The Rooms
Creating immersive experiences through projected augmented reality

Jacob Michelsen[1]
[1]The Interactive Institute
Lindholmsplatsen 1
417 56, Göteborg, SE
+46 (0) 702-889759
{staffanb|jacobmi}@tii.se

Staffan Björk[1,2]
[2]Gothenburg University
Dept. of Applied IT
412 96 Gothenburg, SE
+46 (0) 31-77210393
staffan.bjork@ait.gu.se

ABSTRACT
In this paper, we describe *The Rooms* – a horror game that uses projected augmented reality to enable a new type of immersive gaming experience. Interviews and questionnaires from 20 players of the game showed that projected augmented reality games can support immersion and can avoid the problem of nausea that VR experiences can invoke. However, since players experienced different types of immersion the study suggests that a model that allows different and parallel types of immersion may provide more informative results when used in play tests. *The Rooms* also suggested that a new type of immersion, *spatial immersion*, might be a relevant addition to such models.

1. INTRODUCTION
Novel computer technologies often open up for new forms of gaming experiences. This can perhaps most easily be seen in how personal computers and game consoles made possible the ubiquity of video games, but other technologies have created a larger diversity of possible games. Widespread availability of Internet access made massively multiplayer games such as *World of Warcraft* feasible. Cheap GPS devices and GPS integration in smart phones have made *Geocaching*[1] a popular recreational outdoor activity. Other more specialized examples include Google's use of augmented reality in *Ingress*[2] and Nokia's use of image recognition in *Conspiracy for Good*[3].

Projected augmented reality – casting images from projectors onto objects while maintaining correct perspectives – is a developing technology that allows multiple people to experience the same imagery without wearing any form of glasses. This paper describes the development of *The Rooms* - a collaborative horror game. This was developed as a case study to explore how projected augmented reality can support collaborative immersive gaming. The development is positioned within related research in virtual and augmented reality and a formative evaluation consisting of 10 pairs of players is described and analyzed.

Figure. 1: The projected augmented reality game *The Rooms*.

2. BACKGROUND
The development of *The Rooms* builds upon concepts and knowledge from several different areas. These are described in the following subsections to provide a framing for later descriptions of the game and its development.

2.1 Virtual and Augmented Reality
The idea of providing displays that covered the whole or parts of peoples' field of vision came soon after computer graphics was invented. Prototype virtual reality (VR) systems were available in research labs from the 60s, e.g. Sutherland's *Sword of Damocles* which consisted of a head-mounted VR display that could detect head movement and updated the displayed image accordingly [30]. It was however not until the 1990s that such display systems became more generally accessible, e.g. through Virtuality's 1000CS[4] arcade system (the Nintendo Virtual Boy[5] is not an example as it does not perform any tracking). Modern technology driven by the wish to create more immersive games allows these kinds of experiences to be created using off-the-shelf-components. An example is Project Holodeck[6], currently in development at the University of Southern California. This uses the Oculus Rift headtracking 3D headset[7] together with

[1] www.geocaching.com/
[2] www.ingress.com/
[3] www.conspiracyforgood.com/

[4] www.amigahistory.co.uk/virtuality.html
[5] www.officialnintendomagazine.co.uk/article.php?id=15283
[6] www.projectholodeck.com/
[7] www.oculusvr.com/

PlayStation Move[8] and Razer Hydra[9] controllers for full body tracking and wide field of view. Influential game developers have raised concerns that current display systems do not provide low enough latency for VR without risking motion sickness[10,11] and tests have shown increased nausea due to oscillations around pitch, yaw, and roll axis when using VR [28].

Augmented reality (AR) is similar to VR but uses a semi-transparent display to show the real world overlaid with digital content. Examples of AR applications are tourist information given directly in a smartphone camera viewfinder[12] and showing virtual furniture overlaid onto an existing room[13]. The ubiquity of smartphones, and possibly eye-mounted displays such as Google Glass[14], is making AR experiences widely available. However, most applications of virtual and augmented reality focus on single-user experiences due to challenges of synchronizing multiple personal display devices. However, using a projector as the display device offers natural multiuser experiences and this technique is called *projected AR*.

2.1.1 Projected AR

The main technical issue with projected AR is that the image needs to be adjusted in real-time for the projection target surface. While typically the surface can be kept stationary or is naturally so, many times the projector needs to be moveable to suit various activity. This requires that the pose (position and orientation) of the projection device is tracked with a high degree of accuracy. Early work include the Everywhere Displays Projector [23], which used a static projector together with a rotating mirror, as well as iLamps [24] and a wearable mixed-reality system developed by Karitsuka and Sato [17].

