Exploring the Social Challenges and Opportunities of Group Use of Augmented Reality Through Speculative Design Workshops

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Abstract

With augmented reality (AR) soon expected become part of our everyday lives there is a pertinent need to consider how it should be used within social settings. We explore individuals' inclinations towards incorporating AR into small group social interactions across a diverse range of settings. Through six speculative design focus groups involving 21 participants, 100 ideas were generated across three scenarios: *living room settings* (public – sociopetal), *public transport seating* (semi-public – mixed proxemics), and *crowded public spaces* (public – sociofugal). We discuss the challenges being addressed through the proposed social AR designs, ranging from functional use cases around conveying shared information and supporting group cohesion, to addressing boredom, to facilitating shared imagination.

CCS Concepts

• **Human-centered computing → Mixed / augmented reality**.

Keywords

Shared, Social, Augmented Reality, Mixed Reality, Sociopetal, Sociofugal, Speculative Design

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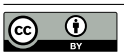
1 Introduction

As we grow closer to everyday Augmented Reality (AR) [3], this technology will increasingly be used in shared, social contexts [23, 28], e.g. around friends, family, colleagues, etc, and in the home [13, 32], on public transport [29], and more. However, social contexts can vary dramatically in their affordances, e.g. consider differences in our interactions when in the private setting of a home compared to the public setting of a walk in the park [11, 12], or how we physically position ourselves relative to others in our social groups (proxemics) based on our relationship to individuals [36]. Simply put, where we are, what we are doing, and who we are with changes how we interact with each other. However, AR's use in shared social contexts - from augmenting shared social spaces [7, 23] to mediating interpersonal interactions [2, 17, 27, 30, 31] - has not been extensively considered from a user-centred perspective, and we lack an overview of what prospective users envision for how AR will benefit existing, and create new, shared, social interactions in groups. In this WIP, we explore how individuals envision AR might be used in small groups across a range of settings, presenting results from a formative study exploring AR group experiences. We conducted six focus groups where participants (n=21) completed individual and group ideation around how they might use headworn AR across three scenarios (private, sociopetal; semi-public, mixed proxemics; and public, sociofugal). Our results provide user-centred anticipated social use cases of AR across a variety of social contexts, informing the design of our future work exploring the integration of everyday AR within these social contexts. We address the following **Research Question:** *What social challenges do participants express a desire to address specifically through the use of AR, and what opportunities to address them exist?*

2 Study: Focus Group Co-Design of Shared, Social AR Experiences

To explore the potential use cases of AR in social settings, a speculative design approach was taken. Speculative design [6] uses imagined future scenarios to explore and provoke discussion on possible social and technological outcomes of emerging technologies, and is an approach often used to explore the design of future immersive technologies [8, 26]. We invited participants to take part in co-design workshops, where they created short descriptions of ideas for AR use-cases across three scenarios. To capture as broad



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a set of ideas as possible, and to be able to identify any trends regarding user preferences for social AR use cases as social settings change, two axes were chosen along which to vary scenarios: *proxemics* and *publicness*. Along both axes, we chose to examine the two endpoints: *sociofugal* (the discouragement of social interaction) and *sociopetal* (the encouragement of social interaction); *public* and *private*, and a midpoint between these extremes. This midpoint, in terms of proxemics was defined as *"smaller sociopetal groups in a sociofugal arrangement"* and in terms of publicness as *"a closed group in a wider public setting"*. We chose to vary proxemics and publicness together to afford maximum discussion time in our workshops, assuming groups in a private space would naturally adopt a sociopetal layout, whereas groups in a public setting may be forced into a sociofugal arrangement [10]. The three scenarios created were: *S1 - Private, Sociopetal:* A small group socialising in the living room of a friend, *S2 - Semi-Public, Mixed Proxemics:* a small group travelling on an arbitrary mode of public transport, where they are forced to sit in a way such that they are split up into two separate smaller group, and *S3 - Public, Sociofugal:* A small group attempting to walk through a busy public.

2.1 Procedure

Each workshop lasted 90-120 minutes and consisted of 3-5 participants and a researcher who acted as a moderator. Workshops were conducted in-person using Miro as a brainstorming tool to help focus participants ideas. A workshop consisted of an introduction followed by discussion of the 3 scenarios, with each scenario discussion having 3 phases.

In phase one, participants first experienced using a Meta Quest 3 headset. They first used *First Encounters* by Meta; then experienced a basic AR prototype we developed to demonstrate AR 3D objects, virtual screens, and HUD and wrist-worn displays to exemplify the potential capabilities of an everyday AR headset [23, 25]. Finally, they watched a video created from short clips from Apple and Microsoft, envisioning near-future AR technology. After the video ended, participants were warned the examples shown were not an exhaustive list, and were urged to think creatively and voice any ideas they may have during the session.

In phase two, participants were asked to brainstorm as many ideas for social AR usage in the specified context as possible encountering each of our three created scenarios in a counter-balanced order. We provided a template to guide participants through this ideation process (see Figure 1). Participants then described their ideas to each other and briefly discussed them, and then rated each idea on a scale of 1-5 in terms of perceived "usefulness" and "usage frequency" (with 5 indicating the highest perceived usefulness/frequency, and 1 indicating the lowest). A second template was used to guide participants through this process (see Figure 2).

