Fear Inducing Play in an AR Escape Room with Human and Robotic NPCs

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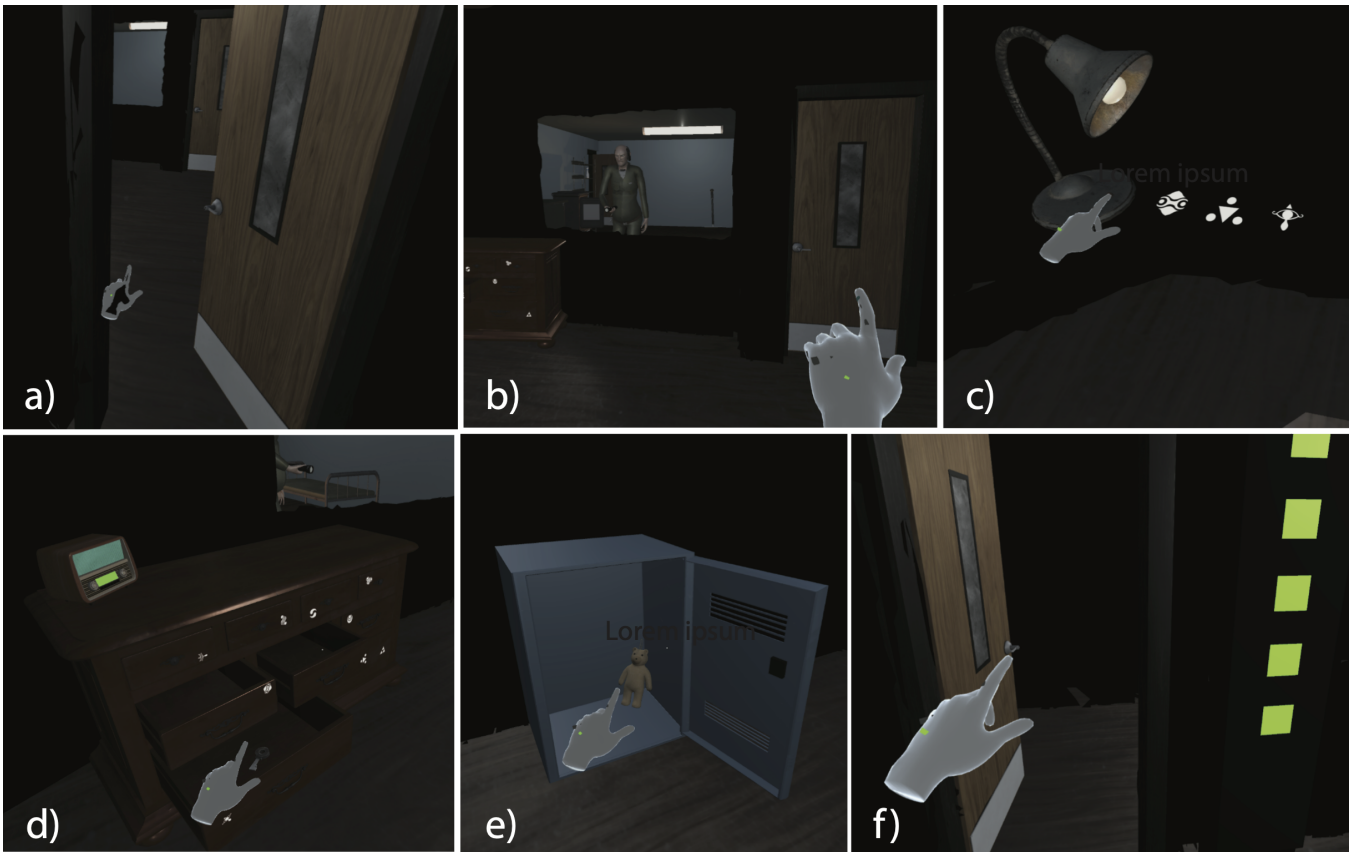

Figure 1: First person view of key game events, (a) play begins by entering the room, (b) player notices the janitor (NPC enemy) in the adjoining room and sense of urgency heightened, (c) player solves puzzles and finds codes, (d) using the codes unlocks a drawer to retrieve a key, (e) unlocks the locker to retrieve the teddy bear, (f) solve another puzzle to unlock the door before being captured by the janitor.

ABSTRACT

While the horror genre has been a staple in computer games on consoles and personal computers, there are surprisingly few examples of Augmented Reality (AR) horror games. Considering that AR experiences are valued for taking advantage of the physical environment to situate the experience and increase the sense of realism and immersion, there are surprisingly few examples of research that have examined factors that contribute to player experiences in horror games. We developed an AR horror experience in which players need to enter an escape room, solve puzzles and retrieve a teddy bear under the threat of being captured by an enemy NPC. We conducted a study in which players completed the task twice, once facing the enemy NPC in the form of a human-like janitor and another with a robot. Most players rated the human-like enemy as more intimidating than the robot. Players provided various explanations for game elements that contributed to their sense of

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fear and intimidation including the sound, relatability of the enemy, and scary atmosphere.

