Mobile Realities: Designing for the Medium of Smartphone-VR

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ABSTRACT
We present two proof of concept experiences for a virtual reality (VR) game that draws on several medium-specific qualities of mobile, location-based, and tangible storytelling. In contemporary smartphone-VR, experiences are limited by short playtimes, limited interactions, and limited movement within a physical space. To address these limitations, we suggest a reconceptualization of smartphone-VR. Rather than design that deems the smartphone the least capable VR platform, we propose design that adds VR to an already rich mobile storytelling platform. We argue that by drawing on otherwise separate storytelling media, designers can circumvent limitations related to smartphone-VR while also extending the range of smartphone-based storytelling. We conclude by reflecting on possible implications of this extended design space.

Author Keywords
Mobile virtual reality; storytelling; location-based; tangible; embodied; diegetic; interactive narratives; VR; AR; games.

ACM Classification Keywords
Human-centered computing~Virtual reality • Human-centered computing~Interaction design theory, concepts and paradigms • Software and its engineering~Interactive games.

INTRODUCTION
Contemporary virtual reality (VR) offers a range of experiences that are shaped, in part, by the technologies they employ. Smartphone-enabled VR headsets, as compared to higher-end, PC-enabled VR, offer limited tracking capabilities, limited movement and limited interaction. The specificity of the design challenges for smartphone-enabled headsets like Samsung Gear VR, Google Cardboard and Daydream, warrant design that considers the specificity of this medium, which we call smartphone-VR. These challenges necessarily include many of the broader limitations of VR. For example, commercial VR experiences are also primarily indoors, single-player, and depending on the headset, designed for seated interaction (cf. research that offers an early glimpse at outdoor VR [15, 30] and multiplayer VR [10, 41]). Another limitation of VR is the duration of experiences. The health and safety warnings for Oculus suggest that many of the adverse effects of VR can be avoided with frequent breaks, and by closely monitoring one's own sense of discomfort [46]. The current content design strategy for smartphone-VR appears to be relatively short and easily shareable experiences [16, 27]; the most popular of these experiences, ironically, is roller coaster simulations, which are also said to cause discomfort [61].

We argue that despite these limitations, there is an opportunity to reimagine the scope of smartphone-enabled VR storytelling, offering the means to overcome some of the more general limitations of the platform while clarifying its affordances (cf. the "transmedial" motivation in [4]). Our effort here is not to propose new technologies to address particular constraints, but rather to engage what is readily available through a reconceptualization of the medium of smartphone-VR. Rather than design that considers the smartphone to be the least capable of VR platforms, we propose a design rationale that adds VR to an already rich mobile platform. We suggest that the medium we must consider is not (only) VR–-the medium, at the very least, is the smartphone, which now includes the possibility of VR as well as other tangible and embodied experiences. To define smartphone-VR is to differentiate it from other VR platforms. It is more portable than a PC-enabled headset, affording the possibility to use it outdoors, and unlike a self-contained mobile headset like the Oculus Go, it is powered by a smartphone, affording the possibility to

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integrate the various media of a smartphone into a VR experience.

Using a research through design approach [23, 70, 71], we present two proof of concept prototypes that aim to demonstrate these possibilities within narrative experiences that draw on many of the affordances of today's smartphones, including a camera, text messages, GPS, a website, audio narratives, and augmented reality (AR). We also include a tangible object as well as a focus on some of the site-specific characteristics of real-world locations, arguing that there is an opportunity to engage with research that focuses on tangible and embodied interaction as well as a history of gaming in real-world environments (e.g., [38, 56]).

Figure 1. Opportunities for smartphone-VR, including a tangible object, an audio narrative, and text messages.

Our work proposes ways in which smartphone VR can extend beyond brief, seated, indoor experiences, offering a design opportunity to examine interactions made possible by crossing a variety of media within real and virtual environments (Figure 1). Throughout, our proofs of concept are driven by two design questions:

DQ1. Using the example of smartphone-VR, how might we employ the strengths of one medium to compensate for the limitations of another?

DQ2. What are some of the implications and/or challenges of the design space of smartphone-VR?

Reflecting on these questions throughout our design process and preliminary user test, we also contribute a discussion of some of our concerns and recommendations for the design of smartphone-VR.

RELATED WORKS

In order to reconceptualize smartphone-VR, this review of related works highlights several interconnected strategies for digital storytelling, many of which use or could be complemented by the technologies within smartphones. These traditions come with many names (transmedia, augmented reality, alternate reality, cross-platform, pervasive, hybrid, mixed, location-based, etc.), but these names do not necessarily indicate or set the bounds of what stories might exist within their scope. As technologies play a significant part in defining the medium, and thus the choices made by designers, by storytellers, and by players, this review loosely categorizes examples by the extent of their use of media.

Although a wider, more systematic review is beyond the scope of this paper, a useful framework might categorize a spectrum of media and media relationships. We follow the rough outline of such a spectrum, from stories that rely on several platforms at once, often using a combination of the physical and the technological, to stories that combine physical and spatial realities, to stories that rely only on physical places. Overall, what is relevant to our own work is the sheer range of online and offline storytelling histories. We argue that smartphone-VR does not need to draw on the history of VR alone. These areas of interest signal broader possibilities for smartphone-VR, and a contribution of our work is in drawing insights from a variety of fields, expanding the state of the art by applying lessons from a history of digital and non-digital storytelling.

Across a mediated landscape

Popularized by researchers such as Henry Jenkins [35, 36], "transmedia" storytelling was touted as the "future of storytelling" [34]. Drawing on contemporary examples, Jenkins argues that stories can offer new experiences by building on a single storyworld that crosses a variety of media ([45] is a recent VR example of this). In contrast, Fast and Örnebring [18] argue that such story constructions can be messy and complex in attempting to respond to changing audiences, technologies, and corporate interests. For Janet Murray [43] predictions of the future of transmedia miss the mark when they ignore an underlying trend towards the digital, with digital-specific affordances shaping how stories are told. Rather than (or in addition to) a brand that crosses media, Murray argues that the defining feature is the pervasive presence of digital forms and formats.

Yet even when they are primarily digital, games and experiences delivered across media can also exist offline by including encounters and interactions with people, places, and objects. The related traditions of alternate reality games show the possibility of including phone calls, websites, text messages, as well as interactions with actors or other players in physical locations. Such offline experiences expand the scope and the affordances of the larger storyworld. For O'Hara, Grian & Williams [47], these games can offer a spectrum of player roles and participation, from those who collaborate and participate at every level, to those who spectate from afar or online. Such stories and the players' levels of narrative agency can be categorized along a spectrum of closed- to open-ended (designer-driven to player-driven), while still emphasizing a particular storyline [6, 25].

The physical and the technological

There have been many recent efforts to expand VR beyond the limitations of its headset and controllers. These efforts include the tactile feedback of a shape display [19], tangible objects, both at-hand [9, 29] and presented by a robot arm [2], and the expanded interactions of modified controllers [12, 68]. Further attempts within the field of tangible and embodied interaction include varying degrees of sensory and/or real-world environments [30, 51, 60], as well as the possibility of the embodied, kinesthetic action of wakeboarding [33], swinging [64], or using gym equipment [50]. In the majority of these cases, VR appears to be the dominant medium. In other words, VR is the medium in which the experience takes place, with other media or interactions catering to, or attempting to supplement, its constraints. The real world and real objects are not part of the experience unless the player is wearing a VR headset. One indication of this is the lack of research examining what happens immediately before or immediately after the experience [39]: there is no designed experience beyond VR. This suggests that there is an opportunity to include other media and real-world experiences before and after VR. Our proofs of concept examine this possibility.