After this, in phase three, participants were asked to select 3 ideas created within the group, and to expand upon these ideas through shared brainstorming. As in the previous phase a template was provided to assist participants with this process (see Figure 3). In particular, we asked participants to focus on how they envisioned users providing input, and what visuals or other feedback they think the augmentation would provide users with. And encouraged them

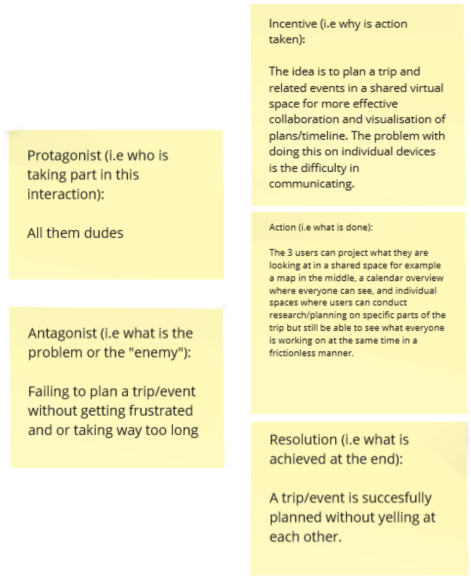

Figure 1: The template used during focus groups and an example response (Phase 2a)

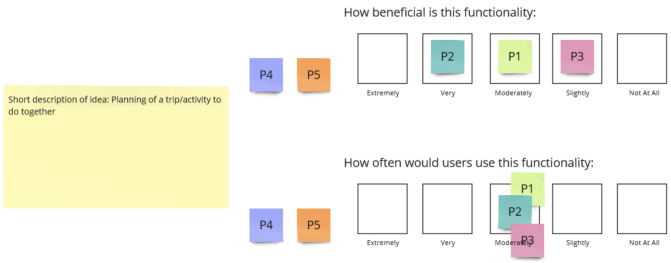

Figure 2: The template used during focus groups and an example response (Phase 2b)

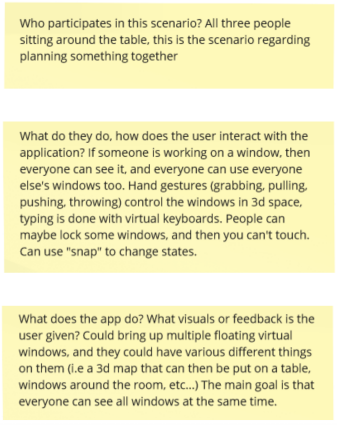

Figure 3: The template used during focus groups and an example response (Phase 3)

to iterate upon the original idea and to deviate from it's design where necessary.

3 Results: Social Problems and Opportunities

Participants were recruited from University mailing lists and social media. We ran 6 focus group workshops, each consisting of at least 3 and at most 5 participants. 21 participants (age: median = 22, std = 11 yrs; 5 female 16 male) completed the study.

A total of 100 ideas were collected from the workshops, with 3 ideas excluded as being out of scope (i.e. not being related to shared/social AR) leaving 97 ideas to be analysed. The ideas were grouped using a thematic approach [33] over repeated cycles. A single coder performed two cycles and reviewed the results with two other researchers.

Note: In our results section the numbers enclosed in round brackets, e.g. *(9, 10, 28, ...)*, refer to the specific ideas generated by participants during the workshops. The full reference index for these terms, and their additional details, is provided in Appendix A, with a preview of this shown in Table 1.

3.1 Boredom and Play

Participants created 32 entertainment-based ideas to address "boredom" or a "lack of entertainment" within the experienced scenario. These ideas could be subdivided into three subthemes: traditional games *(9, 10, 28, 35, 37, 38, 39, 40, 46, 61, 62, 73, 80, 83, 91, 94)* media consumption *(60, 79, 82, 88, 95, 96, 97, 101)*, and mass entertainment *(19, 20, 30, 44, 68, 70, 104)*. Ideas within the traditional games category attempted described experiences to existing games, i.e. tabletop games or video games genres not inherently unique to AR, and most were envisioned as being multiplayer experiences. There was a noted difference in how gameplay elements were envisioned as being integrated within the user's environment. Some described games which "fit" within the physical environment which forced users to move, interact, and engage with a singular point in space, e.g. a table on which a tabletop AR game was played. Others, however, described simply augmenting one or more digital screens within the environment for users to play a game on. A wide variety of gameplay types were envisioned, from virtual boardgames and tabletop RPGs, to more physically engaging AR sport experiences such as AR NERF fights, to more subtle play experiences such as AR paper aeroplanes, mini interactive games, or fun facts/quizzes that could move with groups and were lightweight and innately familiar. Many of these experiences were similar to those described in the media consumption theme, i.e. shared experiences for watching films simply on augmented displays or by create an immersive environment and transforming the physical space into a shared movie theatre-like experience.

Across games and media, the tension between group versus communal experiences was repeatedly raised, covering augmentations intended for a private group *(10, 34, 36, 38, 39, 40, 62, 94)*, and augmentations intended to be enjoyed by an audience of unlimited size *(19, 20, 21, 30, 44, 68, 70, 104)*. E.g., large scale collaborative art experiences to enliven public spaces were described where art could be embedded in public and shared spaces and either shared publicly or preserved for the group as a situated semi-private shared experience An especially interesting idea was the concept of a communal game of catch *(30, 44)*, where users could opt-in to see a digitally rendered ball, and any number of people could join in the game ad hoc, emphasizing AR games with the same accessibility and freedom of participation as real physical games.

3.2 Group Cohesion and Togetherness

There were 9 ideas that attempted to ensure group cohesion and efficient mobility in a highly public and mobile contexts *(17, 15, 32, 47, 51, 52, 53, 67, 102)*. These ideas were quite uniform, usually including some form of visual indicator to aid in locating group members who may not be visible, and integrating various path overlays into the environment, to direct users along the most efficient path through a crowd of people. Crowd management where diminished reality was used to downplay the presence of the general public, real-time person trackers, and find-a-friend functions all spoke to a desire to remain together as a group, and facilitate ways to come back together, in high density social environments. A further 2 ideas *(54, 100)* envisioned a form of virtual partitioning in public spaces, using AR to block out parts of the physical world, with this being either people around a group of users, to create the illusion of a private space, or, as described by the participant, "a real-life version of AdBlock".

