Designing our Weird Social XR Future: Tactics to support hybrid ways of embodied knowing

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Abstract

This paper builds from the foundation of Dourish's **embodied interaction** and Höök's **somaesthetic design** writings to address the strange hybrid nature of embodiedness in the context of XR interaction. Working from the authors' lived experience prototyping 'weird social' interactions, the paper uses VR as a case study toward illuminating some of the oddities of the embodied prototyping of XR experiences. Several tactics for design are proposed that others may find helpful, toward contributing to a rich panel discussion of embodied **ways of knowing** in the practice of shaping social XR experiences.

CCS Concepts

• **Human-centered computing** → Human computer interaction (HCI); Human computer interaction (HCI); Interaction paradigms; Virtual reality; Human computer interaction (HCI); Interaction paradigms; Mixed / augmented reality; Interaction design; Interaction design process and methods.

Keywords

XR, VR, mixed reality, embodied interaction, somaesthetic design, embodied sketching, hybrid embodiment, 'weird social', ways of knowing

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1 Introduction

In 2001, in his foundational book *Where the Action Is*, Paul Dourish laid out an approach to thinking about the future of computing that drew upon advances in tangible and social computing of the time, foregrounding the notion of **embodied interaction** [8]. Dourish drew upon phenomenological approaches in philosophy to point out the essential position of the body and sensorial experience in relation to our ways of knowing, as we engage with computational systems. This turn made a great deal of sense, as computing at the time moved from offices and desktops into portable, tangible, and wearable devices, and from text terminals toward graphical user interfaces that might be readily shared among distributed workers whose rich social context needed to be taken into account.

More recently, Kristina Höök's 2018 text *Designing with the Body* has grounded the **design process** more deeply in the presence of the body–Höök proposes that designers engage in **somaesthetic** interaction design, considering the body as design material that is also shaped by the system that is being crafted, encouraging an inward turn that includes **embodied sketching** as one component of the soma design methodology [12]. Höök's team creates digitally enhanced physical systems–a central example in the book being the Soma Mat, which "uses heat feedback to direct your attention to different body parts while you follow the instructions of a prerecorded, Feldenkrais-inspired lesson"[12]. This system showcases the somaesthetic approach, engaging the body in a subtle and sensitive manner in a process of awareness and understanding that makes adept use of the interplay between person and system.

The challenge presented in this paper is the deeply felt **embodied oddity** of XR, in a somaesthetic sense. In the terrain of mixed reality, computation can wrap around our senses and co-mingle digitally grounded sensory experiences more deeply into our felt reality. We are still in our bodies, but our senses and our felt sense of ourselves can be powerfully gripped by the visual, auditory, and even haptic textures and rhythms of artfully crafted computation. In this context, we believe it is important to extend the work of Dourish and Höök and explore **new ways of knowing**—and making within/alongside—the new, alien, embodiments of XR. This oddity is compounded in social engagements, as it perturbs our shared social sense of one another–our mutual ways of knowing and knowing one another, which as Dourish pointed out *Where the Action Is*, also leads to the need for radically different tools for understanding and design.

How shall we craft this strange new 'material'? What design tactics and methods will help support designerly intuition and invite participatory co-shaping of 'beyond being there' [11] futures that we all can enjoy and embrace? How might we ward off dystopian futures of zombified absence and abdication of will (and embodied presence) to attention economy business models?

We're interested in shaping this material from not just an individual point of view, but from a shared, **social** perspective. In this paper, we use our own lived experience prototyping 'weird social' interactions in VR/XR as case studies that illuminate some of the oddities of the embodied prototyping of experiences in this medium. Embracing the spirit and opportunity of the Halfway to the Future Symposium, we depart from a more traditional research report here,

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to instead weave together these cases as provocations for broader insights and methodological recommendations. We propose several tactics that others may find helpful, toward contributing to a rich panel discussion of embodied **ways of knowing** in the practice of shaping social XR experiences.

1.1 The Already Half-Present Social Body

To set the somaesthetic felt stage for design practices that are adept with XR's weird reality, we can consider the oddity of the present mobile-computing and videoconference saturated moment. It can perhaps provide clues to overcome what we've described elsewhere as humanity's proverbial blindness to the strangeness just around the corner [20]. We are all familiar with the social sensation of someone being there, and also not being there, when present with us in a room using a mobile device. At the same time, we are all familiar with engaging in a text chat over mobile devices with someone who we know is elsewhere, and feeling the co-present attentional exchange ebb and flow as the person moves about the physical world elsewhere, feeling our own attention and presence in our physical place shimmer (or glitch) in and out of focus. When it comes to videoconferencing, we accept layers of embodied presence—video camera on, or off with a picture and name standing in for the person, hearing a voice and/or reading text chat, and even our video captured fleeting hand gestures triggering floating emojis interwoven into the experience. Our notion of what it means to be co-present, to be attuned in an 'embodied' manner to our connection with another person, is already deeply 'weird' in the present day. Where are we when we are together? What is the place that we occupy together? A 'meeting' is collapsed into a grid of videos and a text chat window occurring over a set period of time. It's normal and accepted for peoples' attention to drift in and out of felt co-presence in these new contexts. And we are comfortable digitally hybridizing our bodies and communication–exchanging pictures, animations, overlaying our faces with filters, as we engage.