The spatial and the technological

Designing VR for outdoor locations is in its early stages. Members of the Madeira Interactive Technologies Institute designed two separate experiences that involve VR and outdoor locations; these two appear to be among the very few that exist. In Dreamscope [44], VR is used as part of a physical art installation, while AR is used outdoors with location-based tags. Fragments of Laura [15] is closer to our own conceptualization, as the authors propose to investigate how the portability of VR might change the medium. Players wear a VR headset outdoors, again with location-based tags. Our own proofs of concept draw on and expand this work, which the authors call “the tip of the iceberg” for mobile VR [15]. Whereas the authors study the difference between a mobile phone and VR headset in the same location-based experience, reflecting on DQ1, we examine how both might be used: how might one medium compensate for what is lacking in another?

AR contrasts VR in its history of design catered to physical locations, both indoors and outdoors, and in its tradition of design for cultural history [5] and fictional narratives [59]. Outdoors, AR is said to offer ways to subvert power by telling alternate or lost narratives of particular sites [40]. For example, Engel [17] argues that such locative media applications (which can include location-based audio, text, and photos) are an opportunity to engage with queer sites and narratives that might otherwise be invisible or erased. Reflecting DQ1, one medium can be emphasized above others, or in conjunction with others, like the “location-aware” sound design of the AR game Viking Ghost Hunt [49]. Similarly, the “walks” designed by Janet Cardiff and George Miller [8] use the physical space as both physical and virtual setting, with events taking place as audio narratives and/or on smartphone screens while the player is in the represented location.

The absence of the technological

In their emphasis on the technological affordances of particular stories, what is lacking in some of the above cases is a consideration for the quality and extent of player’s role(s) within particular environments. Thus, another storytelling tradition that smartphone-VR can draw upon is the history of live action role-playing games (LARPs), in which players take on characters within real-world environments to varying degrees of fidelity. As with the other categories of storytelling traditions in this section, a detailed discussion of LARPs is beyond the scope of this paper (see e.g., [56]), but LARPs are said to offer examples of ways to engage with the personal and/or national politics of discourse, the economy, labor, and gender identities within communities across several countries [38].

While these offline games do share similarities to online role-playing games [66], a key difference is players’ embodied and social actions within their physical spaces. Even when LARPs use technology, these technologies must fit into the larger storyworld that the LARPs create [58]. The concept of combining VR and LARP experiences across a physical-virtual continuum has been proposed by Junior et al. [37], which the authors suggest could rely on context-aware objects, surfaces, and spaces. Yet, offline LARPs exemplify a rich variety of non-tracked, open-ended, physical and social interactions that do not require any technological mediation. Extending DQ1, designers could ask how the strengths of the offline world could compensate for the limitations of the technologically-mediated world.

DESIGN RATIONALE

In order to address our two design questions, DQ1 and DQ2, we propose a research through design (RtD) approach that offers “design artifacts as outcomes” [70], which “embody the myriad choices made by their designers” [23]. Following Gaver [23], we suggest that the value in this approach is in its “generative” qualities, contributing conceptual artifacts through which we can examine the design challenges and implications of smartphone-VR. In Gaver’s terms, we seek to “give dimensionality to [a] design space,” by creating proofs of concept as an exploration of “what might be” in the medium of smartphone-VR.

We engage this design space by proposing that smartphone-enabled VR has the potential to be much more than VR alone. VR is a decades-old medium [62] but lacks the history of storytelling of the other media described here. Moreover, VR has several limitations imposed by its hardware and its software, as shown by the health and safety warnings for current headsets [46]. While technological research and development may one day ensure a comfortable VR experience, it is troubling that this medium has gone to market with so many known risks, and so few mitigation strategies [53]. Our effort here is not to propose new technologies to solve such problems, but rather to re-engage what is already available by reconceptualizing the medium of smartphone-VR.

Rather than design that considers the smartphone the least capable of VR platforms, we propose a design rationale that adds VR to an already rich storytelling platform. We argue that storytelling with VR does not need to be bound to the constraints of VR. According to the health and safety warnings from Oculus, players should limit their first experiences to a few minutes, and after becoming more accustomed to the headsets, should still take 10-15 minute breaks every 30 minutes, "even if you think you don't need it" [46]. If current VR must be limited in duration, we propose to continue the story with other media, transitioning between media while drawing on the strengths of a variety of digital and non-digital storytelling. Similarly, if smartphone-VR is constrained by seated, indoor experiences, we propose stories that transition to other media to highlight the storytelling possibilities of mobile interactions and outdoor spaces.

Drawing on the related works, the storytelling traditions in both digital and non-digital settings offer many opportunities to conceptualize an expanded design space for smartphone-VR in both indoor and outdoor settings. Storytelling with smartphones already includes examples of text messages [24, 28], GPS [1, 49], a website [28, 47], audio narratives, [8, 49], AR [49, 65] and real-world locations [15, 28], but there is nothing to suggest that these storytelling possibilities need to be separate. Further, experiences can include other available sensors (see e.g., [48]) and storytelling outside the virtual environment could also include tangible objects [29], or other players or characters [3, 11, 22].

With our proofs of concept, we suggest that a medium-specific story within this design space might attempt to draw these characteristics together to tell a story that could only be told with this medium (or more specifically, this combination of media). To draw together these otherwise disparate platforms, we draw on the notion of diegetic design [30], whereby such aspects as the technology and the physical locations become integral to the story. The diegetic smartphone, then, is not just a medium through which the story is told, but is also part of the story, directly linking the player to the fictional environment.

Reconceptualizing and expanding the design space of smartphone-VR is well suited to an RtD approach because a consideration for a variety of media and locations adds complexity just as it adds a range of design possibilities. The combination of possible media choices (including medium-specific problems like cybersickness), with the unknowns of open-ended interactions, and the differences in physical bodies and physical spaces, suggests that work in this design space must actively question and examine its parameters. Any holistic attempt to reconcile these interdependent contingencies is an impossibility if each of these variables can change from one experience to another. The proofs of concept, therefore, do not intend to offer a complete solution. Instead, the proofs of concept offer a lens through which to ask questions about the design space. This, in turn, "provides an opportunity for the research community to engage in discourse on what the preferred state might be as an intentional outcome of the research, allowing us to consider the ethics of what we design" [71].

INTERACTION SCENARIOS

We developed two proof of concept scenarios to better assess our design questions and to demonstrate some of the extended possibilities of smartphone-enabled VR. Following our RtD approach, our proofs of concept are sketches of narrative experiences, just as our virtual environments, user interfaces, and tangible object are prototyped examples. These aspects combine to form conceptual artifacts used to explore the design space.

Both experiences follow a similar plot: the player is drawn into a mystery in which they must solve their own impending "vanishing." The player is guided by an external character who directs the player to clues, taking the player to real world locations using a variety of smartphone-enabled media. The second scenario iterates on the first, in part to show how different locations can contribute unique storytelling possibilities to the experience, but also because our first location raised concerns related to DQ2 (i.e., what are the implications and challenges of this extended design space?) that prompted us to re-examine what we include and exclude from our design (see Discussion).

Figure 2. The greenhouse. VR shows the location of the tangible object, which in turn provides more clues.