3.3 Conveying Information and Context

There was 15 ideas centred around communicating information effectively and efficiently regarding a topic to another person. Here, two subthemes emerged: *static information (21, 31, 41, 64, 98, 103)*, and *dynamic information (6, 33, 34, 58, 69, 74, 76, 77, 90)*. Static information involved using AR to convey information that does not change, with examples suggested including educational visualisations of plants, animals, planets, or similar topics *(21)* or virtual tour guides *(31, 64, 98)*. Conversely, dynamic information contains AR augmentations were the information the user wants to convey is changing constantly, e.g. a minimap with locations the user wants to visit in the vicinity *(33)*, or a 3D projection of photographs and videos taken at a specific location to show friends *(34)*.

There was 8 ideas centred around using AR to enable users to easily retrieve information regarding their surroundings that would otherwise be difficult to obtain *(12, 16, 18, 49, 84, 85, 86)*. While the ideas are diverse in terms of the information gathered, all follow a similar trend of overlaying context-relevant information onto the environment, e.g. onto billboards, storefronts, etc.

3.4 Distanced and Hybrid Group Experiences

There was 10 ideas focused providing distanced communication and envisioned opportunities for hybrid group experiences *(7, 8, 11, 14, 42, 45, 63, 65, 89, 99)*. The envisioned approaches varied considerably in their implementation, from 3D projections of the person being communicated with, and their immediate surroundings integrated into the users environment *(89)*, to purely audio based augmentations *(99)*. Interestingly, one benefit posited was accessibility, allowing group members who might ordinarily be unable to participate or attend an event to nonetheless feel present and, to some degree, part of the shared experience.

ID	Scenario	Name	Participant description
5	1	Visualiser for a tabletop rpg	Based on pre-made artifacts, can create visuals to use in a TTRPG. Alternatively, could be continuously generated using AI
6	1	Furniture design	Can place various pieces of furniture into an existing space to help visualise them.
7	1	Distanced communication	AR used to create shared experience for distanced people. Experience could be just a call, but could include shared activities (boardgame/movie)
8	1	Distanced communication	AR used to create shared experience for distanced people. Experience could be just a call, but could include shared activities (boardgame/movie)
... Full table can be found in the appendix ...			

Table 1: A subset of the ideas generated during our workshops. The full reference index table is provided in Appendix A.

3.5 Creative Conversation and Avoiding Miscommunication

Conversational supports were infrequently mentioned, but are noteworthy because ideas centred around creative enhancements or amplification of social interactions, transposing ideas of emotes and reactions to real physical group interactions, and aiding natural communication between people by facilitating some form of shared-screen interaction, aiming to help thoughts and intentions to be conveyed more clearly. 8 ideas cited the problem of miscommunication or difficulty with collaboration as the main issue they addressed *(25, 43, 55, 56, 57, 71, 72, 75, 78)*. These ideas took tasks which today require screen-based interactions and used AR to create virtual shared screens to allow multiple users to work on simultaneously, with participants noting during design they hoped such shared interfaces would reduce frustration and foster collaboration.

3.6 Imaginative Environments

For 3 ideas, participants indicated they envisioned the augmentation being used as a tool to enable shared imagination for a small group of people *(5, 23, 59)*. Concepts included disappearing into shared dream worlds, adorning the environment with shared memories and photos or other virtual objects to create shared ambience in a physical space by augmenting it with virtual plants or a virtual campfire *(36)*, or leveraging augmentations that might provoke different forms of affective reactions such as AR "bugs on a wall", and even presenting warped versions of reality to mimic an experience on drugs that can be shared across the group.

4 Discussion

Regarding our **RQ**, we found a set of common social problems or challenges being implicitly addressed. Foremost of these was boredom and the desire to seek out shared, engaging group activities, evidencing Nijholt's conceptualisation of AR as a technology which allows the playful thoughts of groups to be act out [21] and supporting the discussion of prior works of AR being a technology many will use to create shared play experiences [16, 20, 26]. In addition to this we found a plethora of other challenges participants attempted to solve, in particular around supporting shared information needs (e.g. shared maps, augmenting conversations to avoid miscommunication etc.); distanced communication as a means to make group experiences more inclusive to those not able to be physically present; and supporting group cohesion such as aiding navigation and meetups during a busy music festival. There were also clear opportunities in creating experiences that could flexibly transition from group to "global" interactions or experiences, where participants expressed a desire for applications that could be used by an unlimited amount of people, and involved playing games together or engaging in shared artistic creation in public spaces in ways that were inclusive and welcoming to broader communal social interactions. And these challenges again all support problems discussed by researchers in prior work, e.g. to increase group cohesion [5] and improving accessibility [19, 37, 38], to create honeypot effect experiences [15], and more [1, 4, 9, 14, 18, 22] And what these challenges suggest is that social AR could meaningfully interleave itself into the group experience - supporting not just entertainment needs, but also very functional concerns that might make managing and maintaining a social experience easier - and, *crucially* there is a desire and want from prospective users for these use cases within everyday AR technologies.

4.1 Limitations

Using fictional design with non-expert designers brings the risk of creating ideas that may be more fictional, and less grounded within the current understanding of augmented reality interactions. Prior work has also indicated consumers' mental model of immersive technologies is predominantly as an entertainment device [24, 34, 35] which may have influenced the extent to which addressing boredom was represented in our results. However, our participants also generated ideas for many other types of potential use cases, and the introductory materials used in our workshops as part of participants on-boarding presented a more neutral framing of AR as a more general purpose technology.