It's fair to say we are already pretty far along in projecting ourselves into strange alternate shared 'places' [10] woven out of the cyberspace between us in these networked experiences. XR is a progression from this state that promises to more pervasively involve many of our senses, expanding the possibility space for felt co-presence and immersion.

We would argue that when Dourish, and even Höök, were writing, their presumption was that there was a sensing body working from the usual understanding of the sensory capacity of a physically present human being. But the advent and broad dissemination of smartphones and videoconferencing, we believe, has created an increasing sense in which most of us are half-present persons, for more and more of our daily experience, extending our sense of place and social co-presence far afield of our felt bodies, using our eyes and our hands to detach from the rest of the soma for hours at a time. The digital attention economy and remote work have acclimatized us to a strange form of **nonpresence** in our own skin.

In the research described here, we aim to work along the grain of these strange trends, while aiming toward using XR as a material that supports people in being meaningfully **present** and **grounded** together, enjoying a shared 'weird' somaesthetic reality that envelops and supports our social ways/structures and also accounts for our physical bodies and needs.

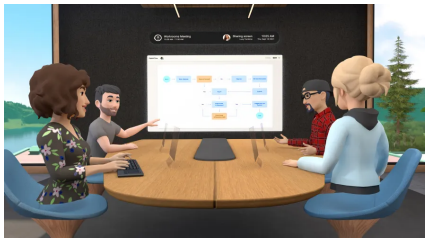

Figure 1: Meta's Horizon Workrooms featuring integration of physical keyboards and hand tracking. From the Meta Newsroom (2021).

2 From Staid Simulacrum to Embracing the Strange in VR and XR

Before we discuss how strange and alien VR and XR can be, we should acknowledge the investment that industry leaders have had in convincing consumers that XR is *not strange*, but rather, an extension of our embodied experience of physical space. Like the outward facing animated eye display of Apple's Vision Pro, the recent tendency of commercial leaders in this sector is to emphasize how much XR can reproduce what is familiar about the physical world. This framing is of course a departure from the visions of virtual reality as a psychedelically inspired altered form of consciousness that proliferated in the 1980s. In the wake of COVID, an emphasis on instead approximating the physical office space proliferated among enterprise-facing VR tools [28], likely as a response to the social stuntedness of ubiquitous video conferencing. Amidst a pandemic milieu of privileged remote workers bemoaning the loss of embodied social interaction, commercial leaders like Meta sought to reproduce the office conference room as a virtual arena for shared co-presence (Figure 1).

2.1 The Alternative? Envisioning the Strange Sociality and Embodiment of XR

We have argued that framing VR and XR as turbo-charged skeuomorphic faux reality elides the unique capacities for somatic hybridity and creativity inherent to VR (and XR more broadly) [20, 21]. Instead, we propose embracing the alien soma of VR and XR, exploring the strange social opportunities this medium affords. Our current research explores these opportunities from both a design and research perspective [16, 18, 20–22, 24, 28]. The approach we develop shares ground with related XR research that seeks an expanded understanding of situated embodiment and sensorial experience, for example through tactics such as: transformed social interaction [1], social augmentation [30], homuncular flexibility [34], frictional reality [29], extending/remixing bodies [5], and intercorporeal design [31].

2.2 Warping Sociality in Productive Ways

Here we take up the concept of "weird social" [20] toward productively envisioning this future as a 'beyond being there' for social VR/XR [21]. In a nutshell, 'weird social' means weird co-embodiment—strange, embodied affordances that warp sociality in playful and productive ways. This can involve throwing new

Figure 2: Emoji sending prototype. Developed on a customized version of the Mozilla Hubs code base, this tool enabled users to send emojis to one another in VR. The emojis spawn above the sender, travel in an arc, and then rain down on the recipient. Designed by Anya Osborne, Joshua McVeigh-Schultz, Katherine Isbister, and Alex Leeds, and developed by Caelen Wang.

social signals into the mix, such as copying someone's avatar on the fly to signal affiliation or tossing emojis like virtual confetti [27]. It can involve making tacit social cues more salient (for instance by externalizing conversational mechanics through real-time data visualization [18, 27]). It can accentuate the strange fictions of hybrid presence when co-present participants are present in the same physical space but have access to different virtual layers. Or it can leverage our abilities to improvisationally remake or modulate our shared environments, for example through reconfigurable architecture, modular ambiances, or ambient cues that would only be feasible given the strange physics of the medium [24, 27]. To unpack these ideas further, we highlight a few illustrative examples.