Cao et al. were among the first to achieve accurate pose tracking without onboard cameras or markers [5]. Their system uses an optical motion capture system with markers on the projection device. The CastAR system[15], first shown at the World Maker Faire in 2013, promises to support both projected AR and VR by utilizing head- and surface tracking together with stereo projectors mounted on 3D glasses. Examples of applications for this system includes games. However, the suggested projection surfaces only reflect back to the user at a narrow angle and will look doubled if not viewed through 3D glasses, so the projected experience is not as easily viewable by multiple users without multiple glasses.

2.1.2 Lykta

Lykta (Swedish: Lantern) is a projected AR system developed on Unity3D[16]. This was the technical system the *Rooms* game was developed on. Lykta is a simple projected augmented reality system that uses an accurate 3D model of the projection surface running as a simulation on a smartphone connected to a handheld projector. The location and orientation is determined using Sony's Move.Me system, which uses inertial and optical tracking of

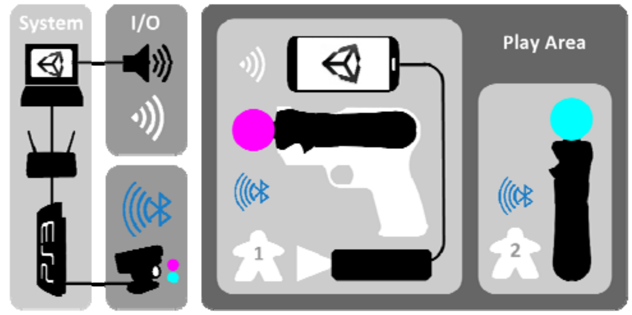

Figure 2: Overview of the improved Lykta system used by *The Rooms*.

PlayStation Move game controllers. Pose data, calculated on a PlayStation 3, is sent to a server computer that updates the projection surface model and synchronizes between multiple handheld units. These units, or controllers, consist of a projector with video connection to a smartphone, which in turn is attached to a PS Move controller. The data is sent from the server to be displayed through the projector via the smartphone so that the projector image is in sync with any pose changes. All components are commercial of-the-shelf, and only a camera is necessary to set up in the space where projection is to take place. However this limits tracking to the area that is covered by the camera, roughly 3.5×4m. Figure 2 shows an overview of the Lykta system, with the extra controller and audio system added during development of *The Rooms*.

2.1.3 Games using VR and AR

Both VR and AR have been used for many types of games. The earlier mentioned Virtuality's 1000CS supported *Dactyl Nightmare*, an early VR first-person fighting and shooting game which leveraged the head-tracking, motion aiming and body sensing of the system to have players fight each other in a virtual arena. Augmented reality gaming, or mixed reality as it may also be called, has been explored in a number of research projects since the 1990s. The Mixed Reality Systems Laboratory produced several of these such as *AR2 Hockey* and *RV-Border Guards* [31]. These used body tracking and see-through VR glasses to overlay the environment and other players with 3D graphics. The MIND-WARPING system [29] tested two different kinds of augmented reality, one first-person view using a see-through VR-helmet, and one projected on a table with cameras detecting movement. Both of these devices tied into the same game experience. While not using moving projectors, PingPongPlus [14] is another early example of a system for projected AR games. It used a ceiling-mounted projector over a physical ping pong table to augment the existing sports game. Mueller also used projectors to augment physical games, creating e.g. *Breakout for Two* [21].

2.2 Game and Interaction Design

Interaction design has been described as the creation of digital artifacts and how these affect their surroundings [20]. A challenge for the field is that most design projects are *wicked problems* [25] in that they do not have clear, easily testable, nor unique solutions. Since interaction design promotes a very user-centric approach, a common design methodology is that of iterative design [2][20][27]. Here, after an initial prestudy, prototypes are built and tested in a context that mimics the intended real use context. The results from the test then feed into another development loop with new versions of the prototypes, which are tested again, etc. While much interaction design is focused upon efficiency and usability, researchers have noted that other design

[8] us.playstation.com/ps3/playstation-move/

[9] www.razerzone.com/gaming-controllers/razer-hydra/

[10] http://www.gamesindustry.biz/articles/2013-01-02-valves-michael-abrash-latency-is-getting-in-the-way-of-vr

[11] http://www.eurogamer.net/articles/2012-07-09-john-carmack-on-virtual-reality-uncut

[12] thinkdigital.travel/best-practice/augmented-reality-in-tourism/

[13] www.gizmag.com/ikea-augmented-reality-catalog-app/28703/

[14] www.google.com/glass/start/

[15] www.technicalillusions.com/?page_id=197

[16] www.unity3d.com/

goals may be interesting. Benford and Greenhalgh claim that the consequences of *uncomfortable interaction* may make designs worthwhile regarding entertainment, enlightenment, or sociality [1]. Similarity, *ambiguous design* – the enforcement of ambiguity – can provoke people to search for deeper meanings and interpretations in digital artifacts [12].