5 Conclusion

We explored how users may wish to use AR in small group social interactions, across various social contexts, through 6 speculative design focus groups with 21 participants, resulting in 100 ideas being generated across the 3 scenarios being examined, which were seated in a living room (public – sociopetal), seated on public transport (semi-public – mixed proxemics) and moving through a moderately crowded public area (public – sociofugal). While there is a desire for multi-user entertainment experiences, particularly in gaming, AR is envisioned as a multi-purpose tool for communication, collaboration, and information sharing in group settings. We see this formative work as helping to further explore the design

space of shared, social AR by providing a user-centred set of anticipated social use cases, informing the design of our future work exploring the integration of everyday AR within social contexts.

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References

[1] Ammar Al-Taie, Andrii Matviienko, Joseph O'Hagan, Frank Pollick, and Stephen Anthony Brewster. 2025. Around the World in 60 Cyclists: Evaluating Autonomous Vehicle-Cyclist Interfaces Across Cultures. In *Proceedings of the 2025 CHI Conference on Human Factors in Computing Systems (CHI '25)*. Association for Computing Machinery, New York, NY, USA, Article 217, 18 pages. https://doi.org/10.1145/3706598.3713407

[2] Jolie Bonner, Florian Mathis, Joseph O'Hagan, and Mark Mcgill. 2023. When Filters Escape the Smartphone: Exploring Acceptance and Concerns Regarding Augmented Expression of Social Identity for Everyday AR. In *Proceedings of the 29th ACM Symposium on Virtual Reality Software and Technology (VRST '23)*. Association for Computing Machinery, New York, NY, USA, Article 14, 14 pages. https://doi.org/10.1145/3611659.3615707

[3] Hyunsung Cho, Drew Edgar, David Lindlbauer, and Joseph O'Hagan. 2025. Evaluating Dynamic Delivery of Audio+Visual Message Notifications in XR. In *2025 IEEE Conference Virtual Reality and 3D User Interfaces (VR)*. 277–287. https://doi.org/10.1109/VR59515.2025.00052

[4] Diego Drago, Jacob Bhattacharyya, Fahim Kawsar, and Stephen Anthony Brewster. 2025. The Effects of Physical Context on Collaborator Placement in Augmented Reality Meetings. In *Proceedings of the Extended Abstracts of the CHI Conference on Human Factors in Computing Systems (CHI EA '25)*. Association for Computing Machinery, New York, NY, USA, Article 517, 12 pages. https://doi.org/10.1145/3706599.3720195

[5] Diego Drago, Joseph O'Hagan, Fahim Kawsar, and Stephen Anthony Brewster. 2025. Exploring Avatar Seat Allocation Strategies in Social AR. In *Proceedings of the Extended Abstracts of the CHI Conference on Human Factors in Computing Systems (CHI EA '25)*. Association for Computing Machinery, New York, NY, USA, Article 239, 7 pages. https://doi.org/10.1145/3706599.3719867

[6] Anthony Dunne and Fiona Raby. 2024. *Speculative Everything, With a new preface by the authors: Design, Fiction, and Social Dreaming*. MIT press.

[7] Chloe Eghtebas, Gudrun Klinker, Susanne Boll, and Marion Koelle. 2023. Co-Speculating on Dark Scenarios and Unintended Consequences of a Ubiquitous(Ly) Augmented Reality. In *Proceedings of the 2023 ACM Designing Interactive Systems Conference (DIS '23)*. Association for Computing Machinery, New York, NY, USA, 2392–2407. https://doi.org/10.1145/3563657.3596073

[8] Cristina Fiani, Robin Bretin, Shaun Alexander Macdonald, Mohamed Khamis, and Mark Mcgill. 2024. "Pikachu would electrocute people who are misbehaving": Expert, Guardian and Child Perspectives on Automated Embodied Moderators for Safeguarding Children in Social Virtual Reality. In *Proceedings of the 2024 CHI Conference on Human Factors in Computing Systems* (Honolulu, HI, USA) *(CHI '24)*. Association for Computing Machinery, New York, NY, USA, Article 113, 23 pages. https://doi.org/10.1145/3613904.3642144

[9] Mihael Gajic, Flurin Selm, Adrian Preussner, and Florian Mathis. 2025. SpeculAR: An In-the-wild Exploration of Users' Perceptions of a Social Augmented Reality. In *Proceedings of the Extended Abstracts of the CHI Conference on Human Factors in Computing Systems (CHI EA '25)*. Association for Computing Machinery, New York, NY, USA, Article 492, 8 pages. https://doi.org/10.1145/3706599.3719812

[10] Erving Goffman. 2008. *Behavior in public places*. Simon and Schuster.

[11] Jan Gugenheimer, Christian Mai, Mark McGill, Julie Williamson, Frank Steinicke, and Ken Perlin. 2019. Challenges Using Head-Mounted Displays in Shared and Social Spaces. *Extended Abstracts of the 2019 CHI Conference on Human Factors in Computing Systems* (May 2019), 1–8. https://doi.org/10/ghwfrq

[12] Jan Gugenheimer, Mark McGill, Samuel Huron, Christian Mai, Julie Williamson, and Michael Nebeling. 2020. Exploring Potentially Abusive Ethical, Social and Political Implications of Mixed Reality Research in HCI *(Conference on Human Factors in Computing Systems - Proceedings)*. Association for Computing Machinery, 1–8. https://doi.org/10.1145/3334480.3375180

[13] Ilyena Hirskyj-Douglas, Anna Kantosalo, Andrés Monroy-Hernández, Joelle Zimmermann, Michael Nebeling, and Mar Gonzalez-Franco. 2020. Social AR: Reimagining and interrogating the role of augmented reality in face to face social interactions. In *Companion Publication of the 2020 Conference on Computer Supported Cooperative Work and Social Computing*. 457–465.