2.2.1 New Social Signals. While sending emojis have long been a fixture in VR and XR applications, they are typically externalized as virtual assets that float up above the signaling avatar and then disappear (as was the case in AltspaceVR). Instead, in our prototype depicted in Figure 2**,** emojis can be "thrown" in a parabolic arc at a particular avatar and then proceed to "rain down" as smaller emojis, reshaping the interpersonal emotional space between avatar bodies and making it explicit who is the sender and who is the receiver of affective signaling [27].

2.2.2 Visualizing Previously Tacit Cues. By externalizing normally tacit aspects of social interaction as more explicit environmental cues, social XR can transform signals that would otherwise be implicit into more salient features available for conscious, embodied experience and reflection. For example, in meetings, the question of who is speaking more can sometimes arise as an implicit social signal, but this cue can be made more salient, reshaping social interaction in the process. Research has demonstrated the value this kind of salience can have for balancing conversation and strengthening communication [35], and HCI has long demonstrated how visualizing participants' speech over time can help participants keep track of who is speaking more and, as a byproduct, improve parity in meetings, [2, 6, 7, 15, 17].

Prior research has also explored how conversational parity can be supported in VR and XR [9, 18]. In the prototype shown in Figure 3, elongating cylinders correspond to the avatar color of VR meeting participants. The cylinders grow while the respective participant speaks, and the collective "tube system" rises over time leaving a trace of the relative contributions over time [9, 18, 27].

2.2.3 Accentuating Friction between Overlayed "Realities" as a Resource for Play. Much has been made of the awkward lack-of-presence of a person wholly immersed in a VR experience, in terms of social engagement with other physically co-present bodies, and in turn, we tend to feel physically vulnerable when our vision and hearing are taken over by VR. Astaire, Figure 4 [36], is a two player VR experience that tackles these issues, using a novel combination of mixed presence to bridge the wholly immersive realm of VR with social engagement in the room. One player wears the VR headset and holds one VR controller, the other player straps the second VR controller to their foot and then partner-dances with the first. Player 2 uses an in-room screen showing a top-down view of the VR world to guide their actions, while Player 1 is immersed visually in that same realm. Spectators in the physical room enjoy the spectacle of the partner dance, which is comical because of Player 1's 'absence', and which becomes a graceful navigation of the two players across the hybrid space. In this way, the game uses this hybrid presence as a playful challenge.

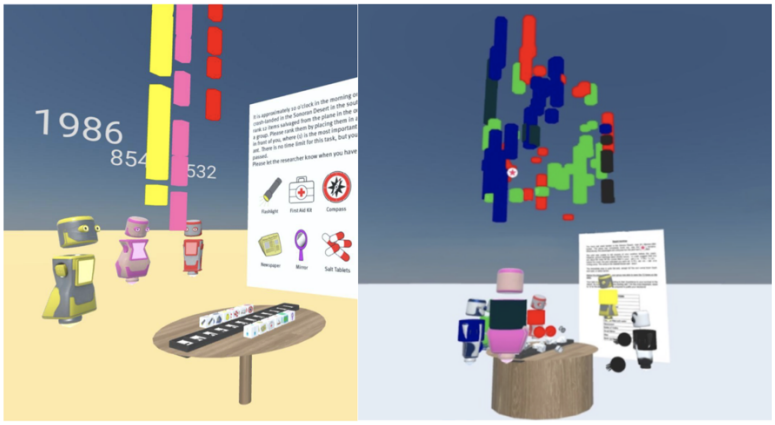

Figure 3: Conversation parity is externalized in this prototype through the appearance of cylinders that match the color of avatars and elongate as a participant speaks. Designed by Max Kreminski, Anya Osborne, Katherine Isbister (PI), Joshua McVeigh-Schultz (PI), with assistance from Tym Lang and Alex Leeds. Developed by Kreminski, Caelen Wang, and George Butler on a custom Mozilla Hubs code base. Experimental research team included: Victor Li (lead), and Tara Lamb. Special acknowledgment to Sean Fernandes who designed and developed an earlier iteration as part of his MS thesis [9].

Figure 4: In Astaire, one player sees a fully immersed view of the virtual dance floor (left), while wearing the VR headset and holding one controller (center). The second player wears a controller on their foot (center), helping the first player navigate in the physical room using a screen-based display that shows complementary game information (right) that spectators in the room can also see. Designed and developed by Zhuoming (Jimmy) Zhou, with assistance from Elena Márquez Segura, Jared Duval, Samvid Jhaveri, and Michael John.

