exercise activity. Would deceiving users about their capabilities while in VR skew self-belief in their ability as well as their perceived sense of progression when they exercise in the real world and would this damage their motivation? Furthermore, would such practices even remain effective in the long run, as once users become aware of the deception, it is less likely to be effective and users could also become accustomed to the manipulated feedback without realizing. We had seen some possible indications of this when we attempted to replicate our earlier AR running study as part of a prolonged training regime.

Although, as previously mentioned, we saw an increase in running performance and perceived competence in a one-off controlled session, participants did not show significant improvements in their training results compared to a control group when they trained over a one week period, neither did participants, on average, run at a faster speed in the condition when the speed of the virtual ghost representing their best performance was increased by 10% without informing them (Siriaraya, et al., 2023). Overall, while unanswered questions such as these still remain, the potential of utilizing manipulated feedback in VR to promote exercise is a promising field that warrants further exploration.

Future trends in virtual health-care: The fusion of AI with XR

In the past few years, we have seen several advancements that have made virtual environments more accessible (the commercial release of affordable high performing head mounted display devices), immersive (higher resolution displays and advanced sound and visual rendering algorithms) and interactive (more sophisticated tracking and haptic feedback system).

However, one trend which we anticipate would have a substantial impact in the near future for VR, particularly in the domain of healthcare, is the use of AI technologies to make virtual environments more intelligent and personally meaningful. Of particular

interest is the possible fusion of high performing AI models with various components of the virtual environment. With virtual agents for example, while visual graphics has advanced to a significant degree that they are able to create characters who have realistic physical appearances, past AI technology has yet been able to produce characters who are able to behave and respond flexibly and intelligently enough for users to fully believe in them.

This has so far limited their use in healthcare (as a therapeutic agent or a virtual coach for health management programs etc.). However, given the rapid improvements we are recently seeing with large language models such as GPT-4, realistic looking virtual agents with a high degree of conversational and behavioural intelligence could now be created and integrated into a VR environment. This opens up a number of interesting options for VR-based health-care.

We could easily imagine for example, how, a virtual ecosystem, mixed with both intelligent AI and human characters could be created to help sensitize people with extreme social anxiety to different social situations, such as allowing them to give a public debate in front of a virtual crowd.

Chatbots, integrated with this new technology, could be embedded into a relaxing VR setting for a therapeutic listening session or as a coach in a VR exercise environment controlled using real-world workout equipment to facilitate an immersive hands-on virtual exercise regime. In addition, we are already seeing promising results from several proof-of-concept AI models developed to automatically generate 3D environments from text-based user instructions. Such models would, in essence, allow users to “dictate” past memories into immersive 3D environments on-the-fly, which would have clear practical implications for VR based reminiscence therapy.

Finally, in the context of AR, we are also seeing the emergence of geospatial generative AI algorithms, which are able to produce content based on map and location information. By using, geo-tagged data from Twitter, Flickr or Open Street maps, we are able to develop AI models to generate virtual crowds based

on the characteristics of the space to improve social immersion (such as people talking about how nice their picnic is at a park) or to create content specific to the features of the location (such as an Aesop story about two crabs talking next to a river bank) to be used to teach English in AR (Siriaraya, Kiri, Kawai, & Nakajima, 2018).

Yet for all the recent hype surrounding the capabilities of Generative AI, we should be careful of how we integrate AI into VR systems designed to support healthcare, lest we also unintentionally incorporate the various problems currently encountered when AI is implemented in this domain into our VR systems as well.

Of particular concern are issues related to safety. Although as a whole, researchers have found current chatbot technology to be safe, we have also seen examples of them propagating biased information and stereotypes and unfairly representing certain user groups, as such models tend to be trained based on online data that has not been curated and tend not to be equally representative (Ray, 2023). In our own works developing a social support and grief care chatbot, we have had to build in an add-on machine learning model to prevent the chatbot from giving harmful advice when participants are depressed and suicidal. If such issues are not addressed, they could result in the immersive capabilities of VR inadvertently amplifying the AI model's worst tendencies, resulting in an outcome that could be multiple times worse. ■■■■■

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The Re-Emergence of the Metaverse

Marcus Carter

An Interview with Leighton Evans

Marcus Carter: Thank you so much for joining us. Could you give us a bit of a brief introduction to your research on VR? What have you been interested in in the past and what are you working on now?