[14] Ross Johnstone, Neil McDonnell, and Julie R. Williamson. 2022. When Virtuality Surpasses Reality: Possible Futures of Ubiquitous XR. In *Extended Abstracts of the 2022 CHI Conference on Human Factors in Computing Systems* (New Orleans, LA, USA) *(CHI EA '22)*. Association for Computing Machinery, New York, NY, USA, Article 6, 8 pages. https://doi.org/10.1145/3491101.3516396

[15] Ryan M. Kelly, Hasan Shahid Ferdous, Niels Wouters, and Frank Vetere. 2019. Can Mobile Augmented Reality Stimulate a Honeypot Effect? Observations from Santa's Lil Helper. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems* (Glasgow, Scotland Uk) *(CHI '19)*. Association for Computing Machinery, New York, NY, USA, 1–13. https://doi.org/10.1145/3290605.3300515

[16] Matjaž Kljun and Klen Čopič Pucihar. 2015. "I was here": enabling tourists to leave digital graffiti or marks on historic landmarks. In *Human-Computer Interaction–INTERACT 2015: 15th IFIP TC 13 International Conference, Bamberg, Germany, September 14-18, 2015, Proceedings, Part IV 15*. Springer, 490–494.

[17] Mikko Kytö, Ilyena Hirskyj-Douglas, and David McGookin. 2021. From Strangers to Friends: Augmenting Face-to-face Interactions with Faceted Digital Self-Presentations. In *Augmented Humans Conference 2021 (AHs'21)*. Association for Computing Machinery, New York, NY, USA, 192–203. https://doi.org/10/gmk7c9

[18] Aurélien Léchappé, Ross Johnstone, Aurélien Milliat, John H Williamson, Mathieu Chollet, and Julie R. Williamson. 2025. Understanding Social Interactions in Reality Versus Virtuality. In *Proceedings of the 2025 CHI Conference on Human Factors in Computing Systems (CHI '25)*. Association for Computing Machinery, New York, NY, USA, Article 41, 18 pages. https://doi.org/10.1145/3706598.3713628

[19] Florian Mathis, Jolie Bonner, Joseph O'Hagan, and Mark McGill. 2023. Breaking Boundaries: Harnessing Mixed Reality to Enhance Social Engagement. In *Mensch und Computer 2023-Workshopband*. GI, 10–18420.

[20] David K. McGookin, Stephen A. Brewster, and Georgi Christov. 2014. Studying digital graffiti as a location-based social network. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (Toronto, Ontario, Canada) *(CHI '14)*. Association for Computing Machinery, New York, NY, USA, 3269–3278. https://doi.org/10.1145/2556288.2557266

[21] Anton Nijholt. 2020. Playful and humorous interactions in urban environments made possible with augmented reality technology. In *Interactivity, Game Creation, Design, Learning, and Innovation: 8th EAI International Conference, ArtsIT 2019, and 4th EAI International Conference, DLI 2019, Aalborg, Denmark, November 6–8, 2019, Proceedings 8*. Springer, 273–289.

[22] Anton Nijholt. 2021. Experiencing social augmented reality in public spaces. In *Adjunct proceedings of the 2021 ACM international joint conference on pervasive and ubiquitous computing and proceedings of the 2021 ACM international symposium on wearable computers*. 570–574.

[23] Joseph O'Hagan, Jan Gugenheimer, Jolie Bonner, Florian Mathis, and Mark McGill. 2023. Augmenting People, Places & Media: The Societal Harms Posed by Everyday Augmented Reality, and the Case for Perceptual Human Rights. In *Proceedings of the 22nd International Conference on Mobile and Ubiquitous Multimedia* (Vienna, Austria) *(MUM '23)*. Association for Computing Machinery, New York, NY, USA, 225–235. https://doi.org/10.1145/3626705.3627782

[24] Joseph O'Hagan, Mohamed Khamis, and Julie R. Williamson. 2021. Surveying Consumer Understanding & Sentiment Of VR. In *Proceedings of the International Workshop on Immersive Mixed and Virtual Environment Systems (MMVE '21)* (Istanbul, Turkey) *(MMVE '21)*. Association for Computing Machinery, New York, NY, USA, 14–20. https://doi.org/10.1145/3458307.3460965

[25] Joseph O'Hagan, Pejman Saeghe, Jan Gugenheimer, Daniel Medeiros, Karola Marky, Mohamed Khamis, and Mark McGill. 2023. Privacy-Enhancing Technology and Everyday Augmented Reality: Understanding Bystanders' Varying Needs for Awareness and Consent. *Proc. ACM Interact. Mob. Wearable Ubiquitous Technol.* 6, 4, Article 177 (jan 2023), 35 pages. https://doi.org/10.1145/3569501

[26] Joseph O'Hagan, Graham Wilson, Thomas Goodge, Diego Drago, and Mark McGill. 2026. The BrutARlist: Exploring How and Why Individuals Alter a Known Brutalist Building with Augmented Reality. In *Proceedings of the 2026 International Conference on Advanced Visual Interfaces* (Venice, Italy) *(AVI '26)*. Association for Computing Machinery, New York, NY, USA. https://doi.org/10.1145/3811427.3811475

[27] Joseph O'Hagan, Graham Wilson, and Mark McGill. 2026. WebPerceptor: An Open Source Chromium Plugin for Real-Time LLM-Based In-Line, In-Browser Re-Writing of Website Content. In *Proceedings of the Extended Abstracts of the 2026 CHI Conference on Human Factors in Computing Systems (CHI EA '26)*. Association for Computing Machinery, New York, NY, USA, Article 734, 5 pages. https://doi.org/10.1145/3772363.3798730