The Greenhouse

The player begins the experience with a smartphone prompt to enter their name and to take a selfie. The player is welcomed into the game with a message that says the game is designed specifically for the player. The first text that the player receives (this could be days later, but in our prototype happens within a few moments) is from a mysterious non-player character (NPC), who sends a link to a webpage. The webpage shows a news article displaying the player's selfie and their name, with text describing a mysterious event in which the player vanishes in front of disbelieving witnesses. The player receives another text telling the player to look again at the news article, and that the date it shows is from the future. It should not be trusted, the player is told; the events of that day can still be changed. The player receives another message with a link to a Google Maps location, with further messages telling the player that there is an object they need to find that will help them prevent this future.

Following the map, the player arrives at a nearby public greenhouse. The player's GPS location prompts another message, telling the player that they will need to use VR to find this object. VR shows the player two views of their real-world location: a 1st-person perspective and a bird's-eye view. In the bird's eye view, the player sees a red beacon where the object can be found, hidden, in the public garden (Figure 2). Retrieving the object, the player finds that it is a digital device with a small flashing LED and sounds that can be played with the press of a button. The back of the object shows an etched map with a marked X and a QR code. To the player who has seen the greenhouse from above in VR, the map shows an overhead view of the greenhouse and the location of another clue. The player scans the QR code, receiving a link to an audio message, finally hearing the voice of the mysterious NPC.

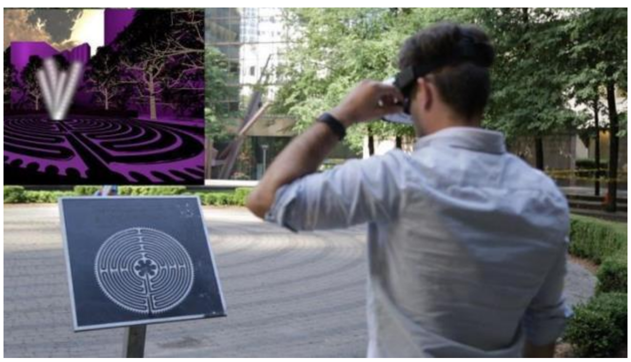

Figure 3. The labyrinth. The VR environment shows the hidden reality of the storyworld.

The Labyrinth

Our second proof of concept uses many of the same characteristics as the first, including the selfie, GPS, the website, and the text messages from the NPC warning the player. In this iteration, the real-world location is a nearby public park that features a labyrinth—a circular walkway that invites parkgoers to follow a maze to its center (Figure 3). As with the greenhouse, a virtual representation of the labyrinth is featured in this version of the story. In lieu of the tangible object we focused our efforts on an audio narrative and AR (see Discussion). Once the player is near the park, they receive a link from the NPC that opens an AR arrow, which is designed as if it always points to mysterious "portals." The NPC communicates with the player via audio clip, telling the player that it is portals causing the vanishings and that he, too, has vanished. The NPC will help, but he can only communicate with a disembodied voice from the virtual world. It is not too late for the player, but these portals must be closed.

With audio, text messages, and the AR arrow, the NPC directs the player to the front of the labyrinth and instructs the player to put on the headset. As with the greenhouse, the player sees an alternate version of their real-world location, now showing the labyrinth as the portal that caused the NPC's sudden vanishing. Within VR, the voice of the NPC again speaks to the player about the danger of the portals. When the player switches to the bird's-eye view, an overhead view of the city shows many portals that must be closed, extending the scope of the player's goal.

IMPLEMENTATION

Our proofs of concept offer examples of ways to expand smartphone-VR to include the storytelling possibilities of smartphones, as well as a tangible object, and real-world locations. Several hardware and software components needed to come together to enable the two interaction scenarios above. In an effort to address DQ1, our design choices reflect an attempt to draw on the multiple affordances of smartphones, with one medium (e.g., SMS) linking another (e.g., a website), before drawing players back to real-world locations (with e.g., an AR arrow). Together, these design choices demonstrate ways that a variety of media can work together, adhering to the limitation of a short playtime in VR while also extending the story beyond VR.

The hardware consisted of a Samsung Note 5, a Gear VR headset, and Bluetooth headphones. We used a Node.js web server to manage the narratives. The server stored player data, kept track of their narrative progress, and triggered narrative actions such as sending automated SMS messages to the player based on predetermined conditions. For example, we used the device's location to trigger SMS messages to the phone; in one case, a portion of the audio narrative designed specifically for a location was sent to the player within a 50-meter radius of that location. We used the Twilio service to send automated SMS messages. An android application allowed the players to upload their data (their name and a selfie) and share the device's GPS location data with the web server. The player's data was used to dynamically modify a fictional news site hosted on the web server to show a date in the future and an article featuring several instances of the player's name. This site was shared via SMS messages. Google Maps were incorporated into the narrative using links sent via SMS.

We created the VR environment in Unity by modifying a 3D model of real-world locations obtained by accessing local geographic information systems (GIS) data. Textures, particle effects, and audio cues were used to create a VR world that represented an alternate version of the real-world location. In the first narrative, for example, a glow was visible in the VR world that correlated with the location of a tangible interactive object in the real world; in both prototypes, the VR world showed an alternate reality blending the fictional worlds and the real world. Drawing on the affordances of VR, the overhead view in both experiences added storyworld information that was impossible to see from the player's real-world vantage point. In the first, the player could see not only the location of the tangible object, but also the overall layout of the greenhouse that they would be asked to navigate; in the second, the overhead view extended the scope of the narrative, with virtual portals across the city.

The tangible object was repurposed from an educational context in which students were tasked with building and programming an Arduino-based object with an LED, a button, and a speaker. For our design, we sought to highlight both the physical and the digital qualities of this tangible object as if it were an object from the storyworld (e.g., [63]). We planned clues based on the digital affordances of the device, with the beeps and the flashing light indicating a code that the player would later be required to input. We added a QR-code to link the player across media to an audio clip. To extend its non-digital characteristics, we used a laser-cutter to etch an overhead view of the greenhouse with an X marked on one of the rooms, linking the knowledge the player would gain in one medium (VR) with the medium of the tangible object.

Our second interaction scenario included many of the elements of the first. We did not include the tangible object, but we added AR, changed the location, and expanded the audio narrative. We created an AR mobile app using Unity. The app used the smartphone's compass and GPS data to overlay an arrow in the camera feed that guided players to a key location in the narrative. Using GPS data, once the player reached a desired location, the app showed buttons to trigger audio narratives on the phone and in VR. To create the audio narratives, we recorded voice narration with binaural microphones in settings that would match the ambience of the narrative location. We processed the audio to increase the "in-your-head" effect that binaural audio provides, and added artificial effects designed to heighten the sense of foreboding in the narrative.

EVALUATION

We conducted a formal user study focusing on the second proof of concept with three male-identified (M) and four female-identified (F) participants (P), ages 19-33. Given the scope of our RtD approach, the goal of this study was not in pursuit of standardization or to attempt to definitively evaluate or compare the many variables of our design. Within this context, as Gaver [23] argues, "tests which are simultaneously unambiguous and ecologically valid are inconceivable." As such, we do not make any claims of generalizability; instead, our findings (like our proofs of concept more generally) are intended to advance discussion on the design space of mobile storytelling interactions that now includes VR, attempting to assess directions for future work.

As the two proofs of concept were similar in scope, we focused on the second because it was a more contained experience while still offering conditions that evoke questions about the design space. It also offered a greater degree of safety: participants did not have to walk as far, and if participants felt unsafe being outdoors, we had nearby access to security staff. This meant that we did not test with the tangible object from our first proof of concept, but our focus in DQ1 and DQ2 was on the variety of possible media including an outdoor experience, rather than the inclusion or exclusion of a particular medium.