Game design can be seen as belonging to the field of interaction design. Lundgren states this explicitly [19] while both Jackson & Schuessler and Fullerton describe game development similar to wicked problems and propose similar development processes [11][15]. The concept of user evaluation in interaction design is mirrored in the common practice of play testing in game design; early testing have been advocated by game designers since the early 1980s [21]. According to Fullerton's notions of what makes a game fun, games should be constructed in a way as to provide meaningful choices and goals, both ultimate goals and smaller subgoals along the way [11]. Fullerton advocates setting player experience goals, such as defining what players should be feeling while playing, instead of stating features when drawing up the early design. The difficulty should be right for the player, either through dynamic difficulty adjustment or player-set difficulty levels, and the controls and feedback good enough to attempt to create the enjoyable state of being described as *flow* [8].

2.2.1 Immersion

The concept of immersion is often talked about both in the contexts of AR and VR and in the context of games. One model investigating both contexts split immersion in Engagement, Engrossment and Total Immersion [3]. Engagement is the lowest level of immersion. To reach this, players need to gain access to the system, be able to use the controls, and be provided appropriate feedback to the degree that they can master the main controls. Engrossment requires that the visuals must match the gamer's expectation, the task must be well-designed and the plot (if present) engaging. The barriers of entry to the final level, total immersion, are lack of empathy for the characters or lack of feeling for the atmosphere. The SCI model of immersion [9] offers a different kind of categorization, separating immersion into sensory, challenge-based, and imaginative immersion. In this model, sensory immersion is a complete perceptual masking of the real world, challenge-based immersion involves total focus on motoric or mental skills, and imaginative immersion relates to becoming absorbed with a narration or fictive world. Unlike the other model, SCI does not put the types of immersions in a hierarchy but acknowledge that people can have parallel types of immersion. The Challenge-based immersion is closely related to Csikszentmihalyi’s flow [8] but over shorter time periods, as is to a less degree Brown and Cairns’ Engrossment level (this should not be confused with Goffman’s Engrossment concept [13] which also has similarities to flow). Looking at video games requiring movement, Pasch *et al*. identify four factors affecting immersion: natural control, mimicry of movements, proprioceptive feedback (awareness of one’s own body parts), and physical challenge [22].

It is important to note that there are voices against the notion of users being fully immersed to the extent that they lose themselves in the virtual game worlds. Salen & Zimmermann, Linderoth, and Juul all argue that players adopt a kind of double approach to the game [16][18][26]. While players may be immersed in a game, these researchers point out that players are always aware of the game within the real world context.

Fagerholt and Lorentzon differentiate between immersion through perception and immersion through reasoning [10]. The first of these relates to how well players can perceive what is relevant for their gameplay activities while the second makes use of how players can relate earlier knowledge with what the game presents. While these two forms can be related both to Engrossment and Total immersion and to Challenge-based and Imaginative immersion, the models do not explicitly relate to *diegesis*. Within film theory [4], this concept refers to the fictive world in which events occur and diegetic elements are those that characters in the world can perceive and interact with. Examples of non-diegetic elements in both films and games include musical score, narrative voices, and subtitles. Fagerholt and Lorentzon note that adding non-diegetic elements to user interfaces can increase immersion through perception while decreasing immersion through reasoning, pointing out that designers may have to do tradeoffs between different types of immersion and implying that these may be dependent on game genre.

2.2.2 Horror Games

A type of experience that is dependent on emotional investment and immersion is that of horror. Though these types of games generally have action elements such as combat, they differ from action games such as *Call of Duty* (Infinity Ward, 2003) and *Half-Life* (Valve, 1998) in that they typically promote aesthetics such as isolation and vulnerability in their game design. The player character may be alone in an unfamiliar environment, with little offensive capabilities, knowing that the dangers they meet may be so powerful that they need to flee if they encounter them. They may also employ game mechanics to give the player less direct control, such as cumbersome controls (*Resident Evil*, Capcom, 1996; *Silent Hill*, Konami, 1999), unusual and difficult combat mechanics (*Fatal Frame*, Tecmo, 2001) or very limited field of view by requiring the player to use a flashlight (*Silent Hill*; *Slender*, Parsec Productions, 2012). Another popular horror game, *Amnesia: The Dark Descent* (Frictional Games, 2010), gives the player a lot of direct control and possibilities to affect the environment, but give the adversaries even more powerful abilities such as teleportation. Horror games may also provide false information to the player, such as showing imaginary enemies (Amnesia) and giving incorrect character health and system status information. The latter was taken to the extreme with *Eternal Darkness: Sanity's Requiem* (Silicon Knights, 2002), This uses techniques similar to Gaver *et al*.'s ambiguity of information [12] and what can be seen as a play with Chalmers and Galani’s notion of seams in the technology [6] to give the illusion of both the protagonist and the player going insane. These “sanity effects” include displaying incorrect information on the HUD, and reporting that the player's memory card save files have been deleted.