[28] Joseph O'Hagan, Jan Gugenheimer, Florian Mathis, Jolie Bonner, Richard Jones, and Mark McGill. 2024. A Viewpoint on the Societal Impact of Everyday Augmented Reality and the Need for Perceptual Human Rights. *IEEE Security & Privacy* 22, 1 (2024), 64–68. https://doi.org/10.1109/MSEC.2023.3333988

[29] Katharina M. T. Pöhlmann, Graham Wilson, Laura Bajorunaite, Mark McGill, and Joseph O'Hagan. 2025. "Everyone Knows You're Watching P*rn": Reflecting on First-Hand User Accounts on the Use and Public Perception of in-Transit Passenger XR. In *2025 IEEE International Symposium on Mixed and Augmented Reality (ISMAR)*. 560–570. https://doi.org/10.1109/ISMAR67309.2025.00066

[30] Jan Ole Rixen, Mark Colley, Ali Askari, Jan Gugenheimer, and Enrico Rukzio. 2022. Consent in the Age of AR: Investigating The Comfort With Displaying Personal Information in Augmented Reality. In *Proceedings of the 2022 CHI Conference*

on Human Factors in Computing Systems (CHI '22). Association for Computing Machinery, New York, NY, USA, 1–14. https://doi.org/10.1145/3491102.3502140

[31] Jan Ole Rixen, Christian Funk, Enrico Rukzio, and Jan Gugenheimer. 2023. May I Still Define Myself? Exploring How Dissonance in Displaying Personal Information Through Head-Mounted Augmented Reality Can Affect Personal Information Sovereignty. In *Extended Abstracts of the 2023 CHI Conference on Human Factors in Computing Systems* (Hamburg, Germany) *(CHI EA '23)*. Association for Computing Machinery, New York, NY, USA, Article 202, 7 pages. https://doi.org/10.1145/3544549.3585821

[32] Rufat Rzayev, Susanne Korbely, Milena Maul, Alina Schark, Valentin Schwind, and Niels Henze. 2020. Effects of Position and Alignment of Notifications on AR Glasses during Social Interaction. In *Proceedings of the 11th Nordic Conference on Human-Computer Interaction: Shaping Experiences, Shaping Society* (Tallinn, Estonia) *(NordiCHI '20)*. Association for Computing Machinery, New York, NY, USA, Article 30, 11 pages. https://doi.org/10.1145/3419249.3420095

[33] Johnny Saldaña. 2021. The coding manual for qualitative researchers. (2021).

[34] Alexandra Thompson and Leigh Ellen Potter. 2020. Defining AR: Public Perceptions of an Evolving Landscape. In *Extended Abstracts of the 2020 CHI Conference on Human Factors in Computing Systems* (Honolulu, HI, USA) *(CHI EA '20)*. Association for Computing Machinery, New York, NY, USA, 1–8. https://doi.org/10.1145/3334480.3382843

[35] Alexandra Thompson and Leigh Ellen Potter. 2020. Overlays and Goggles and Projections, Oh My! Exploring Public Perceptions of Augmented Reality Technologies. In *Proceedings of the 31st Australian Conference on Human-Computer-Interaction* (Fremantle, WA, Australia) *(OzCHI '19)*. Association for Computing Machinery, New York, NY, USA, 295–301. https://doi.org/10.1145/3369457.3369482

[36] Julie R. Williamson, Joseph O'Hagan, John Alexis Guerra-Gomez, John H Williamson, Pablo Cesar, and David A. Shamma. 2022. Digital Proxemics: Designing Social and Collaborative Interaction in Virtual Environments. In *Proceedings of the 2022 CHI Conference on Human Factors in Computing Systems* (New Orleans, LA, USA) *(CHI '22)*. Association for Computing Machinery, New York, NY, USA, Article 423, 12 pages. https://doi.org/10.1145/3491102.3517594

[37] Graham Wilson, Thomas Goodge, Joseph O'Hagan, and Mark McGill. 2026. Towards Responsible Memory Augmentation: Surveying the Intended Uses of Everyday Augmented Reality and Artificial Intelligence for Memory Processes. In *Proceedings of the Augmented Humans International Conference 2026 (AHs '26)*. Association for Computing Machinery, New York, NY, USA. https://doi.org/tbc

[38] Graham Wilson, Thomas Goodge, Joseph O'Hagan, and Mark McGill. 2026. What Role (s) Will GenAI Play in Human Memory? Cognitive Theories for the Design of Responsible "Tools For Memory". (2026).

A Participant Social AR Ideas

This table gives an overview of the social AR ideas proposed by participants, proving the name and description authored by participants for reference. Consequently the language used and detail provided varies.