After a debrief on the technologies and the possible adverse effects of VR, participants signed consent forms and began the experience. Participants were asked to think of the phone, headset, and headphones as their own, and to think of this experience as if they had purchased or signed up for an interactive narrative. Participants were aware that the experience would include VR and would require them to go outdoors. We told participants that at least two members of our team would accompany them in order to observe, answer questions, and be present in case of any concerns.

In our lab, participants entered their name, took a selfie, and then received the website and text messages from the NPC. When prompted by a text, participants followed the AR arrow outside where further messages triggered the audio narrative and the VR experience, which also included audio. Participants returned to the lab where they completed a questionnaire designed to ask about general impressions as well as specific thoughts on individual portions of the experience. Participants were compensated $10 for their time.

Due to the exploratory nature of our work, we did not use standardized questionnaires, but rather designed questions to elicit general feedback around the variety of media involved and to prompt discussion related to DQ1 and DQ2. Towards, DQ2, for example, we asked how participants felt about using smartphones outdoors generally, and how they felt about the outdoor portions of our experience specifically. Our questionnaire included both open-ended questions (e.g., "What did you like the most?", "What did you like the least?", and "How would you describe the experience overall?") and 7-point Likert-style questions ("Making progress in the game was easy," and "I enjoyed the text messaging aspect of the game," strongly disagree to strongly agree). The questionnaire was followed by a semi-structured interview. The questions in the interview were similar to those in the questionnaire, but the semi-structured format allowed us to follow themes and to ask participants to expand on particular impressions and ideas.

RESULTS

We analyzed the data using open coding, classifying participant responses according to themes [13]. Following our RtD approach, our primary interest was in responses that could help to address DQ1 and DQ2. Towards DQ1, we found preliminary evidence of the effectiveness of using a variety of media to compensate for limitations in the story, design, and technological implementation. Towards DQ2, we had asked participants about their thoughts and/or concerns on using VR and cell phones outdoors, which in all cases led to reflections on physical safety and/or social discomfort.

In this section we focus our attention on the qualitative data. Our intention with the quantitative data was to corroborate general sentiments expressed in the interviews rather than to gather comparative, generalizable data. While our Likert data showed that the majority of our participants (all but P3F) said that they enjoyed the experience, and these six out of seven participants also reported that they would like to play a full version of the game (even though half reported that they do not regularly play video games), such positive statements could be due to the novelty of the experience. Future work may hope to gather and analyze more nuanced and comparative data regarding individual aspects of such experiences (e.g., medium, media combinations, genre, story, interface, duration, etc.).

Blurring the Lines Between Media

The seven participants offered various responses with regard to the portion of the experience that they enjoyed the most, but all participants noted ways in which the game "blurs the line of reality" (P6M). For P2F, P5F and P6M, it was the text messages, which were also the first part of the experience. For P4M, it was the audio narrative. For P1F, it was the possibility to "live a story through someone else, vicariously." P3F liked the "surprise factor" of the website, while P7M liked the "suspense element" of the genre. These somewhat disparate responses might suggest that one of the benefits of a design space that includes multiple media is that there are multiple opportunities to engage players. Our reconceptualization of smartphone-VR offers a way to integrate these various media into a single experience.

Reflecting on DQ1, the strengths and limitations of a particular medium are not only technological, but also include the strengths and limitations of the media as perceived by players. P3F called the text messages "weird" and P4M and P6M both called the messages "creepy"—the intended effect; yet when P7M called the website with his name and photo "scary", it was because of an imagined privacy breach rather than the story. Similarly, P3F, deleted the messages (and thus could not progress in the story) because she would not normally read anything from an unknown number. A more holistic design perspective might view media from a variety of perspectives (e.g., technological, social, and individual) in order to relate more realistically to players' own experiences and expectations.

Also, with regard to DQ1, we noticed errors in the GPS accuracy and thus the AR arrow of up to 50 meters. Again, other media helped participants find their way. When the AR arrow failed, P4M found his way to the front of the labyrinth with cues from the audio narrative. In this case, the GPS and use of Google Maps from the first proof of concept might have been more effective, bringing the player to a general area and offering other media to bring the player to a specific location. Similarly, some of the limitations of the technology were circumvented by the storytelling and its rapid pace. P2F and P6M both tried to respond to the NPC, which we had not designed. But since the NPC continued texting with imperative statements, as well as the directive to follow the AR arrow, players did not appear to be aware that their messages would receive no direct response.

Public and Private Safety

All participants were asked about their considerations for safety when using cellphones or VR outdoors. These sentiments were often complicated: P7M first described reasons he did not like the VR experience, but then noted that he did not like using a cellphone or listening to music when outside. "You are basically cut off from the real world" (P7M). Outdoor phone habits such as these could potentially predict a participant's willingness to use VR outside. P6M noted that he and his friends decided to more conscientiously "practice safety (…). If you're on the street, no headphones. Pay attention to your surroundings. Even when you're on the subway." While P3F did not like being outdoors with VR for safety reasons, it was something she liked in our experience. "You actually got to go outside. VR I've tried in the past, we were just sitting down on a couch. It's cool that you could leave and go places" (P3F). Only one participant, P4M, did not have any particular concerns for safety, only a sense that wearing VR in public might be "weird."

Reflecting on DQ2, these issues begin to suggest the need for a more nuanced perspective on what privileges particular players maintain within particular environments. Such design considerations would need to reflect a more diverse population. For example, we struggled with the design of a game centered on characters who "disappear," as it has a problematic, implicit connection to the disproportionate disappearances of Indigenous women in North America. Our attempt to address this was to distance our story from reality with characters "vanishing" into mysterious, hidden portals. Similarly, we struggled with the design of a fictional news article amid a North American cultural context in which claims of "fake news" are prevalent. Yet while other participants enjoyed the mystery of the vanishing and seeing themselves in a fictional news article, P6M hesitated. "In El Salvador, where I'm from, violence, people going missing, is an everyday thing. It's reality, not fantasy" (P6M).

DISCUSSION & LIMITATIONS

We presented two proofs of concept driven by a pair of design questions:

DQ1. Using the example of smartphone-VR, how might we employ the strengths of one medium to compensate for the limitations of another?

DQ2. What are some of the implications and/or challenges of the design space of smartphone-VR?

After completing our design and our user tests, we suggest that these questions must be interlinked rather than separate. Each medium that we employ has a history of storytelling and research. The addition and/or the application of one medium can change players' experiences and thus designers' considerations. As such, designers can benefit from previous years of related research in areas such as games studies (see e.g., ways to engage with the problematic culture of video games [55]), ethical considerations for alternate reality games [14], or research into the challenges raised by a particular medium's affordances, as with recent AR applications [32].

Such interconnected strands of research suggest that the advent of VR into the range of storytelling possibilities with a smartphone requires a much deeper examination of how its various media combine and interact, especially within their broader social contexts. Even conscientious efforts require a consideration of the implications and challenges of expanding the scope of a medium. As suggested by our design rationale, our proofs of concept offer a lens through which we might critically examine our own design choices and contribute to discourse on "the ethics of what we design" [71] as we examine "what might be" [23] in the medium of smartphone-VR.