2.2.4 Leveraging environmental change as a social resource. As humans, we have a unique capacity to make sense of the passage of time through ambient cues like lighting or distance traveled as a proxy for time during a walk. In Figure 5 we show our prototype in which a platform floats through space over the course of a meeting, offering participants an ambient sense of progress through space and time as landmarks are passed [27].

In Figure 6, we show our prototype that enables participants to construct their own meeting environment on the fly. Utilizing the alien physics of XR, participants can reposition, scale, and recombine various architectural elements and geometric shapes to construct the ideal environment for a bespoke meeting. Instead of simply "pulling up a chair," participants collaboratively "conjure up" a room.

3 Working with XR as an Embodied Design Material

At this point, we pivot from examples of 'weird social' XR experiences, to sharing embodied methods and prototyping tactics that support the design of these new modes of social co-embodiment. Over the past decade, practices of VR/XR design methodology have evolved rapidly, both in terms of designing for VR/XR as well as

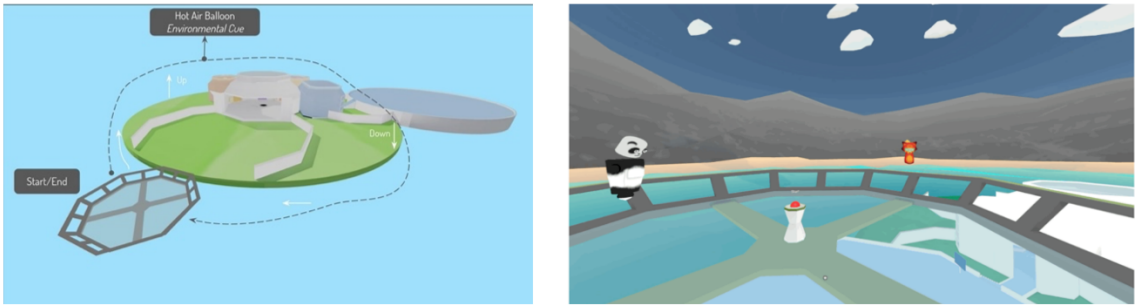

Figure 5: This spatial time management system allows meeting participants to board a platform that then slowly floats on a pre-charted course through a landscape over a set period of time. This allows time management through spatial landmarks (e.g. 'we've passed the hot air balloon, let's move on to the next agenda item'). Part of Anya Osborne's dissertation project. Designed by Timothy Lang, Alexandra Leeds, and Anya Osborne and developed by George Butler on a custom Mozilla Hubs code base (PIs Isbister and McVeigh-Schultz).

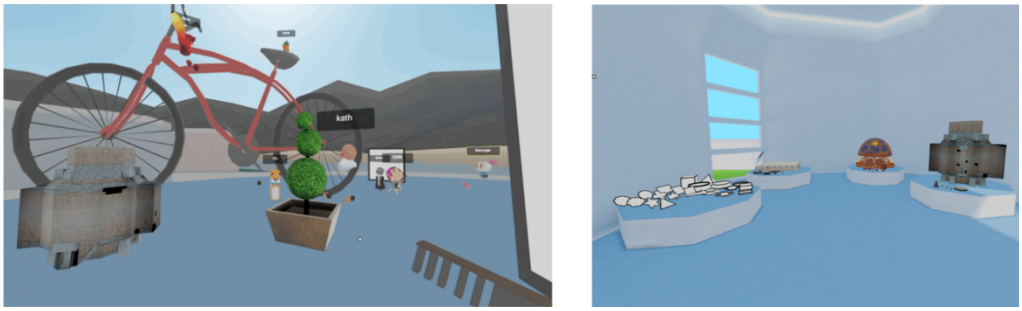

Figure 6: This prototype allows participants to arrange and scale prefab objects to craft their own meeting space tailored to the social needs of the moment (ambience, mood, topic). Part of Anya Osborne's dissertation project. Designed by Anya Osborne and Alexandra Leeds and developed by George Butler on a custom Mozilla Hubs code base.

designing with/in VR/XR. Here we focus in particular on the latter (designing with/in VR/XR). Existing work that approaches VR (and XR more broadly) as a medium for experiential design processes includes: bodystorming and sketching within VR [24, 32] and XR [19, 33, 36], service prototyping and roleplay in VR [3], cinematic XR approaches to immersive Wizard-of-Ozzing [26], mixed reality motion capture for prototyping [25], and "spatially aware interactive spaces" for playful exploration and "acting out" in VR [14]. Other relevant in-headset collaborative methods research has drawn from the legacy of theater, including explorations of 'frictional realities' through mixed reality performance [29] and methods for mixed-reality bodystorming, puppeteering, and performance [33]. These sorts of methods draw upon the unique affordances of VR and XR as media forms. In our own work, we are particularly interested in leveraging the alternative physics of VR/XR as a resource for both in-headset improvisation and "pre-headset" preparation.