As stated earlier, good feedback is necessary to create a flow-inducing experience and this is arguably the case for real-time challenged-based immersion as well. For this reason, many games present information meant as feedback to the player through a heads-up display, a transparent overlay over the game scene, displaying numbers and meters relating to the current state of the player and game world. However some argue that the presence of such a HUD may be problematic for inducing immersion, acting both as a non-diegetic element[17] and as a distraction[18]. Games aiming for a high level of immersion will need to approach the HUD in a suitable manner (see [10] for more details on this).

[17] www.gamasutra.com/features/20060203/wilson_01.shtml

[18] gamecareerguide.com/features/593/invisible_.php?page=1

3. DEVELOPMENT PROCESS

The development of *Rooms* was an iterative process that consisted of two major cycles. This process is seen as best practice within both interaction design [2][27] and game design [11][15], and shares many principles with agile development [7]. While more iterations would have allowed more testing of both the interface and the gameplay, the substantial software development needed made more iterations impossible for the available development time. This was somewhat countered by having several smaller and more improvised tests throughout the process.

3.1 Early Concept Development

Inspired by the notion of seamful design [6], work started on a design that would build upon technical limitation in Lykta, rather than try to cover them up. This made making a horror game an early design decision; many horror games, such as the *Silent Hill* series and *Slender*, limit the vision of the player by forcing them to rely on a flashlight. By disguising the Lykta projector as a flashlight used in a dark environment, the limited visibility offered by projected AR would both have a natural explanation and be a starting point for limiting the awareness they had of their environment. This was in line with Benford *et al*.'s reasoning about creating uncomfortable interactions [1] based upon ambiguity of information [12]. Horror games are also interactive experiences designed with the explicit goal of eliciting a clear emotional response. This was seen as making evaluations easier as it could be compared to different kinds of immersion, one of the design goals of the game.

It was also at this stage decided that the game would be played around the corner of a room. While any kind of geometry could be modelled and used for projecting on, this simple geometry would make it easy to playtest in different locations without remaking the game scene, while providing three surfaces to play on: two walls and a floor. The common horror theme of an abandoned building would be used as it fit well as an overlay of the room corner, unlike e.g. the forest setting in *Slender*. To create a sense of progress and to vary the experience, the layout of this room would be varied by creating the illusion of movement between rooms through the use of darkness and surround sound queues. Aiming at a rather slow initial buildup gameplay was thus quite naturally planned to center upon completing puzzles that would unlock doors leading to the next rooms. To create a climax, a monster was planned to be introduced in later gameplay to create stress. To create meaningful choice for players, most rooms would include two doors so that players would have to choose which to unlock and move through.

Wanting to make use of the fact that projected AR is experienced by all those in the environment, as well as creating an observable dialog between players for easier evaluation, a decision was also taken to make the game into a two-player cooperative game. At this point it was decided to represent the projection device as a gun with an attached flashlight; an item that may be familiar for players from games such as *Resident Evil*. One player would handle this device to both explore the environment and fight monsters. The other player would have a PS Move controller without projector that allowed interaction with the puzzles.

3.2 Formalizing Interaction Possibilities

At the start of the project Lykta was still in an early prototype state and the first work consisted of doing several improvements, primarily for multiple controllers and debugging. Given the overarching decisions made in the early concept development phase and the improved Lykta system, the next step consisted of exploring what interactions the system should support. Four basic interactions were decided upon: press; grab and rotate; grab and move; grab, move, and rotate. They were judged to be of increasing difficulty ranging from easy to expert with pushing a button being an example of an easy interaction and taking a virtual object and fitting into a hole being an expert grab, move, and rotate interaction.

These interactions were the basis for a number of puzzles. While the actions themselves could form challenges to novice users, more difficult ones were created by combining interactions in sequences. Having to locate the objects to interact with could also increase the difficulty of the puzzles. The puzzles were designed to provide steps of increasing complexity as the game progressed, and challenging skills that would be difficult to use while under pressure (see table 1). It was hoped that the teamwork aspects would emerge when the player with the gun needed to provide light for the player solving puzzles while at the same time having to keep a lookout for dangers in the dark.

Interaction	**Example action**	**Puzzle**	**Difficulty**
Press	Push button	Buttons	Easy
Grab & rotate	Rotate dial	Combination dial	Medium
Grab & move	Move object	Blowtorch and door	Hard
Grab, move & rotate	Fit object into hole	Complete electric circuit	Expert

Table 1. Overview of the puzzle types.