Based on our design process and user test, we identified three broad areas that will require further research and consideration. First, while outdoor and site-specific design offers advantages, the social and political dimensions of these spaces can prompt designers to ask, how does the design account for the lived realities of these spaces? Second, while the combination of several forms of media offer new storytelling possibilities, designers can ask, what are the ways in which particular media or particular experiences limit participation? Third, as technologies like VR become more affordable, designers can ask, what forms of data do these experiences require, and how does this data gathering stand to fit into a larger, corporate ecosystem? In this section, we reflect on these questions and lessons learned throughout our RtD process.

Figure 4. The greenhouse with a VR version of the physical environment. How does the design account for the lived realities of these spaces?

The Politics of Spaces

Technologically-mediated outdoor games are said to offer advantages to players, from encouraging exercise [21, 42, 69] to community engagement [17]. Such games are said to foster a better understanding of specific sites, and the potential to allow players to renegotiate systems of power [40]. Our decision to include outdoor spaces started from this idealized position, seeing the opportunities rather than the challenges of DQ2. The greenhouse and the labyrinth have unique qualities. For instance, beyond the importance of being a historical green space in the downtown core of the city, the greenhouse offers heat, humidity, and the smell of the flora in a public, wheelchair accessible manner. Both spaces have long histories that could be highlighted in a story that includes their geographical location. However, such idealized, apolitical abstractions for the possibilities of spaces can lack fundamental considerations of the city as a whole, and the people in it.

Mary Flanagan [20] reminds us that there are politics to the spaces in technologically-mediated location-based games. Flanagan argues that we must critically engage with the ways that such games appropriate, commodify, and abstract space into privileged play that does not account for the "lived realities" of the residents and their histories (Figure 4). Within our design, we acknowledge that we had not adequately considered how both the labyrinth and the greenhouse are located near shelters and social services for people experiencing homelessness, people who are street-involved, and people who consider themselves at-risk, including social services for indigenous peoples [54]. The parks offer a nearby reprieve for many. During our design process, when we tested portions of our prototype at the greenhouse, a verbal confrontation was a reminder of the multiple subjectivities of this space in particular, which in turn influenced our decision to focus the user test on the second proof of concept experience.

As Valente et al. [67] suggest in their conceptualization of "pervasive virtuality," there are ethical concerns and unintended or unknown consequences when we combine the real and the virtual. Flanagan's questions and concerns continue to be relevant: Who has the ability, either socially and/or physically, to navigate these spaces? How does the game account for non-participants; how does it account for those who do not consent to an implicit participation in these forms of play? Such questions are all the more pressing in a country with a history of still-active colonial geographies [52]. Moreover, this does not imply that indoor sites of play will offer a better solution, as the indoor space can politicize the outdoor space by excluding it entirely.

Multiple Platforms & Players' Experience

The logistics of playing a game that uses multiple platforms and multiple locations can imply a familiarity with a variety of technologies and also a willingness to carry these objects around the city. Even the headset is a potential barrier: beyond the physical and social discomfort of wearing a headset, we noticed that P2F had difficulty putting the headset on because the straps are not particularly conducive to Afro hairstyles. Such considerations also raise questions of accessibility: what bodies and what mobilities do such interactions assume? How does the design address differences in players, environments, contexts, games, or stories? Designing for physical spaces might offer an opportunity to engage with the city in new ways, but particular spaces and particular routes are not necessarily accessible. For example, the greenhouse and the labyrinth are public and ostensibly accessible, but the accessible routes are more circuitous than the one shown by our AR arrow, which would point the player through grass and over a small hedge. Just before we began testing, city officials put caution tape on one of the sidewalks, a temporary rather than permanent hazard, but one which our participants had to navigate (Figure 5).

With reference to DQ1, some limitations are simply those of our proofs of concept rather than those of the medium of smartphone-VR. As we have argued, our design choices reflect ways to draw on particular affordances at particular times. Just as we can adhere to the limitation of short playtimes in VR by extending the story beyond VR, the limitation of an AR arrow that is not accessible could be reconfigured to highlight accessible routes, and therefore engage with the on-the-ground realities of navigating these spaces. Designers could draw inspiration from examples such as AccessNow, a map-based application that crowdsources information on the relative accessibility of locations around the world [72]. In addition to such considerations, designers could also account for such aspects as weather conditions and time of day. These aspects could be determined by linking other applications and/or using other sensors on the smartphone.

The notion of crowdsourcing is a reminder that these experiences do not have to be designed for single players. With VR, multiplayer experiences could offer asymmetrical play as a way for players outside the headset to participate [22], or even offer different tasks within the same virtual environment [10]. This strategy could also help to extend the scalability of the tangible objects. One player could bring a tracked object across the city and hide it in order for a player in another game to find it. Our choice not to include the tangible object in our second proof of concept was based partly on the worry that the object would be lost, taken, or thrown in the garbage before the player found it. However, this assumes that the objects do not originate with the player and it assumes an absence of additional actors or additional players. Again, these considerations reflect DQ1, prompting designers to assess the benefits of using particular media, or assess when to transition between media.

While DQ1 raises questions of application, DQ2 raises questions of implication. The majority of our participants noted how particular media can distract: headphones add sound while removing sound from an environment, VR adds visuals while obstructing sight, a smartphone and AR add information while detracting awareness. Designers of such games would have to reconcile the interrelated contexts of technologies, of players, and of environments. When the Oculus Health and Safety document warns that the headset must be used "only in a safe environment" [46], we suggest that it is important to develop a better understanding of what that includes and excludes. With the slew of warnings in the health and safety documents for VR headsets [57], it is reasonable to assume that many otherwise "safe" environments would only remain safe without a headset. The Oculus document also reminds its users that the headset "distracts you from and completely blocks your view of your actual surroundings." A taken-for-granted assumption within these VR games is that the player will be alone and that the experience will be designed for a single player. It also assumes players will have the same experiences in relation to public space; our participants' responses suggest that this does not reflect reality, as spaces can represent differing arrangements of power.

Figure 5. Navigating amid limited accessibility and potential risks to safety.

Privacy & Further Limitations

Recently, researchers in the HCI community have called for greater transparency and a greater consideration for the potential negative impacts of new technological development [31]. This discussion section has attempted to elucidate some aspects of our work that should continue to be improved, as well as offer ways to mitigate some of these potentialities. While the letter to the HCI community did not specifically address entertainment platforms, their concerns about social media and privacy are relevant here, and are reflected in questions that we raised with regard to DQ2. The technologies that we describe do not exist independently of the interests of the multinational corporations that market them. Facebook, with its recent controversies [e.g., 26] owns Oculus, and technology journalists have begun to note the uncertainties and privacy concerns that remain unaddressed in that relationship [7].

Work like ours would not provide these companies with more user data than they already receive, but that does not alleviate the responsibility of these companies, or of designers, to ensure player privacy. Our proofs of concept require access to several sensors in the phone, access which in other circumstances would not be necessary. One model could be to offer ways for players to complete the narrative without having to grant access to particular sensors. Another model that could be pursued is a re-conceptualization of player consent as ongoing, rather than the initial one-time click of terms-of-use policies and access permissions. Drawing on diegetic design, there is an opportunity to weave these player choices into the storytelling, to let players know how and why particular sensors will be used, or to cater experiences to particular access permissions.

We have argued that VR expands the range of the medium of the smartphone, and by extension the possibilities of VR; new technologies could further expand these possibilities. However, a deeper understanding of the medium could go beyond a consideration for its technologies by including a critical engagement of the frameworks and limitations imposed by the companies that own them.