ID	Scenario	Name	Participant description
5	1	Visualiser for a tabletop rpg	Based on pre-made artifacts, can create visuals to use in a ttrpg. Alternatively, could be continouosly generated using AI
6	1	Furniture design	Can place various pieces of furniture into an existing space to help visualise them.
7	1	Distanced communication	AR used to create shared experience for distanced people. Experience could be just a call, but could include shared activities (boardgame/movie)
8	1	Distanced communication	AR used to create shared experience for distanced people. Experience could be just a call, but could include shared activities (boardgame/movie)
9	1	Virtual boardgames	project board and pieces between all players so they can play a virtual boardgame together
10	1	AR NERF FIGHT	Idea was created in phase 3 so no participant description available
11	2	Connected entertainment/comms	Can communicate or participate in shared entertainment with other passengers even if seated seperately or enjoy private entertainment without disturbing other passengers
12	2	Journey overlay	An overlay of your journey, next stop and transport route between stops
13	2	Disappear into dream world during transport	Passenger can heavily augment the world in AR, changing the world outside the window, adding/deleting elements or changing their visual appearance
14	2	Distanced communication	They are connected by earpieces & either have voices amplified or are shown subtitles from the person who is talking
15	3	Directions and group cohesion	Highlights members of your 'group' and creates a navigational overlay to a customisable scale
16	3	Commercial overlay/window shopping	Can view the contents of the shop and purchase from exterior
17	3	Optimal route planner	arrows of direction pointing the group in the most time efficient direction, can direct to quieter shops first
18	3	Last minute planning/booking	They can communicate ideas with each other through voice or visual. Can see suggestions for activities to do, or how full a restaurant is for example
19	1	AR paper aeroplane	Fly a little paper aeroplane around for a bit
20	1	AR bug on wall	put a big funny looking bug on the wall
21	‘1	Educational visualisation	Create a 3d interactive representation of an object of interest
22	1	Sign language translator	AR Glasses analyse and translate the sign language into text displayed/spoken through speakers. Also works with other types of language barriers, although would require high quality microphones instead of sensors
23	1	Tabletop rpg visualisation	We visualise and interact with virtual scenes and objects attuned to the dnd story background. We dive in to deep immersion from the usage of the technology.
24	1	Virtual food	Whilst waiting for food they look at virtual food and consume it virtually to fake fulfilment to their brains and bodies
25	1	Map for trip visulaisation	planning a walk, could use ar to have various 2d maps infront of different people, 3d google earth type profiles. images of various areas that would be fun to visit.
26	2	Virtual ID/Card management	A little screen that keeps record of your important documents i.e bus pass, credit card, id etc...

ID	Scenario	Name	Participant description
27	2	Personal customisation	you can have a little screen around you which displays information youd like strangers to know, could also be used cosmetically
28	2	Mini interactive games	Play games with synchronised vision, with a timer for the journey till set destination
29	2	Virtual drink	Whilst waiting for food they look at virtual drink and consume it virtually to fake fulfilment to their brains and bodies
30	2	Communal game of catch	eye tracked game, maybe like a simple ball keepy upies with your eyes kind of thing, lose when none of the participants are in range of the ball.
31	2	Virtual tour guide	knowledge about the area your in fun historical facts pop up on a flat screen like notifications
32	3	Find friends	AR glasses centre a big pin above each participants head with their name on it, so it is visible from every other participant. Also shows distance to person. Can optionally show their current objective.
33	3	Minimap	Real-time map that minimises when it detects wearer walking, people in groups can be added to sessions where they share the same view but can interact with the locations and stores shown within the map. Like adding reactions or comments, for deciding which direction to go as a group and bring up example images of the activities within the location.
34	3	Share photos	memories if your in a place youve been before ,maybe without these people you could be notified of previous photos from the area and if you want to shrae them with the group and then they fit into real space kind of like a compination of people writting there names on walls and on this day google photo collages
35	1	Tabletop simulator	Use of something similar to tabletop simulator to be able to play/try board games without having to own the product
36	1	Virtual campfire	The people could have a virtual campfire/fire pit in the middle of the room
37	1	Digital card game	digital 3D cards can be placed on a agred flat surface - i.e. a table
38	1	Sandbox building game	A sandbox building game.
39	1	Multiplayer gameplay interface	Playing local multiplayer AR games, such as simulated board games, or games more akin to current VR titles but in a local way.
40	1	Immersive video games/movies	Video games are augmented with changes to your surroundings
41	2	Shared revision	shared flashcards on screen - essentailly kahoot but for the group
42	2	Immersive chat app	Fully immersive chat app, hides surroundings while showing friends.
43	2	Shared journey planner	A shared journey information set up. Such as a list of sites to see that can be turned into a 3D map of the city/place being visited. Then can be used to direct people either wearing an AR device when they get there or sharing information to another device.
44	2	Digital catch	virtual ball thrown between each other to kill the boredom
45	2	Enhanced communication	Chat application, mostly visually non-immersive, but making use of headset microphones/ cameras. People can hear each other as if they are close, and still see/ hear surroundings, but since microphones are per person they can be picked up well. Maybe only used as a voice amplifier? Or have a flat screen showing others' faces.

ID	Scenario	Name	Participant description
46	2	Shared games/movies	watch a movie together, or playing chess/ another game or idk some activity together that wouldn't be too disruptive, eg videos and can comment stuff
47	3	Group communication/visualisation	User highlighting for friends, which shows them in some way to seperate them from others in the croud, maybe others can see that we're a group so they don't walk between us. Also could incorporate the communication idea from previously. Could maybe also have a (quiet) shared music player, for example in the lead up to a concert.
48	3	Crowd management	Crowd management, you can see your friends highlighted through the crowd. But the concert venue can track the volume of AR glasses and use that to direct staff on how to manage the crowd whilst knowing the sizes of groups and their demographics such as disabilities or other needs. The venue can deliver emergency alerts/info.
49	3	Venue direction	Idea was created in phase 3 so no participant description available
50	3	Phone pop-up	Push notifications for normal phone things + potentially ways for other members of the group to send photos + locations (e.g. if people go into different shops/restaurants etc)
51	3	Plot route through crowd	show path around people to get to goal
52	3	Conversational interface	an app which allows better audio hearing between the group of people, but also be aware of surrounding people, and dangers outside eg cars, buses etc.
53	3	Real-time person tracker	show a outline where others are - don't get seperated
54	3	Universal block	
55	1	Trip/activity planner	The 3 users can project what they are looking at in a shared space for example a map in the middle, a calendar overview where everyone can see, and individual spaces where users can conduct research/planning on specific parts of the trip but still be able to see what everyone is working on at the same time in a frictionless manner.
56	1	Food ordering	Foods are being displayed for anyones request
57	1	Vacation planner	Scenes are displayed about places that represent its "overall vibe"
58	1	Self introduction	Displaying vibes of stuff they love
59	1	Rendering alternate reality	mimicking taking drugs/ rendering another reality
60	2	Watch films together	Movie watching together on individual screens. There could be a way to talk about the movie quietly without yelling across the train. Movie is synced across the 3 devices
61	2	Play video games together	some sort of game, potentially multiplayer. The idea is that video games can be much more immersive with the use of virtual displays (projected into the world to seem bigger than a laptop screen would be for example.
62	2	Stickman running game	When we look out the window we can play with our character that is running next to train, bus etc. by parkouring over the actual stuff that is there. The person sitting in the other row has the image of the other window projected to theirs.
63	2	Enhanced communication	display others sentences
64	2	Fun facts	The devices overlayes information about your trip, such as time left, stations coming, up. But also stuff outside your window such as sites, history, geography facts, random cool info.
65	2	Enhanced communication	using AR to modify the volume of speech
66	2	Interactive video	rendering a scenario into reality