Leighton Evans: My interest in VR goes back. Personally, a hell of a long way. I remember reading first about VR in about '91, maybe something like that, as a 12-year-old kid playing Sega games and buying console magazines and being promised – in this kind of really short timeline, by '94 – that we'd all be owning headsets and playing games in an immersive 3D Environment. I was like, yeah, this is gonna be it! To hell with school! This is going to be what I'm going to be doing, right?

And it never happened, and you know, there were furtive attempts. I remember in the 90s. I went up to London, about '96, went to the Trocadero Centre in Piccadilly Circus and had a go on their VR machine there and ... it took about half an hour before my stomach settled again!

But that interest really stayed with me forever. I remember reading an article in a magazine I've never been able to track article down, end of '93, they had a big spread with Jaron Lanier in it. I remember reading that article with the interview and thinking, this is gonna be huge, and that impression that it was gonna be the next big thing never actually left me.

When it came around to sort of 2015, I had completed my PhD, I was working as a postdoc out in Ireland on a smart city project, and then I started seeing bubbling up from nowhere of chat about, you know, Oculus Rift and things like that. My current interest in VR was kind of like a holdover really, from interest



that I had in the 90s, and interest that I had during my PhD as well because my doctoral studies were on the phenomenological appreciation of the difference between space and place.

I read a lot of the scholarship from the 90s and 2000s about VR during that time to sort of conceptualise presence in in that thesis. So, it's always bubbled under there. But when it started to – as I say in the book – reemerge in 2015, I thought I was at a nice little juncture. I wanted to do something different. I'd said everything I wanted to say on location-based applications, and that's where it headed from.

Really my research on VR has been looking to understand how immersion, embodiment and presence fit together in our experiential understanding of computer simulated worlds.

That's the core of everything that I look at. How our relationship with technology and technology influenced or created environments affects our understanding of the world itself. So VR fits perfectly with the stuff that I've been talking about for the last 15 years!

MC: In your first book, the Re-Emergence of Virtual Reality, one of the things that I really like is that attention to the politics of who's creating and imagining VR. How do you see this having changed since the book was completed, particularly with this resurgent interest in the 'Metaverse' and how that maybe changes things?

LE: The book was written at a sort of interesting time, right? I conceived of it not long after Facebook had bought Oculus out. The road map – and I’m not Nos- tradamus, right? – the road map was pretty obvious from that point onwards what was going to happen and there’s a whole chapter of that book dedicated to why I thought that was an extremely bad idea. We know, and we knew at the time, and we’ve known for many, many years what the implications are of Facebook getting involved with any organisation which is, you know, planetary scale data harvesting and processing.

So, when I was looking at that in 2017 I was asking a fundamental question: Why would Facebook want this? What does this do for Facebook? If you look at the history of Facebook, they buy up organisations in order to improve the efficiency of their business model. So, you look and think, OK, so what the hell does Oculus actually add to that business model? And then you say, OK, so what does VR do? Well, it allows you to create enclosed environments where you have ultimate control over what is displayed and how you stimulate users within that environment, visually, auditory, etc. At the same time, you are doing that via a peripheral wearable which can be equipped with all kinds of sensors and trackers.

So that sounds obvious to me: You’re this vast data harvesting company. What data can’t you get at? Well, you haven’t really gone into the wearable market, so you haven’t really tapped into bio data in a way that would be efficient. Yeah, you’ve got ways of tracking attention on apps and so on, but that’s flawed in many ways; this is a way of doing it differently. So you look at those things at that time and you think, right, I can see the business model case. In terms of what that means for those people who are going to be using virtual reality, this is a really, really bad idea.

Now I think there are two ways we can look at something like the ‘Metaverse’, if you look at the ideas which have been put forward about the metaverse, going back to Stephenson, but even going back to before Neil Stephenson coined the phrase in ‘92. It is in popular fiction, a dystopian world controlled by

an evil organisation. Always! And it’s like, you’ve read these things, right, Zuckerberg? I mean, you’re a geek! You have read these books! Why are you trying to do this?

The politics of VR has become really, really problematic for me because another consequence of Facebook getting involved was the lockout in terms of capital investiture needed to actually make stuff in VR. What Facebook have very cleverly done is corner the market. They have the capital to make and develop virtual reality technology. I’d argue there’s five or six companies in the world who can actually do this, in terms of invest the kind of money that’s needed to make this stuff work.