CONCLUSION

We presented two proof of concept experiences that examined ways in which smartphone-VR can extend beyond the short, seated, and indoor experiences of contemporary VR. Like other technologically-mediated storytelling, VR is, to some extent, shaped by the technologies it employs. We argued that, to date, content for smartphone-VR has not extensively considered the history of storytelling traditions made possible by the technologies within smartphones, as well as the storytelling possibilities when including offline people, places and things.

Our proofs of concept were guided by two design questions using a research through design approach. In the first design question, we examined and demonstrated ways in which the strengths of particular media might compensate for the limitations of another. The seated, indoor experience of contemporary smartphone-VR might be extended by other smartphone-enabled experiences outdoors. Such design choices led to our second design question, in which we examined some of the challenges of our reconceptualized design space for smartphone-VR. In addition to a consideration for issues of safety, we strongly call for a more nuanced examination of how particular bodies and spaces carry particular forms of access and privilege in technologically-mediated environments.

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REFERENCES

[1] Naomi Alderman. 2012. Zombies, run! Retrieved from https://zombiesrungame.com/

[2] Bruno Araujo, Ricardo Jota, Varun Perumal, Jia Xian Yao, Karan Singh, and Daniel Wigdor. 2016. Snake Charmer: Physically Enabling Virtual Objects. In Proceedings of the TEI '16: Tenth International Conference on Tangible, Embedded, and Embodied Interaction (TEI '16). ACM, New York, NY, USA, 218-226. DOI: https://doi.org/10.1145/2839462.2839484

[3] Peter Arnold, Rohit Ashok Khot, and Florian 'floyd' Mueller. 2018. You Better Eat to Survive: Exploring Cooperative Eating in Virtual Reality Games. In Proceedings of the Twelfth International Conference on Tangible, Embedded, and Embodied Interaction (TEI '18). ACM, New York, NY, USA, 398-408. DOI: https://doi.org/10.1145/3173225.3173238

[4] Shaowen Bardzell, Vicky Wu, Jeffrey Bardzell, and Nick Quagliara. 2007. Transmedial interactions and digital games. In Proceedings of the international conference on Advances in computer entertainment technology, (ACE '07). ACM, New York, NY, USA, 307-308. DOI=http://dx.doi.org/10.1145/1255047.1255141

[5] Mafkereseb Kassahun Bekele, Roberto Pierdicca, Emanuele Frontoni, Eva Savina Malinverni, and James Gain. 2018. A Survey of Augmented, Virtual, and Mixed Reality for Cultural Heritage. Journal on Computing and Cultural Heritage (JOCCH) 11, 2: 7. https://doi.org/10.1145/3145534

[6] Elizabeth Bonsignore, Vicki Moulder, Carman Neustaedter, Derek Hansen, Kari Kraus, and Allison Druin. 2014. Design tactics for authentic interactive fiction: insights from alternate reality game designers. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, (CHI '14). ACM, New York, NY, USA, 947-950. DOI: https://doi.org/10.1145/2556288.2557245

[7] Kent Bye. 2017. Oculus' VR Privacy Policy Serves the Needs of Facebook, Not Users – Road to VR. Road to VR. Retrieved July 12, 2018 from https://www.roadtovr.com/oculus-vr-privacy-policy-serves-needs-facebook-not-users/

[8] Janet Cardiff and George Bures Miller. N.d. Janet Cardiff & George Bures Miller | Walks. Retrieved July 17, 2018 from http://www.cardiffmiller.com/artworks/walks/index.html

[9] Lung-Pan Cheng, Li Chang, Sebastian Marwecki, and Patrick Baudisch. 2018. iTurk: Turning Passive Haptics into Active Haptics by Making Users Reconfigure Props in Virtual Reality. In Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems, (CHI '18). ACM, New York, NY, USA, Paper 89, 10 pages. DOI: https://doi.org/10.1145/3173574.3173663

[10] Lung-Pan Cheng, Sebastian Marwecki, and Patrick Baudisch. 2017. Mutual Human Actuation. In Proceedings of the 30th Annual ACM Symposium on User Interface Software and Technology, (UIST '17). ACM, New York, NY, USA, 797-805. DOI: https://doi.org/10.1145/3126594.3126667

[11] Lung-Pan Cheng, Thijs Roumen, Hannes Rantzsch, Sven Köhler, Patrick Schmidt, Robert Kovacs, Johannes Jasper, Jonas Kemper, and Patrick Baudisch. 2015. TurkDeck: Physical Virtual Reality Based on People. In Proceedings of the 28th Annual ACM Symposium on User Interface Software & Technology, (UIST '15). ACM, New York, NY, USA, 417-426. DOI: https://doi.org/10.1145/2807442.2807463

[12] Inrak Choi, Eyal Ofek, Hrvoje Benko, Mike Sinclair, and Christian Holz. 2018. CLAW: A Multifunctional Handheld Haptic Controller for Grasping, Touching, and Triggering in Virtual Reality. In Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems, (CHI '18). ACM, New York, NY, USA, Paper 654, 13 pages. DOI: https://doi.org/10.1145/3173574.3174228

[13] J. Corbin and A. Strauss. 2008. Basics of qualitative research: Techniques and procedures for developing grounded theory. Retrieved from https://0ch4qb4rjd08.storage.googleapis.com/EjZJjiZZf8okxurrQB08.pdf

[14] Hugh Davies. 2017. Towards an ethics of alternate reality games. Digital Studies/Le champ numérique 0, 0. https://doi.org/10.16995/dscn.36

[15] Mara Dionisio, Paulo Bala, Valentina Nisi, and Nuno Nunes. 2017. Fragments of laura: incorporating mobile virtual reality in location aware mobile storytelling experiences. In Proceedings of the 16th International Conference on Mobile and Ubiquitous Multimedia, (MUM '17). ACM, New York, NY, USA, 165-176. DOI: https://doi.org/10.1145/3152832.3152868

[16] Brahim Elbouchikhi and Darren Delaye. 2017. What's New on Daydream (Google I/O '17). YouTube. Retrieved July 18, 2018 from https://www.youtube.com/watch?v=-RD7fkl7GpY

[17] Maureen Engel. 2017. Perverting Play: Theorizing a Queer Game Mechanic. Television & New Media 18, 4: 351–360. https://doi.org/10.1177/1527476416669234

[18] Karin Fast and Henrik Örnebring. 2017. Transmedia world-building: The Shadow (1931–present) and Transformers (1984–present). International Journal of Cultural Studies 20, 6: 636–652. https://doi.org/10.1177/1367877915605887

[19] Daniel Fitzgerald and Hiroshi Ishii. 2018. Mediate: A Spatial Tangible Interface for Mixed Reality. In Extended Abstracts of the 2018 CHI Conference on Human Factors in Computing Systems, (CHI EA '18). ACM, New York, NY, USA. DOI: https://doi.org/10.1145/3170427.3188472

[20] Mary Flanagan. 2007. Locating play and politics: Real world games & activism. Leonardo Electronic Almanac 16, 2-3: 1–13. Retrieved from https://www.leonardo.info/LEA/perthDAC/MFlanagan_LEA160203.pdf

[21] Florian "Floyd" Mueller, Richard Byrne, Josh Andres, Rakesh Patibanda. 2018. Experiencing the Body as Play. In Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems, (CHI '18). ACM, New York, NY, USA, Paper 210, 13 pages. DOI: https://doi.org/10.1145/3173574.3173784