ID	Scenario	Name	Participant description
67	3	Find friends	the app can display the locations of your friends either on a virtual map overlay type thing with AR directions (arrows, line on floor to follow) or could show an arrow above your ifriend's head if they're nearby
68	3	Art installations	a way to create art in the real world that is permanently bound to a real location. Think of a virtual graffiti
69	3	Interactive AR maps	We could ping or place flags over actual places that visible e.g. lets go here, wait you there. Or show where to go next. Or e.g. meet you at this spot in the store (and some anchor actually stays there).
70	3	3D memes	Watching them memes
71	1	Planning a summer vacation trip	people view a map together
72	1	Night out planner	We can take a look at a number of recommendations together, in the form of pop-ups maybe
73	1	Virtual tabletop games	We can project an interactive game board between us, and play on it together. This game board can facilitate a number of games
74	1	Kitchen remodel	Using AR glasses, we can create projections that we can show each other to discuss how the kitchen could/should be remodelled
75	1	Plan a Sunday meal	We plan the dinner on an interactive whiteboard or something similar
76	1	Garden remodel	Everyone can design there own little version, and then show the others to discuss
77	1	Optimisation or remodelling a part of a house	We can see how the redesign would affect the space in 3 dimensions, and discuss it
78	2	Task planner	See a screen ahead of you that can be controlled by multiple users. Users should be able to communicate through a voice channel and assign chores to eachother
79	2	Mid-travel movies	Drown out people around and be able to watch a film on a large virtual screen
80	2	Shared games	Be able to play some basic games together (i.e battleships)
81	2	Mid-travel productivity	I bring up various digital screens to be able to do productivity activities, such as read emails, or fill out excel sheets
82	2	Shared playlist	Can create a shared "room" to listen to music, be ble to discuss, basically a way to have a shared silent disco
83	2	Shared games	We can play various games together a=on a small virtual screen
84	3	Efficient shopping	Add an overlay on to shops, to see if pre-specified items are available to buy there
85	3	Shop finder	Given a list of stores where we could potentially buy an item we are looking for, and are given a route to guide us to that store
86	3	Deal finder	We are given overlays for deals on billboards within the mall, that are most relevant to us
87	3	Celebrity finder	Highlights celebrities when walking past them
88	1	Watch film while moving around house	A movie is being synced for all watchers and projected in AR on the goggles. It would allow the watchers to move around the living room and attend other activities without missing the movie
89	1	Communication projection	Augmented video calling system. AR representations/3d models of participants in a call would appear in the living room across the caller, creating an immersive feeling during the call.
90	1	Virtual furniture planner	Add in furnitures from a catalogue/remove existing furniture in the room

ID	Scenario	Name	Participant description
91	1	Board games in AR	"Board games boards, playing mats, miniatures could be projected for a more immersive experience. They can be moved around, data and score can be projected over HUD of players."
92	1	Pop-up notification HUD	"Notifications would appear on the HUD in the corner and disappear after a short time. This would allow users to be aware of notifications without looking distracted from the conversation they're having."
93	1	Social fitness challenge	A virtual trainer appears in the room, and guides us through a number of exercises
94	1	Integrated overlayed games	Can create a realistic feeling overlay, to play a number of games, such as hide virtual items for a scavenger hunt, or turnthe floor into lava
95	1	Virtual concert	Use AR to create a realistic audio and visual experience of being at a liove concert
96	2	Virtual shared playlist	The applcation plays music (much like spotify), but we can create shared playlists, or show each other snippets of songs
97	2	Group photo challenge	Have a set of challenges/filters/etc.. and be able to take videos and photos, that seem like we're together even if we aren't actually sitting next to eachother
98	2	AI tourguide	Sights are subtly highlighted outside the window, and an audio voiceover gives us fun facts about the sights
99	2	Conversational interface with spatial translation	"Friends that you choose appear next to you, even if they are sat in a different place. This would allow to communicate with your friends no matter where they sit
100	2	Remove people	AR goggles add darkness where other people are located and dampen the sound made by other people to limit outside interference. If people that are being concealed approach closer, the goggles alert that and outline them in the darkness
101	2	Joint entertainment	Movies or music is played synchronously with other participants. Metadata is displayed in the corner of the HUD to not clutter the view, and the movie screen is transparent to the sides to make sure that users don't miss things IRL
102	3	Find your friends	The app shows a route to my friend if they go outside of a specific distance
103	3	Portable info board	Have a large 2d screen, which can have enlarged 3D elements, or be minimised into a "minimap", to guide me to wherever I want to go/give information on the event
104	3	Interactive digital experience	Idea was created in phase 3 so no participant description available