3.3 Interaction Testing

Five informal tests were carried out with informed users, mostly interaction design students and members of IT faculty, to test the planned interactions. Since Lykta presents a novel way of interacting with digital media there was little concern that testers would have different levels of experience with similar systems. The interactions tested were those required to activate the objects buttons and dials. It was found that users needed a rather large "grabbing sphere" (⌀ 0.6 m) to reliably be able activate buttons. This was partly due to calibration issues, but also seemed to have to do with parallax effects and meant that puzzles should not have buttons placed too close to each other. In addition, users were observed to hold the tool device rather far from the wall and try to interact with objects. Some would even use the shadow of the wand, cast by the projector, to aim at the wall. To support these types of actions, the system was expanded so an axis perpendicular to the wall is calculated in relation to the controller the moment players grab an object and rotation around this axis is supported. This meant that as long as players did not change controller orientation completely, they could reliably turn dials.

3.4 Game Development

With the basic interactions tested, the focus shifted towards what can be deemed the central aspect of the gameplay design: doing the layout of the rooms, creating and ordering the actual puzzles to be used, and deciding on monster behavior and visual design.

3.4.1 Room design and transitions

The room layout was planned visually using an online drawing tool, see figure 3 for an overview. In many of the rooms, players have the option to try unlocking either the door on the left wall, or the door on the right wall. Generally, the left doors required solving tougher puzzles but meant that one would meet fewer monsters. An issue with mapping the virtual rooms to the physical spaces was it would be hard to dynamically change all the virtual rooms to fit a real room of a fixed size. It was decided to create the illusion of the light from the gun controller fading out to black when shining further out from the play area. That way, the walls

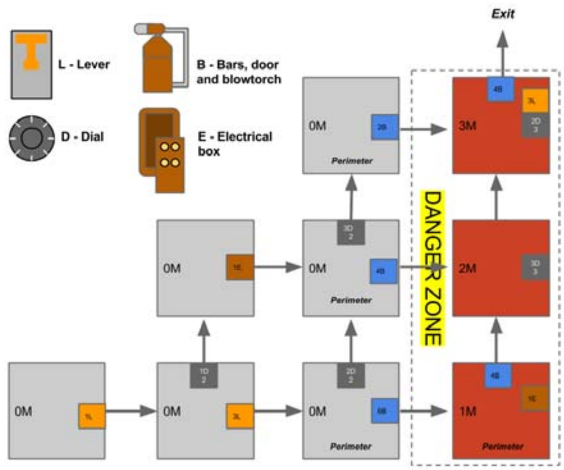

Figure 3: Sketch of the final room layout and puzzle distribution. L: Lever puzzles. E: Electrical box puzzle. D: Dial puzzle. B: Blowtorch puzzle. The first numeral is the number of objects making up the puzzle. For dial puzzles, the second numeral denotes the difficulty.

that were not mapped to the play area would stay veiled in darkness. This was achieved by letting each room be illuminated by a light source originating from the corner around which the puzzles are focused. Another challenge of the experience design was that the buildup made it necessary to have players move between many virtual rooms, while still staying in the same physical room. It was hoped that this transition could be simulated by dimming the projector, moving the audio sources away in the direction of motion so that all room sounds disappeared off in the distance, and then playing a door shutting sound on the opposite wall of the door that the players went through.

3.4.2 Puzzle Design

To satisfy the criteria for both Ermi & Mäyrä's definition of Challenge-based immersion [9] and Csikszentmihalyi's concept of flow [8], the difficulty level needed to be neither too easy nor too hard for the players. While this could be adjusted with the puzzles and properties of the monster, this was a major challenge as all players have different skills levels. Of particular concern was the fact that players could get stuck and not be able to advance to the next room, either by their own inability to solve a puzzle or by some software error. While larger game production can spend the resources on developing dynamic difficulty adjustment systems, such a system was outside the scope of the Rooms project. Instead, a method inspired by the Wizard of Oz usability testing technique [2] was implemented so that a test facilitator could manually advance players. Figure 3 shows an overview of the implemented puzzles and their distribution in the rooms. The numerals in the figure indicate the number of objects making up a puzzle, while the letters signify object type. The last numeral in the case of dials indicates the number of positions needed to solve that object. These puzzles are placed in the rooms along the walls for the door they would correspond to. The number followed by an M in each room indicates the monster danger in that room. The rooms within the danger zone would have a different visual style, to signify the players traversing inside the space occupied by the monster. This notion was further strengthened by placing blowtorch puzzles along the perimeter of the danger zone, alluding to players breaking into a cage.