[22] Steel Crate Games. Keep Talking and Nobody Explodes. Steel Crate Games. Retrieved July 19, 2018 from http://www.keeptalkinggame.com/

[23] William Gaver. 2012. What should we expect from research through design? In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, (CHI '12). ACM, New York, NY, USA, 937-946. DOI: https://doi.org/10.1145/2207676.2208538

[24] Tim and GCM. 2015. Sara is Missing by saraismissing. itch.io. Retrieved July 26, 2018 from https://saraismissing.itch.io/sim

[25] Sabiha Ghellal, Ann Morrison, Marc Hassenzahl, and Benjamin Schaufler. 2014. The remediation of nosferatu: exploring transmedia experiences. In Proceedings of the 2014 conference on Designing interactive systems, (DIS '14). ACM, New York, NY, USA, 617-626. DOI: https://doi.org/10.1145/2598510.2600881

[26] Emma Graham-Harrison and Carole Cadwalladr. 2018. Revealed: 50 million Facebook profiles harvested for Cambridge Analytica in major data breach. The Guardian. Retrieved August 5, 2018 from http://www.theguardian.com/news/2018/mar/17/cambridge-analytica-facebook-influence-us-election

[27] Chetan Gupta. 2017. Oculus Connect 4 | Scaling Immersive Media on Facebook. YouTube. Retrieved July 18, 2018 from https://www.youtube.com/watch?v=nk9mO2GPWVQ

[28] Frank Allan Hansen, Karen Johanne Kortbek, and Kaj Grønbæk. 2008. Mobile Urban Drama – Setting the Stage with Location Based Technologies. In Proceedings of the 1st Joint International Conference on Interactive Digital Storytelling: Interactive Storytelling (ICIDS '08), Ulrike Spierling and Nicolas Szilas (Eds.). Springer-Verlag, Berlin, Heidelberg, 20-31. DOI=http://dx.doi.org/10.1007/978-3-540-89454-4_4

[29] Daniel Harley, Aneesh P. Tarun, Daniel Germinario, and Ali Mazalek. 2017. Tangible VR: Diegetic Tangible Objects for Virtual Reality Narratives. In Proceedings of the 2017 Conference on Designing Interactive Systems, (DIS '17). ACM, New York, NY, USA, 1253-1263. DOI: https://doi.org/10.1145/3064663.3064680

[30] Daniel Harley, Alexander Verni, Mackenzie Willis, Ashley Ng, Lucas Bozzo, and Ali Mazalek. 2018. Sensory VR: Smelling, Touching, and Eating Virtual Reality. In Proceedings of the Twelfth International Conference on Tangible, Embedded, and Embodied Interaction, (TEI '18). ACM, New York, NY, USA, 386-397. DOI: https://doi.org/10.1145/3173225.3173241

[31] Brent Hecht, Lauren Wilcox, Jeffrey P. Bigham, Johannes Schöning, Ehsan Hoque, Jason Ernst, Yonatan Bisk, Luigi De Russis, Lana Yarosh, Bushra Anjum, Danish Contractor, and Cathy Wu. 2018. It's Time to Do Something: Mitigating the Negative Impacts of Computing Through a Change to the Peer Review Process - ACM FCA. ACM FCA. Retrieved July 12, 2018 from https://acm-fca.org/2018/03/29/negativeimpacts/

[32] Larissa Hjorth and Ingrid Richardson. 2017. Pokémon GO: Mobile media play, place-making, and the digital wayfarer. Mobile Media & Communication 5, 1: 3–14. https://doi.org/10.1177/2050157916680015

[33] Yu-Jun Hong, Chen-Yuan Hsieh, Keng-Ta Yang, and Liwei Chan. 2017. Wakeboarding: an exertion game in virtual reality. In ACM (SIGGRAPH '17). ACM, New York, NY, USA, Article 15, 2 pages. DOI: https://doi.org/10.1145/3089269.3089271

[34] Henry Jenkins. 2003. Transmedia Storytelling. MIT Technology Review. Retrieved July 12, 2018 from https://www.technologyreview.com/s/401760/transmedia-storytelling/

[35] Henry Jenkins. 2006. Convergence Culture: Where Old and New Media Collide. NYU Press. Retrieved from https://market.android.com/details?id=book-RlRVNikT06YC

[36] Henry Jenkins. 2010. Transmedia Storytelling and Entertainment: An annotated syllabus. Continuum 24, 6: 943–958. https://doi.org/10.1080/10304312.2010.510599

[37] Alexandre Silva Ribeiro Junior, Esteban Clua Walter Gonzales, Luis Valente, and Bruno Feijó. 2016. First steps towards Live-action Virtual Reality Games. SBC Journal on Interactive Systems 7, 1: 3–16.

[38] Kaisa Kangas, Mika Loponen, and Jukka Särkijärvi (eds.). 2016. LARP Politics: Systems, Theory, and Gender in Action. Ropecon ry.

[39] Jarrod Knibbe, Jonas Schjerlund, Mathias Petraeus, and Kasper Hornbæk. 2018. The Dream is Collapsing: The Experience of Exiting VR. In Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems, (CHI '18). ACM, New York, NY, USA, Paper 483, 13 pages. DOI: https://doi.org/10.1145/3173574.3174057

[40] Tony Liao and Lee Humphreys. 2015. Layar-ed places: Using mobile augmented reality to tactically reengage, reproduce, and reappropriate public space. New Media & Society 17, 9: 1418–1435. https://doi.org/10.1177/1461444814527734

[41] Jiabao Li, Honghao Deng, and Panagiotis Michalatos. 2017. CatEscape: An Asymmetrical Multiplatform Game Connecting Virtual, Augmented and Physical World. In Extended Abstracts Publication of the Annual Symposium on Computer-Human Interaction in Play, (CHI PLAY '17 Extended Abstracts), ACM, New York, NY, USA, 585-590. DOI: https://doi.org/10.1145/3130859.3130860

[42] Joe Marshall and Paul Tennent. 2013. Mobile interaction does not exist. In CHI '13 Extended Abstracts on Human Factors in Computing Systems, (CHI EA '13). ACM, New York, NY, USA, 2069-2078. DOI: https://doi.org/10.1145/2468356.2468725

[43] Janet H. Murray. Transcending Transmedia: Emerging Story Telling Structures for the Emerging Convergence Platforms. In Proceedings of the 10th European Conference on Interactive TV and Video (EuroITV '12). ACM, New York, NY, USA, 1-6. DOI: https://doi.org/10.1145/2325616.2325618

[44] Valentina Nisi, Mara Dionísio, Paulo Bala, Tom Gross, and Nuno J. Nunes. 2017. DreamScope: Evaluating Interactive 360° Virtual Reality in a Physical Narrative Art Installation. In Proceedings of the 8th International Conference on Digital Arts, (ARTECH2017). ACM, New York, NY, USA, 67-75. DOI: https://doi.org/10.1145/3106548.3106601

[45] Oculus. 2018. MARVEL Powers United VR | Oculus. Oculus. Retrieved July 12, 2018 from https://www.oculus.com/marvel-powers-united-vr/

[46] Oculus.n.d. Oculus Health and Safety Warnings. Retrieved July 17, 2018 from

https://www.oculus.com/legal/health-and-safety-warnings/

[47] Kenton O’Hara, Hazel Grian, and John Williams. 2008. Participation, collaboration and spectatorship in an alternate reality game. In Proceedings of the 20th Australasian Conference on Computer-Human Interaction: Designing for Habitus and Habitat, (OZCHI ‘08). ACM, New York, NY, USA, 130-139. DOI: http://dx.doi.org/10.1145/1517744.1517787