3.1 Embracing Alien Physics

At a basic level, differences in physics, materiality, and interactive affordances make different kinds of embodied design processes possible in VR (and in XR more broadly). Designers can and should utilize alternative rules of physics. For example, during embodied sketching and bodystorming sessions, virtual assets can be positioned anywhere in space without gravity or momentum. Alternative physics in VR/XR also enable fluid movement between different experiential scales. Moreover, since interactive features can become a resource for embodied sketching, bodystorming, and improvisation, early digital prototyping can leverage more modular, customizable, or otherwise manually driven feature sets so that designers can test out various options in an improvisational way during in-headset bodystorming.

This shift towards provisional, more open ended, features enables different kinds of discoveries. For the conversation visualization example described above, the team would not have gotten a feel for what the design possibility space felt like without putting our soma into that context (in-headset) and trying out a wide range of visualization options on the fly. We couldn't develop a design intuition or understand the implications for alternative decisions without calibrating/configuring the various visualization opportunities on the fly. We needed to step in and understand how various options felt in a lived social context and tweak the parameters in an ad hoc way.

When we first began working in the social VR space on conversation balance support, our own prototypes lacked this flexibility.

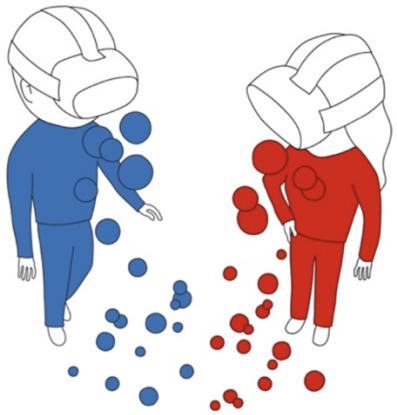

Figure 7: Illustration of the first prototype of our conversation balance intervention, which had colored balls spewing from avatars' mouths at a set rate while the person was speaking. Designed and developed by Sean Fernandes for his MS thesis at UCSC [9]. Research team: Sean Fernandes, Joshua McVeigh-Schultz, Elena Márquez Segura, Katherine Isbister.

(See [9] for a more detailed description of this work and see [24] for a deeper dive into our design process). Inspired by a similar concept (described here [20]), this early work utilized colored spheres spawning from participants' mouths at a set rate while speaking (Figure 7).

Since key parameters such as the spawn origin of spheres, spawn rate during speech, spheres size, sphere physics, and sphere accumulation zone were all fixed parameters, it was difficult to communicate, externalize, or otherwise explore alternatives to one another in a richly embodied way that took advantage of our share co-presence in the virtual medium, and iteration on these interconnected variables became far too cumbersome.

Instead, to refine this experience in a more flexible way, we needed to craft a custom **bodystorming sandbox** so the team could explore alternatives on the fly in social VR. Figure [24] illustrates a later prototype, adapted this time to be a bodystorming sandbox for the design team to collaboratively explore the social impact of a wide range of options from within headset.

Using this new VR sandbox approach, sphere-spawning was now anchored to controllers (enabling us to fluidly test out different spawn positions in action). Sphere-spawning was also now driven manually (by a button press) so that we could simulate the experience and make ad hoc decisions about how often spheres should spawn and what should count as speech. Sphere-scale was now adjustable on the fly, enabling us to test out various sizes and relationships between size and time during speech. Repositionable/scalable spheres without gravity/physics were included in the scene so that we could propose alternative accumulation zones (for example spheres could accumulate in a cloud above the meeting participants' eyelines). Importantly, none of these customization features were intended to be present in the final design, but rather, were intended to support exploration during in-headset bodystorming. Figure 8 shows designers experimenting with different spawn positions and spawn rates for the speech spheres and evaluating impact on: eyelines, self-awareness of one's own speech, the salience of speech duration, and the accessibility of cumulative speech comparison among meeting participants.

We contend that the experiential outcome of prototype decisions is really not accessible to designers without doing this work in-headset together. Utilizing more flexible, in-headset, bodystorming tools enabled us to ask different kinds of questions. Should utterances map onto visualization scale, or spawn rate, or something else altogether? Will I notice that my utterance-visualization color is mapped to the color of my avatar? In later sessions, we even started to question the sphere as our visualization unit, and after experimenting with alternative shapes eventually shifted to the elongating cylinders as shown earlier in Figure 3.