3.4.3 Monster Design

The behavior of the monster was seen as essential for providing a horror experience during the final parts of the game. It was decided that the monster would erratically move along the walls towards the closest player after entering the scene. Once in attack range, they would scream to give players a chance to move away before they were attacked. The monster would hide after attacking, reappearing once a timer had counted down. This timer could be set individually for each room to provide increasing levels of challenge as players got further into the game, potentially helping them stay in a state of flow. The monster could be defeated in two ways. It would scream and flee when targeted with the flashlight but would disappear with a ghostly scream if the players managed to keep them lit up for a certain amount of time. Another way to temporarily make the monster disappear was to shoot it with the gun. By simply aiming straight at the monster and pulling the trigger, the monster would disappear. However, ammunition was intentionally made limited (six shots) with no indication of how many bullets were left. This would require players to make tradeoff decisions between the two ways of defeating the monster, since choosing the easier shooting option could leave them in pressed situation without ammunition.

Figure. 4: In-game screenshot from the server showing a room with a three-dial puzzle of the left and a blowtorch puzzle on the right.

3.4.4 Visual Design

To improve the visual representation of buttons, the appearance and animation was changed to that of a large flip switch. The button activation action was still kept to just pressing the trigger of the tool wand. If users felt like adding a motion to the grab press, the switch would still trigger. To provide clearer feedback, especially when multiple puzzles had to be solved to unlock a door, a system of wires and gauges reminiscent of the feedback system in the *Portal* games (Valve, 2007) was introduced (see figure 4), providing audiovisual feedback on puzzle state. It was hoped this would provide a useful guide for players to find the puzzles connected to the door, especially in later rooms were puzzles could be spread out over multiple walls.

4. THE ROOMS: FINAL DESIGN

The resulting horror game concept has two players who find themselves in a dark and strange underground facility. Using nothing but a flashlight-equipped gun and a multitool they must break through the old security system and open doors in the hope of getting out. On the way they break into the holding pen of something unknown, and need to fight off this monster while escaping from the last rooms.

The final game consists of 9 virtual rooms that can be mapped to a physical space where two walls meet to create a corner. The three first columns of rooms are populated with various lever, knob and power box puzzles that can be solved by the tool controller. Players then break into the "danger zone" using a blowtorch. The monster appears inside the three rooms of the danger zone, where players also face harder variations of the previous puzzles. The monster can be forced to hide temporarily by illuminating it for some time. Using the gun, the monster can be shot and scared away, but ammunition is limited to six bullets.

Rooms are generally approached by having the flashlight player searching for doors and puzzles, guided by the wires running between the doors, gauges and puzzle elements. The tool player goes up to the projected puzzles and tries to solve them using the tool controller to grab, pull, rotate and carry objects, while the gun aids in vision while also keeping a lookout for the monster. Cleared puzzles activate the corresponding gauges and are accompanied by an audio queue, and when all puzzles connected to a door are cleared the door opens and players automatically advance to the next room.

4.1 Controller

The main casing of the gun type controller was manufactured in a 3D printer and allowed a projector, a smart phone, and a PlayStation3 controller to be attached to a Playstation Move gun handle. Figure 5 shows the gun handset. For the final testing the Samsung Galaxy S4 was used which had performance was good enough to provide smooth video rendering.

5. USER TESTING

The Lykta platform and the *Rooms* experience concept was made available to the public in an event where indie game developers exhibited home built arcade game. This event was chosen as it would provide a good supply of visitors willing to test, had a darkroom that could be dedicated to Lykta, and could potentially lead to media exposure of the project. The test was seen as a formative evaluation to provide feedback on future development rather than a critical test on how well the game provided immersion, so the informed developers were seen as an asset.

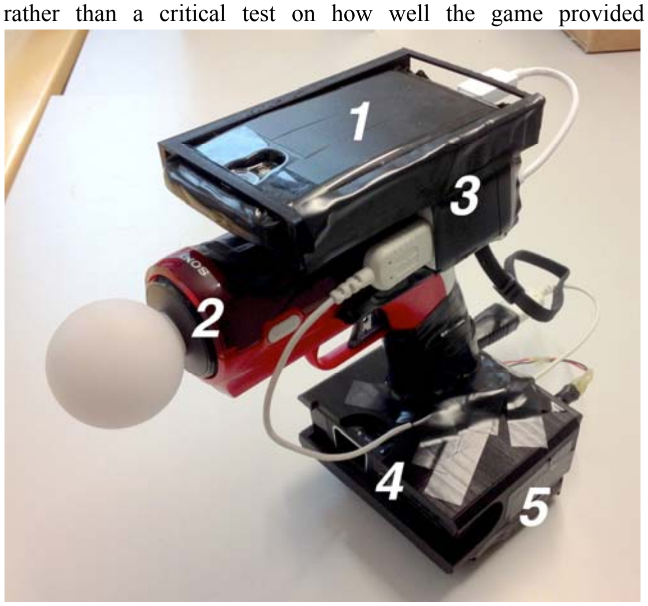

Figure 5: The gun controller consisting of a Smartphone (1), a PS Move controller (2), a video adapter (3), a projector (4) and a power pack (5).