[48] Game Oven. 2014. Bounden. PlayBounden. Retrieved July 17, 2018 from http://playbounden.com/

[49] Natasa Paterson, Gavin Kearney, Katsiaryna Naliuka, Tara Carrigy, Mads Haahr, and Fionnuala Conway. 2013. Viking Ghost Hunt: creating engaging sound design for location-aware applications. International Journal of Arts and Technology 6, 1: 61. https://doi.org/10.1504/IJART.2013.050692

[50] Fazlay Rabbi, Taiwoo Park, Biyi Fang, Mi Zhang, and Youngki Lee. 2018. When Virtual Reality Meets Internet of Things in the Gym: Enabling Immersive Interactive Machine Exercises. Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies 2, 2: 78 (July 2018), 21 pages. DOI: https://doi.org/10.1145/3214281

[51] Nimesha Ranasinghe, Pravar Jain, Nguyen Thi Ngoc Tram, Koon Chuan Raymond Koh, David Tolley, Shienny Karwita, Lin Lien-Ya, Yan Liangkun, Kala Shamaiah, Chow Eason Wai Tung, Ching Chiuan Yen, and Ellen Yi-Luen Do. 2018. Season Traveller: Multisensory Narration for Enhancing the Virtual Reality Experience. In Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems, (CHI ‘18). ACM, New York, NY, USA, Paper 577, 13 pages. DOI: https://doi.org/10.1145/3173574.3174151

[52] Sherene H. Razack. 2000. Gendered Racial Violence and Spatialized Justice: The Murder Pamela George. Canadian journal of law and society = Revue canadienne de droit et societe 15, 2: 91–130. https://doi.org/10.1017/S0829320100006384

[53] Lisa Rebenitsch and Charles Owen. 2016. Review on cybersickness in applications and visual displays. Virtual reality 20, 2: 101–125. https://doi.org/10.1007/s10055-016-0285-9

[54] John Rieti. 2018. Allan Gardens revitalization could highlight park’s Indigenous roots. *CBC News*. Retrieved July 12, 2018 from https://www.cbc.ca/news/canada/toronto/allan-gardens-refresh-1.4507953.

[55] Bonnie Ruberg and Adrienne Shaw. 2017. Queer Game Studies. University of Minnesota Press. Retrieved July 17, 2018 from https://muse.jhu.edu/book/51275

[56] Eleanor Saitta, Marie Holm-Andersen, and Jon Back. 2014. The Foundation Stone of Nordic Larp. Knutpunkt. Retrieved from https://market.android.com/details?id=book-gVsbBQAAQBAJ

[57] Samsung. 2017. Gear VR: Safety and Health precautions | Samsung Support Australia. Samsung. Retrieved July 17, 2018 from https://www.samsung.com/au/support/mobile-devices/gear-vr-safety-and-health-precautions/

[58] Elena Márquez Segura, Katherine Isbister, Jon Back, and Annika Waern. 2017. Design, appropriation, and use of technology in larps. In Proceedings of the 12th International Conference on the Foundations of Digital Games, (FDG '17). ACM, New York, NY, USA, Article 53, 4 pages. DOI: https://doi.org/10.1145/3102071.3106360

[59] Roy Shilkrot, Nick Montfort, and Pattie Maes. 2014. nARratives of augmented worlds. In 2014 IEEE International Symposium on Mixed and Augmented Reality - Media, Art, Social Science, Humanities and Design (ISMAR-MASH’D), IEEE, Munich, Germany, 35–42. DOI: https://doi.org/10.1109/ISMAR-AMH.2014.6935436

[60] Adalberto L. Simeone, Eduardo Velloso, and Hans Gellersen. 2015. Substitutional Reality: Using the Physical Environment to Design Virtual Reality Experiences. In Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems, (CHI '15). ACM, New York, NY, USA, 3307-3316. DOI: https://doi.org/10.1145/2702123.2702389

[61] Rade Stojsavljevic and Brock Heinz. 2017. Oculus Connect 4 | What’s Working in Mobile Games. YouTube. Retrieved July 18, 2018 from https://www.youtube.com/watch?v=9FgmzMadbWA

[62] Ivan E. Sutherland. 1968. A head-mounted three dimensional display. In Proceedings of the December 9-11, 1968, fall joint computer conference, part I, 757–764. https://doi.org/10.1145/1476589.1476686

[63] Karen Tanenbaum, Joshua Tanenbaum, Alissa N. Antle, Jim Bizzocchi, Magy Seif el-Nasr, and Marek Hatala. 2011. Experiencing the reading glove. In Proceedings of the fifth international conference on Tangible, embedded, and embodied interaction, (TEI '11). ACM, New York, NY, USA, 137-144. DOI=http://dx.doi.org/10.1145/1935701.1935728

[64] Paul Tennent, Joe Marshall, Brendan Walker, Patrick Brundell, and Steve Benford. 2017. The Challenges of Visual-Kinaesthetic Experience. In Proceedings of the 2017 Conference on Designing Interactive Systems, (DIS '17). ACM, New York, NY, USA, 1265-1276. DOI: https://doi.org/10.1145/3064663.3064763

[65] The Pokemon Company International, Inc and Niantic, Inc. 2016. Catch Pokémon in the Real World with Pokémon GO! PokemonGo. Retrieved July 26, 2018 from https://www.pokemongo.com/

[66] Anders Tychsen, Michael Hitchens, Thea Brolund, and Manolya Kavakli. 2006. Live Action Role-Playing Games: Control, Communication, Storytelling, and MMORPG Similarities. Games and Culture 1, 3: 252–275. https://doi.org/10.1177/1555412006290445

[67] Luis Valente, Bruno Feijó, Alexandre Ribeiro, and Esteban Clua. 2018. Pervasive virtuality in digital entertainment applications and its quality requirements. Entertainment computing 26: 139–152. https://doi.org/10.1016/j.entcom.2018.02.006

[68] Eric Whitmire, Hrvoje Benko, Christian Holz, Eyal Ofek, and Mike Sinclair. 2018. Haptic Revolver: Touch, Shear, Texture, and Shape Rendering on a Reconfigurable Virtual Reality Controller. In Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems (CHI '18). ACM, New York, NY, USA, Paper 86, 12 pages. DOI: https://doi.org/10.1145/3173574.3173660

[69] Emma Witkowski. 2018. Running With Zombies: Capturing New Worlds Through Movement and Visibility Practices With Zombies, Run! Games and Culture 13, 2: 153–173. https://doi.org/10.1177/1555412015613884

[70] John Zimmerman, Jodi Forlizzi, and Shelley Evenson. 2007. Research through design as a method for interaction design research in HCI. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, (CHI '07). ACM, New York, NY, USA, 493-502. DOI: https://doi.org/10.1145/1240624.1240704

[71] John Zimmerman, Erik Stolterman, and Jodi Forlizzi. 2010. An analysis and critique of Research through Design : towards a formalization of a research approach. In Proceedings of the 8th ACM Conference on Designing Interactive Systems, (DIS '10). ACM, New York, NY, USA, 310-319. DOI=10.1145/1858171.1858228 http://doi.acm.org/10.1145/1858171.1858228

[72] Maayan Ziv. 2016. Access Now - pin-pointing accessibility worldwide. AccessNow. Retrieved July 25, 2018 from http://accessnow.me/