By leveraging their huge profits across the rest of their businesses, they’ve been able to drive the price down (every headset is sold at a loss). Who can cover that? We know that’s frightening even for companies that can afford it.

MC: I just wanted to say – throwing back to your book – that when the rumors were coming out about the ‘Meta’ rebrand, I hadn’t ever read Snowcrash, but I had read your book which discussed the Metaverse, so thank you for including that!

LE: I mean, it’s an interesting thing, Marcus. I’ll be quick on this point, but for me, VR and the metaverse have always been intricately linked. I can only say this from my own perspective, but that really comes from reading stuff like Neil Stephenson’s book and terrible movies like Lawnmower Man. The idea that VR operates at a scale which is much larger than an individual game ... it opens up worlds.

If you look at some of the stuff Jaron Lanier talked about in the 80s, there was a vision thereabout what VR was gonna be about: it was gonna be about the creation of this vast sort of space for human existence, which was independent of physical space. I guess that discourse got taken over by cyber space in the 90s, but for me, the Metaverse and VR have always been co-constituents.

MC: That brings us to your most recent book – From Microverse to Metaverse – with Jordan Frith and Michael Saker. If it is the case that you see VR and the metaverse always having been really re-interlinked, how do you see the field has having changed? Or maybe you don't see the field has really changed?

LE: It's really interesting the way the field is developing at the moment.

I remember putting the first book together and looking at the state of literature at the time, in terms of cultural studies, and there just wasn't anything out there. Nothing had been written for years on virtual reality. You had some more technically minded stuff, but in reality, there just wasn't a hell of a lot out there. So it gave me a free slate to you know, basically talk about whatever the hell I wanted. I was quite happy with that!

Reviewing the fields as it stood for writing the metaverse book. Obviously, there's a huge amount of development, and we are starting to see (although it's not on the scale that I expected) there is more and more out there. There is more stuff and emerging all the time, which is fantastic, right? It's really good and we're starting to see an actual real conversation in academia between the pieces now as well and, you know, linking up all these pieces as well. And we're starting to see that kind of almost like dialectical process emerging, where real progress is being made in terms of ideas, which is, which is absolutely brilliant.

What the purpose of that Metaverse book was to do was really to show that – at least in my mind – a lot of the stuff that we're talking about in VR at the moment still conceptualises a lot of things about VR as being different. What the emergence of the Metaverse showed is that actually we need to bring on board all the other stuff as well. We have to look, or at least try to start looking at, what are the huge problems and issues at the moment in digital culture, and how are they going to be reified through the Metaverse?

This matters because that's what's gonna be in the Metaverse. It's not just gonna be people wandering around an empty town square with no legs, people

are gonna be doing all these other things as well. How is the metaverse gonna problematize these things which are already problems? Because it's not as if the problems of digital culture have been solved in any sort of way at the moment.

Digital culture is a wonderful thing, but it's got massive issues and really the attempt of that book was to say: OK, we all know about the Metaverse now, and we all know about VR, now let's try and think of the scale of what's trying to be achieved here, and what are the problem areas within this?

MC: With a concept like the Metaverse, where every week now we see a headline of the 'Metaverse is dead' or 'Meta is giving up on the Metaverse'. Where do you think we are right and how might the book have changed for you if you wrote it today?

LE: Yeah, everyday my Feedly is 'the metaverse is dead!' 'the metaverse is dead!' And then what do we have, a few days ago Meta do a huge thing about the business case for the Metaverse and how much it's gonna add to GDP and by 2030. Well, they don't think it's dead, OK? This is interesting!

There's something really, really strange going on at the moment, but it's like Nietzsche says right; we're doomed to repeat history, and I think we're seeing a little bit of this. If you look back to the early 2000s and the emergence of social networking sites, you had like, Friendster and Bebo and MySpace and then the Goliaths appeared on the top of all those. Maybe what we've got here is: the Metaverse isn't dead, Meta's version of it might well be dead. That's a distinct possibility. I think there's far more interesting contortions gonna happen before we see what actually will emerge as the 'Metaverse'.

Meta's vision of this is really compromised by their marriage to virtual reality, I think, which means that they haven't paid attention to augmented reality. Which you know is – on one end of the scale – much easier to do, given that virtually everyone has a smartphone, you can put augmented reality in people's hands really, really quickly. You don't need a headset and so on. But the technical limitations of actually putting some in a pair of glasses are still a

long way off. Apple's Vision Pro will be a really good stepping stone though. What Apple are intending to do with spatial anchors will be interesting in showing the form of an 'AR metaverse'. A digital object that exists in a composite space of the digital and physical where two users interact with each other, the digital object and physical space is a vision Meta really don't have yet in terms of spatial computing.