The venue provided a sound isolated black box type room for the experience. In this a 4.5×4.5m square area was created by hanging up black curtains, and the PlayStation Eye camera was attached to the wall in the corner 2.85m up and angled about 60 degrees down. The play area was further fenced off to 1.8×2.3 meters to limit player movement within the PlayStation Eye range, while still making it possible to project on surfaces further away. The camera placement created an additional dead spot closest to the corner where there was no tracking, but otherwise provided good coverage. The puzzle placement in the *Rooms* was adjusted to take this into account.

The goal of the play test was to perform observed play test with as many participants as possible over the course of the day, following each play test with an interview. Nielsen notes that there are diminishing returns with a higher number of participants and that three iterations of five testers are more effective than one iteration with fifteen[19]. However with only one proper testing opportunity a goal of 10 groups (20 participants) was aimed for. The testing procedure was similar to the one suggested by Fullerton [11], with an interview following the test but the 5-minute warm-up discussion was replaced with a questionnaire. However the notion of only being a passive observer and not talking to the play testers was mostly adhered to, except when players got stuck and had to be advanced manually.

Before starting to play, testers were required to fill out a short questionnaire. This mainly dealt with their previous experience in games, their motivations for playing games, and how easily they felt they experienced different forms of immersion in games and other media as well as what factors they thought created this feeling. They were also given a brief introduction of how to hold and handle the gun and tool.

Some minor adjustments to the system was done during the testing. The difficulty of the blowtorch puzzle was made easier by removing some of the locks that players needed to remove. This was done as it was noticed that players thought the puzzle was tedious and had some issues controlling the blowtorch. Further, for the last group the time for the monster to reappear in the final room was increased, and though they quickly ran out of bullets, this helped them clear the puzzles before the monster defeated them. They were the only group that "beat" the game.

After the test the two players were interviewed together, though their responses were recorded separately. Notes were taken during the interview in addition to the audio recorded. The testing resulted in 10 interview backed up by audio recordings, and 20 matching individual questionnaires. Besides general questions regarding the experience, people were asked to estimate how long they had played and state how much they would pay for similar experiences.

Average playtime was about 12 minutes, with shortest 8:30 minutes (group 2) and the longest 16:15 minutes (group 6). All but three of the groups said they had played for a shorter time than they actually did. Three of the groups (group 1, 3 and 6) as well as the tool player from group 9 gave estimates that were more than 5 minutes less than the actual time.

5.1 Feedback

Several different types of feedback were collected from the questionnaires and interviews. Generally, the game provided

[19] nngroup.com/articles/why-you-only-need-to-test-with-5-users/

players with immersion and seven of ten groups said they felt present in the game world. Of the other three, one group had a member that became engrossed in the puzzles while the other became scared and another group experienced time differently, so eight or nine of ten groups had some form of immersive experience.

While players appreciated the cone of light effect from the projector and stated it felt like a real flashlight, some other aspects of the graphical presentation was questioned. The monster was perceived as flat and not scary – group 2 described it as a leather jacket – but even so three groups stated that they felt genuinely frightened the first time they saw it. Two groups wished for a more abstract threat, both in terms of visuals and game mechanics. Group 10 thought the graphics were a bit too clear and that blurriness, perhaps indicating increasing insanity, would be appropriate. Group 1 and 10 thought the tracking light from the Move controllers was too strong and affected their immersion in the experience negatively.

Two groups expressed that they wished the field of view from the projector was wider. Four of the groups wished they could turn around and use all walls, with two of them noting it felt strange (and possibly immersion-breaking) that they could hear sound from that direction, i.e. a door slamming shut, but not see anything. Group 7 did find it immersion-breaking when the game projected images on the back of the tool player. While other groups reported feeling that their relative positions did not have much effect on the gameplay, three groups mentioned that the relative positioning between the players that was needed to avoid projecting on each other actually increased their sense of immersion as it made them more aware of both being together in the game world. This seems to relate somewhat to the sensory immersion, but more in a spatial sense. One group suggested adding puzzles where players needed to carry out actions simultaneously, e.g. lifting heavy beams.

One gun player thought that holding a gun prop increased his sense of immersion, while another was reassured by holding what felt like a gun. Two of the groups thought the dial rotation had very good feedback and felt real, and brought them into the game. That players felt immersed even though the rotation action is quite unlike that of a real dial indicates Engagement or Challenge-based immersion rather than the Engrossment or Imaginative variants. Supporting this, the tool player in group 5 answered not thinking much about the graphics and sound as she felt so into the game world. However, she also noted that she never reacted reflexively or emotionally as she "knew it was just a game". This is in line with the arguments that the notion of total immersion in games is a fallacy [16][18][26]. Many groups mentioned various problems controlling the movable objects in the power box and blowtorch puzzles. This was not seen as negative by group 4 and 9; they thought the difficulty added to the horror aesthetics.