In other prototyping sessions, we embraced the alien physics of XR by preparing XR bodystorming sandbox environments with a range of movable/scalable assets with zero physics (objects could be repositioned and released without inertia or gravity). Figure 8 shows a prepared environment for exploring eyelines and blocking of avatars and an intervening NPC agent during a VR meeting. VR users positioned small-scale avatar proxies around a meeting table. Among our team, we described this technique as **dollhousing**—the process of arranging and manipulating prepared assets at different scales in order to explore and externalize design choices related to, for instance: environmental layout or social proxemics. While doll-play has been used as a design method within physical space [4, 13], our experience deviated from existing techniques due to our ability to manipulate the scale of virtual assets, position assets anywhere in space (i.e. without gravity), and even fluidly take on the perspective of a virtual doll (by scaling it up and positioning our own bodies from its vantage point).

Manipulating assets at various scales can also be particularly valuable as a way of doing environmental design. Figure 9 shows two team members in a custom Mozilla Hubs environment with a collection of small-scale assets prepared for an in-headset environmental design session.

3.2 Preparing the Environment for Embodied Design in VR/XR

Due to the wide range of possible affordances in VR/XR, some of the most important early design decisions involve making choices about the specific application, environment, and resources to be utilized for in-world ideation. This adds a layer of abstraction to the early design process insofar as designers need to consider the specific application, virtual environment, affordances, assets, and other resources to support effective exploration. In the physical world, designers rarely start by redesigning the whiteboard or the sticky note prior to beginning the design process. And while existing methods of experiential prototyping might involve gathering props or crafting environments as design resources, abstract concepts like physics and basic affordances of material objects don't need to be considered in the same way they do in VR. Instead, with VR, we found ourselves recursively designing VR sandbox environments for the collaborative design process itself—an approach we've come to refer to as **meta-design** in VR. (Meta-design, here,

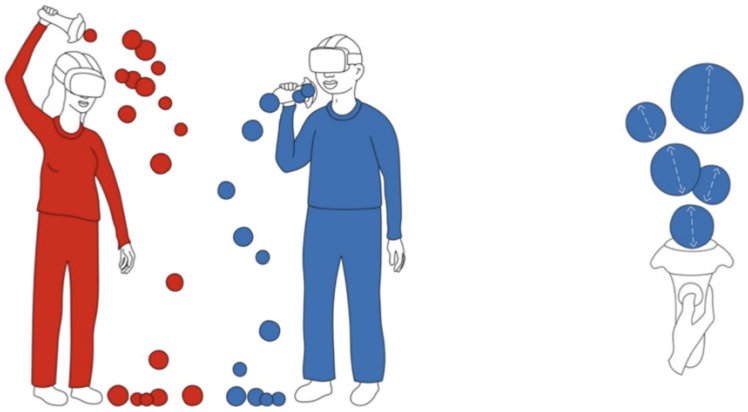

Figure 8: [24] Left: illustration of designers using a VR "sandbox" to try out different spawn-positions and spawn-rates for the speech balls. Right: illustration of the controller mechanic for adjusting scale. Designed and developed by Sean Fernandes for his MS thesis at UCSC [9]. For a more detailed description of design process, see [24].

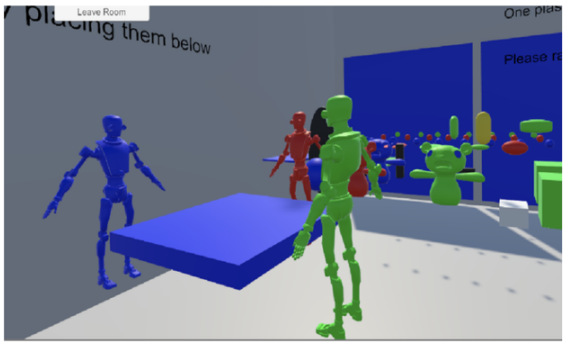

Figure 9: Arrangement of virtual assets and avatar proxies at small scale. See [9, 24] for a more detailed description of design process. Research team: Sean Fernandes, Joshua McVeigh-Schultz, Elena Márquez Segura, Katherine Isbister.

denotes designing an interactive system which will later be used to support embodied design processes.) This preparatory design step includes decisions, for example, about what out-of-the box tools, virtual assets, novel interactive features, or semi-authorable environments best support the kind of embodied exploration needed for a particular design goal.

3.2.1 The alien physics of XR can open new avenues for experiential prototyping. The alien physics of XR enables "cheap" prototyping of experiences that would be extremely costly to construct in the physical world. In VR/XR the cost of gathering virtual props, constructing environments, and mocking up interactive simulations in a shared world is strikingly low. Here, bringing in 3D models found via online repositories of free models serves as the "dollar store" equivalent of finding props to use as resources for experiential prototyping. Meta-design preparation can often involve this kind of virtual resource gathering and environmental positioning as preparation for bodystorming and dollhousing in VR. Later, during in-headset bodystorming, these virtual assets can be repositioned, scaled, and manipulated on the fly. We have come to refer to the arrangement and repurposing of 3D assets for embodied design as **virtual bricolage**. The difference in materiality of VR/XR changes the calculus of what props are readily available or adaptable, and their behaviors are malleable in new ways.