There's a role for augmented reality in this vision, I think, and I don't think Meta have ever really looked at doing that. But more importantly, the problem with Meta's vision of the metaverse is Meta itself, and how they operate as a company. Their vision for what this should be and how it should do. Because you look at anything that they produce and you think, 'Well, I don't wanna live in PlayStation 2 two world', you know? It just doesn't make any sense it! It's almost like a classic example of the phenomena of group-think, where you get a bunch of people in the room who just agree with one another and think, yeah. This is going to be ace! this is going to be money! And they put it out and it absolutely sucks.

MC: Yeah, amazing. Would there be anything else you'd like to add, that we haven't talked about today?

LE: I think (despite my earlier comments!). VR is still a really exciting space and scholarship is growing in VR and that's fantastic. Hopefully we can encourage more and more scholarship in VR because I think there's untapped areas as well. For example, you know in sort of game studies as well, I think there really needs to be a view of what VR is bringing to games and how that's evolving and changing as well, because the Meta Quest 2 is basically a games platform at this point, and we're not really understanding what that means. I still think it's a really exciting, technology and medium and it's incredibly exciting time to be involved in it. ■■■■■

The identity, emotion and gaze behind Apple's Vision Pro

By Chris Chesher / University of Sydney

When Apple introduced their Vision Pro it represented another iteration of the immersive head-mounted display dating back to Ivan Sutherland's experiments in the 1960s, but with a difference. Apple's Vision Pro is not only a high-resolution immersive display for the person wearing it, but also features an external display that gives the impression for those around that they can see the eyes of the wearer. It was an expensive but motivated choice to add a curved glass front to the device with a complex lenticular lensed display that presents images of the user's eyes which are different depending on the angle from which they are seen. Even though others may think these are the user's actual eyes, the image is an animated 3D model driven by sensors inside the helmet and generated from data collected when the user set up the device. So, why so much effort to reveal an animated image of the users' eyes on the external display? There are some basic communicative principles at play in the ways eyes see and are seen in everyday space. The external display is designed to have social efficacy because human eyes are highly communicative, in three ways.

First, the unique appearance of the eye can communicate identity. People are able to distinguish friends from strangers, thus establishing for both participants a shared history, experience and established relationship. Recognising others is, for most people, a precondition for sociality (Bruce 2017).

Second, facial expressions are a key way of communicating feelings, which Ekman (1971) claims is manifest as a set of universal emotions: anger, contempt,

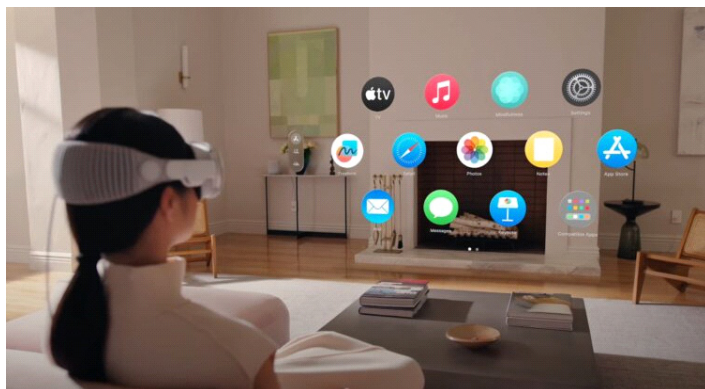


disgust, happiness, fear, sadness and surprise. Others disagree that emotional expressions are universal, arguing that there are cultural differences in how faces and eyes are able to communicate (Keltner et al, 2019). Either way, if the Vision Pro can represent the emotional expressiveness of eyes, so the logic goes, the user can participate in social interactions more fully.

Third, the eyes communicate through gaze, which indicates attention, interest and interpersonal demands. Gaze structures social power, in particular gendered power relations. The gaze is central to other media – in particular, the cinema, which can be understood as a medium structured according to the logic of gazes: between the viewer and the eyes of characters in the film, and among the characters within the film (Mulvey 2001). Many social robots are designed to give the impression that they are meeting the user's gaze (Chesher & Andreall, 2022). If 'spatial computing' becomes a widespread media paradigm, it will operate to mediate the power of the gaze (Beer 2018).