Only group 5 reported that they thought the puzzles were too difficult, while a majority of the groups thought the puzzles were interesting but somewhat easy. Group 8 said that they thought the monster was brought in at a good time, just when they were starting to master the existing puzzles and get bored of them.

The gun player in group 3 explicitly said he was holding back his reactions to the experience in order to not scare his girlfriend, who was the tool player. Group 7 however said it would have been scarier to play alone, a sentiment mirrored by group 8. In group 6 the tool player was observed as being scared for real and somewhat panicked, and also admitted this openly afterwards. Meanwhile the tool player in group 5 said that while she was typically scared by horror games *The Rooms* was not as scary as expected. Group 8 seemed to have enjoyed the experience the most, with the gun player saying he loved it and could have played for another two hours. He said it was the most immersive (though the word he used was "present") game experience he had experienced.

When asked to set the cost for a similar experience, most groups set a price somewhere between the equivalent to 2 and 8 dollars, with the exception of group 3 and 8 that where in the 15 to 25 dollar range. Group 4 made a comparison to laser dome games, another kind of experience played in the dark using all the senses. They were willing to pay around 80% of that price. To pay twice as much, players suggested projection on all walls, a tool and gun for each player, improved monster mechanics, the ability to move back and forth between rooms, longer playtime, a fan blowing a cold wind, fewer bugs, and stronger introduction into the experience.

6. DISCUSSION

While the test of *The Rooms* was mainly aimed at providing information for further development, it did also provide several observations regarding immersion and projected AR. As the user feedback showed, the experience of playing *The Rooms* was overall immersive although different users found various different aspects immersion-breaking.

Several of the comments from the users echo the statements about visual and audio presentation being important parts of sensory immersion [9] and both engrossment and total immersion [3]. Many groups thought that audio added even more to the immersion than the graphics, especially group 3 who thought the graphics were "just ok" but that the audio really made it feel they were surrounded by the game. Two groups remarked that the gun shot sound and other loud noises surprised them and scared them. However, the projections onto players' backs and hands challenged these types of immersion and the shifted sound during room transitions drew attention to the fact that only two walls and the floor was available for interaction. Also related to visual presentation was the fact that the flashlight would flash red when players were attacked and turn redder with lower health. Fagerholt and Lorentzon label this as meta-perception [10], being non-spatial and emulating internal human perception such as health levels, and is a non-diegetic element which can increase immersion through perception while decreasing immersion through reasoning. The use of red filter in *The Rooms* seem to have worked as only one group mentioned this as reminding them it was only a game. While one player in group 6 was genuinely scared, no other players of *The Rooms* reported an experience matching that of Brown and Cairns' concept of total immersion. Further, over half the groups said they didn't even think of themselves as two separate players but did not put this in relation to immersion in any way. These comments were however not mentioned as being a problem or disappointment; something that may argue that Ermi and Mäyrä's model – which allows different kind of immersions to exist in parallel – may be more informative when applied to understand actual gaming experiences.

Three groups noted that the relative positioning that was needed between the players actually increased their sense of immersion. This aspect has not been noted in tests of other shared AR gaming experience, and points towards a possible fine-grained distinction that can be made for immersion. Awareness of the position of oneself and the other player relate to Pasch *et al.*'s factors proprioceptive feedback and physical challenge [22] but for *The*

Rooms this becomes a rather trivial challenge that draws the players' attention to where they are in relation to each other and could be described as a form of *spatial immersion*. Some supportive arguments for this new type of immersion were found in the interview answers. Two players found that the gun prop increased their immersion or provided reassurement. Similarly, two of the groups thought the dial rotation had really good feedback and felt real, and brought them into the game. As mentioned earlier, group 4 and 9 thought the difficulty in solving the power box and blowtorch puzzles (which were partly due to a bug in the network code) actually added to the experience. This is in line with Pasch *et al*.'s observation that while proper feedback is required to not disorient gamers, movement does not need to mimic the real movement perfectly to still have an immersive effect [22].

While not asked about directly, no play testers remarked about dizziness or confusion in relation to the display technology. One possible explanation can be that users have unrestricted sight and can to a certain degree see the physical walls; this avoids disagreements between any visually perceived movement and their internal sense of movement. While this may point to a way of having immersive experiences without risk of motion sickness, this needs further studies and it should be noted that *The Rooms* provided a very specific experience.

7. CONCLUSION

In this paper we have introduced *The Rooms*, a projected augmented reality horror game. The user test showed that the game was immersive although in different ways for different players and pointed to several possible improvements that can be done to make projected AR more immersive. *The Rooms* avoided the problem associated with VR system of invoking nausea and user feedback of the game suggests that *spatial immersion* may complement Ermi and Mäyrä's immersion model.

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