3.3 Hybridity can be embraced in the design process

The unique affordances of hybrid forms of embodiment, that exists simultaneously in both physical and virtual layers, can serve as a resource for play and experiential prototyping. Here we offer a couple brief examples.

3.3.1 Hybrid embodiment as a resource for play. The design of Astaire combined traditional bodystorming tactics of using physical props, with explorations of digital prototyping and hybridized control schemes (Figure 10). This blend of methods helped designers stay attuned to the lived experience of those 'in the room' who were spectating, as well, and encouraged designers to explore an asymmetric form of control that allowed for a new kind of co-embodiedness of players. This allowed the designers to free themselves from the design parameters and imaginary of pure social VR play, toward finding flexible co-presence that bridges these realms, which we see as a promising harbinger of future XR design.

3.3.2 XR sketching and Wizard of Ozzing with hybrid objects. Hybridity can also be used as a resource for "Wizard of Oz" style experiential prototyping and sketching. In a project partnering with, Steelcase, researchers from Scott Fisher's lab at USC created an ideation tool for sketching with furniture in VR. Researchers worked with co-design participants who sketched their ideal speculative XR work environment in VR (Figure 11). (See also [23].) Participants in headset could draw in VR and attach different parts of their virtual sketch to hybrid objects (including a table and various primitive shapes) which existed simultaneously in both physical and virtual layers. Objects in the physical world were tracked in virtual space with VIVE Trackers, meaning that all virtual sketches

Figure 10: Two avatars in a custom Mozilla Hubs environment interact with a collection of assets prepared for an in-headset environment design session. Designers Timothy Lang and Joshua McVeigh-Schultz (PI), through a larger dissertation project led by Anya Osborne with Katherine Isbister (PI).

Figure 11: Prototyping the Astaire experience using a combination of headset and physical props and constraints. Research team includes: Zhuoming (Jimmy) Zhou (lead), Elena Márquez Segura, Jared Duval, Michael John, and Katherine Isbister, with assistance from Samvid Jhaveri.

could be positionally anchored to movable objects in the physical world. Designers both in- and out-of-headset could take on the "Wizard of Oz" role by manipulating the hybrid objects (in both physical and virtual layers simultaneously) to simulate a movement-based interaction.

3.3.3 Hybrid bodying storming and Wizard of Ozzing with physical objects and video passthrough. Another example worth bringing forward is hybrid bodystorming using physical objects and passthrough video from a VR headset to co-envision a possible future XR experience for surgeons-in-training to learn and practice suturing [21]. Alongside a VR headset with video passthrough capabilities, the "bodystorming basket" [22] included physical props. Some were relevant to surgery, such as a suture kit simulating the skin and fat that surgeons in training use to learn; and others relevant to the possible future application, such as visual markers (Figure 13, left), and a pair of articulated wooden hands, to simulate ghost hands providing guidance and feedback to surgeon-in-training. During the hybrid bodystorming, the surgeon would act as a surgeon-in-training, walking designers through typical mistakes, and designers would use the physical props to experience how to best signal those errors and help the surgeon-in-training correct them during key phases of sututing. This hybrid bodystorming helped designers to envision possible meaningful future design concepts from a pedagogical, design and technical perspectives, and demonstrated how combinations of physical and virtual assets can support embodied co-design processes.

4 Recommendations/provocations

Having presented the design of prototypes of 'weird social' interactions across multiple research projects and accompanying designerly tactics, we make the following three recommendations/provocations toward meeting the moment of supporting the evolution of XR somaesthetic design practices:

1. *Embrace the alien physics and materiality of this medium.* The medium of XR can be, by its nature, strange and unfamiliar. To properly design for a new hybrid felt experience that bridges lived experience across the virtual and the 'real', it's crucial to do everything possible to make the design process more proprioceptively intuitive. We have described the importance of physical properties (like gravity and scale) being adjustable so that objects (and even sketches) can be repositioned and manipulated in support of in-headset bodystorming.
2. *Increase emphasis on meta-design by creating and preparing embodied sandboxes.*

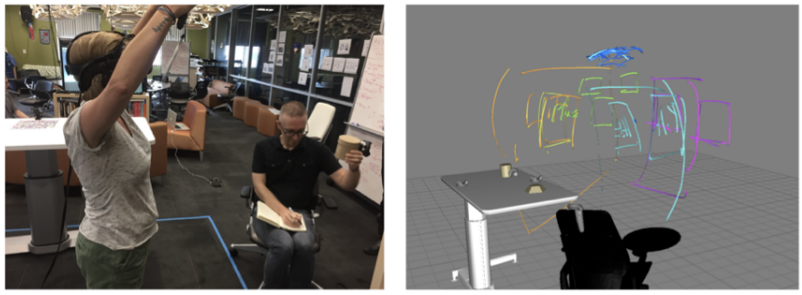

Figure 12: A co-design participant sketches a speculative XR work environment in VR. Different parts of the sketch are positionally anchored to hybrid objects that exist in both physical and virtual layers. A designer holds up one of the hybrid objects to simulate movement of a particular part of the virtual sketch. Research team includes: Joshua McVeigh-Schultz, Max Kreminski, Kesav Prasad, Perry Hoberman, Scott Fisher.