The Vision Pro is a critique in design of virtual reality goggles that immerse users into another space altogether but eliminate social presence. There is something inhuman about a person wearing a traditional VR head-mounted display like Meta's Quest. For most of the time, the user's vision is completely occluded, and when the device is running, users are segregated from the physical and social space around them. While users are aware there may be others nearby, and can even conduct a conversation, they effectively become blind and masked. It could

be a form of torture. For those nearby, the VR user becomes a subject of some pity, lost in a world that they cannot share with others (unless their view is externalised somehow – such as by being projected onto a monitor – which changes the scene again). Apple is distancing itself from this segregated model of virtual reality, even if their technology is quite capable of working in this way. It's an effort to head off Meta's pied piper quest to draw everyone into an animated Metaverse, phenomenologically separated from the everyday world. This was based on a very 1990s vision of VR as opening new frontiers of virtual territory (Chesher, 1994).



By contrast, Apple's promotional videos are quite conservative in representing users as having a familiar experience of working with interface elements like screens, windows, desktops and floating keyboards situated in the user's immediate space. VisionOS incorporates these elements into an everyday lifeworld of the user who can use eye movements and hand gestures to manipulate the virtual elements embedded in the high-resolution view of the world. This is an extension of working with Macs, iPhones and AppleTVs.

The idea of combining computer-generated elements with a view of the surroundings in fact preceded the closed-off version of 'virtual reality'. Sutherland's 1968 'Sword of Damocles', slung from the ceiling, used a half-silvered mirror that allowed users to see the world around them – and for those present to see the users' eyes (McLellan, 1996). The computer would mechanically track the movement of the suspended headset and project rudimentary graphics calculated to give the impression of hallucinated objects in the

room.

There have been several such systems since. At Boeing in the early 1990s, Thomas Caudell's 'augmented reality' experiments projected images of computer graphic schematics of aircraft components for technicians working on the 777 (Azuma, 1997). Again, this allowed others still to communicate with them. Google's ill-fated and overhyped 2013 Glass experiment promised to offer a ubiquitous computing display that guided explorers through the physical world but was controversial and underpowered and was discontinued in 2015 (Klein et al, 2020).

Similarly, the heavier and more technically advanced augmented reality smart glasses released by Microsoft – the 2016 HoloLens and 2019 HoloLens 2 – allow the user to see the world around them directly, but use near-eye devices to project images onto the user's retina. These 'optical waveguides' can project colourful 'holograms' that appear to be in the space of the room. Depth sensors allow it to map the 3D space of the room, and cameras track hand gestures. However, these devices have a very narrow field of view, the images are insubstantial, and they have failed to get widespread take-up.

Unlike other augmented reality devices, Apple's strategy is essentially to build a virtual reality headset and enhance it with augmented reality features. Its desegregation strategy is based on a doubled form of illusion that attempts to recover the sense of the copresence of the headset user with other people and things surrounding them. The user's illusion that they remain immersed in their everyday space comes from high-resolution cameras and greater-than 4k displays close to the eye that mimic natural vision.

The operating system is configured to sense the presence of other people and to reveal them to the user. A digital crown allows the user to cross-fade between the virtual scene and the view of the surrounding space. The user's eye movements and hand gestures become user inputs that bring the body into interaction with their space in new ways.

The prospects for developing a communicative medium for 'spatial computing', 'metaverse' or 'ho-

lograms' remain uncertain. Despite their differences, all current head-mounted displays are physically cumbersome, expensive, and (most importantly) lack compelling use cases for a mass market, despite extravagant R&D budgets from the 'Magnificent Seven'. The iterative processes of establishing new media paradigms are often slow, and rarely successful. The telephone was patented in 1876, and was used not widely in use before the turn of the century. Radio broadcasting was slower still: the principles of radio (which also uses only one sensory modality) were known in the 1880s, but broadcasting did not start stabilising as a popular cultural form until the 1920s (Hilmes & Loviglio, 2002). Spatial computing is among the most complex consumer technologies ever built, with the goal of making the most natural and versatile user interface.

Apple chief Tim Cook has been vociferous in criticising VR as socially isolating, but it seems unlikely that his augmented reality headset, with its unique doubled digitally mediated gaze, will ever be the basis for a technology as ubiquitous as the telephone. ■■■■■

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