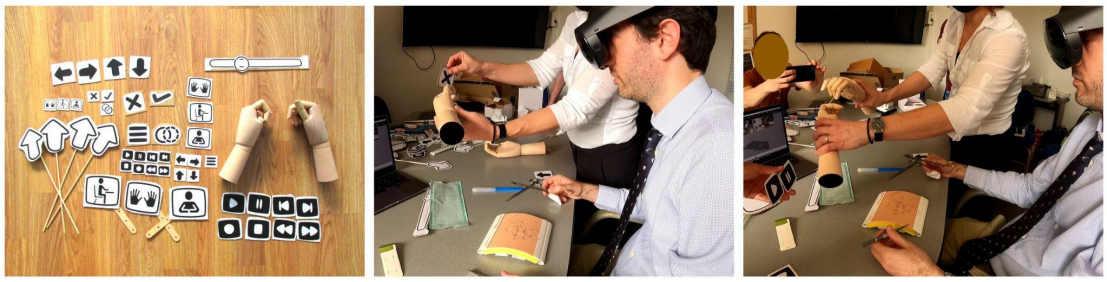

Figure 13: An experienced surgeon and designers co-sketch a future XR experience to learn and train suturing for surgeons in training (middle and right). On the left, key elements in our bodystorming basket. Research team: Elena Márquez Segura, José Manuel Vega Cebrián, Andrés Maldonado Morillo, Lara Cristóbal Velasco, and Andrea Bellucci.

Bodystorming hybrid felt experience benefits from reflecting upon and innovating within the design toolbox. In this piece we have identified a new importance of making meta-design decisions about how to best prepare an XR environment and knowing where to build in modularity for embodied prototyping. Ad hoc reconfigurable lo-fi prototypes are "cheap" to create in VR. The level of resistance for departing from typical reality is lower, leading to a dramatic reduction in the friction of "sketching" or "trying out" new simulated forms of embodied interaction on the fly through in-headset bodystorming. Sandboxes may well require thoughtfully prepared custom physical props (such as those in the surgical example) that are tailor made to support the hybridized embodied experience.

3. *Hybridize felt presence when prototyping.*
Embodied experience in XR, we believe, will mean new constellations, configurations, and continua of 'in room' and 'in digital'. Prototyping new felt experiences means finding ways to move embodied design processes across and between these spaces in novel ways, pushing against the boundaries of current technological configurations. The Astaire project is a good example of deconstructing the use of headset/controllers and mixing in auxiliary displays to arrive at a new social bodily configuration. The XR surgery support project showed how more traditional forms of physical bodystorming can be integrated fluidly with video passthrough. And the speculative work environment project included creative use of in-room object tracking to then 'Wizard of Oz' in-headset interactions. We believe a design team's investment in hybrid bodily brainstorming and prototyping techniques will increase the quality of their felt insights into how best to support people with XR.

5 Conclusion

This paper has built upon foundational work by Dourish and Höök, who both have emphasized the profound importance of an embodied approach to the design of interactive experiences that are taken up by people in their everyday lives in contexts beyond the classical desktop computer. We have added a layer of considerations here concerning embodied ways of knowing focused on XR, and in particular, what it might mean to design for support of being socially co-present within a deeply hybrid shared embodied experience.

We presented a series of prototyped interactions that showcase some approaches to 'weird social' XR, and alongside them, embodied design strategies we have evolved that have supported us in exploring possibility spaces that encourage and enhance connection and co-presence. The piece culminated in a set of recommendations/provocations.

We began with a discussion of the 'weird social' hybridities that have emerged in the present-day as we interweave videoconferencing and texting from mobile phones into our social lives, blurring our shared sense of place and co-presence. We hope the present piece, and the techniques outlined in it, can provide food for thought and for discussion at the Symposium, about how to consciously and gracefully shape future forms of hybrid co-presence that nurture and support our connections and collaborations with one another. For an imagining of such a future see also [20]. Rather than experiencing a stuttering and unpredictable, alienating lack of presence from one another that thwarts a feeling of togetherness, what if we are instead able to have a shared, subtle, and engaged sense of hybrid felt presence as we move between layers? What if we could develop an instinct for which sort of platform or modality to choose for interaction that makes us collectively sense and feel well together? We aspire to this, and look forward to further conversation with others at the Symposium about this hopeful vision.

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