CCS CONCEPTS

• **Applied computing → Computer games**; • **Software and its engineering → Interactive games**; • **Human-centered computing → Collaborative interaction**.

KEYWORDS

Augmented Reality, AR, AI, Escape Room, Horror, Games, Human Computer Interaction

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1 INTRODUCTION

Games often provide opportunities for fun, enjoyment, learning, and excitement. Yet, a growing number of emotionally impactful games aim to stage uncomfortable experiences [8]. This can be done by placing the player into high-pressure environments with uncertain outcomes, forcing them to make difficult decisions, by highlighting loss, or exposing players to disturbing themes and content. We speculate that situating these experiences—horror ones in particular—in the real world and immersing the player in them could further support these mechanics. This is made possible by augmented reality (AR), yet the focus of AR games has been primarily on action and learning, with AR horror experiences not receiving much attention. Considering the possibilities offered by AR (e.g. games can be situated, integrate elements from the physical environment), it seems there is much potential for developing exciting AR horror games.

We therefore developed an AR horror game that utilizes these qualities. In our game, players need to enter into an escape room, solve puzzles and retrieve a teddy bear under the threat of being captured by an NPC enemy. We conducted a study in which players completed the task twice, once facing the enemy in the form of a human-like janitor and once with a robot enemy. We refer to these NPC enemies in the paper as "janitor" and "robot". The results of the study provide insights as to what builds a scary experience and intimidating enemies in AR horror games. We provide implications for design so that the findings can be used by other researchers and designers of AR horror games.

2 RELATED WORK

Our work is an instance of an AR game, but more specifically an AR horror experience.

2.1 Augmented Reality Gaming

An early example of an AR game is *ARQuake*, where players hunt monsters on a campus [17]. Thomas et al. found the monsters difficult to design because the users were very sensitive to lags in their movement and easily noticed misalignment in relation to other objects and failing to look at the player. Similarly, in *Human Pacman*, the player roams through the streets to collect virtual cookies while avoiding ghosts played by other people [3]. The streets are also the setting for *HoloRoyal*, where players in a large play area use virtual drones to attack a virtual robot enemy [14].

2.2 Augmented Reality Horror

While there is a large selection of virtual reality horror experiences, there has only been limited exploration of AR horror. One example is *Kaidan*, a demonstration where users explore an old Japanese home and encounter virtual, screaming ghosts [9]. *The Remediation of Nosferatu* is a location-based AR horror adventure where players have to explore places to find videos and at some point are also attacked by the game's vampire namesake [7]. Similarly, in *Horror at the Ridges*, players investigate a former lunatic asylum where they get to know some of the inmates and slowly uncover "the horrors around them" [6]. Finally, *The Rooms* is an escape room experience with projected AR where players have to solve puzzles while being pursued by a monster [11] Our game is inspired by the latter, but uses headset AR for a more immersive experience (e.g., their monster "was perceived as flat and not scary", likely due to the use of projected AR).

3 AR ESCAPE ROOM GAME PLATFORM

In order to study player experiences in scary AR games, we developed an escape room game that is adapted from the desktop horror game, Root of Guilt[16]. In Root of Guilt, the player/protagonist needs to enter a school after hours to retrieve their teddy bear without being captured by the janitor. The first author of this paper developed that game and therefore was able to reuse some of the game assets.

3.1 Design Rationale

Our goal was to create a scary AR experience that is situated in a physical environment. In order to design for this, we made a range of design choices which we discuss below.

Play connected to the physical environment: AR experiences can take advantage of physical features in the environment so that virtual objects, sometimes referred to as 'holograms', seem to interact with or emerge from the physical world. This can make very realistic and compelling gameplay and reduces the processing power needed by the headset. One example is RoboRaid [4], a shooter game where enemies break through the the walls of the player's room.

Physically active, immersive play: Although distant interactions are possible using HoloLens 2's *ray cursor*, we chose to enable only the *finger cursor*. This requires the player to move in the room and use their finger to touch holograms to interact with them and is often chosen when immersion is important for the experience [1]. Requiring direct touch also prevents players from being stationary and interacting from a distance, thus we encouraged that the players would have a higher level of exertion.

Atmosphere of fear: There were various choices made to heighten the sense of being in a foreboding place and emotionally unsettling. The room was very dark and there was a virtual ceiling light that flickered on and off as if the room was not well

[1] https://docs.microsoft.com/en-us/windows/mixed-reality/design/cursors

maintained. We used the tension-building background sounds from the Root of Guilt game. We designed the enemies to be mysterious and unfriendly.

Heightened sense of urgency: The escape room game-type was selected because it involves solving puzzles in a race against time. In this game, the enemy appears in the next room and the player has to solve the puzzles and escape before being captured. We designed the puzzles to require focus and problem solving to ensure a moderate level of cognitive demand.

Support a variety of play studies: From initial pilot studies, it became clear that players vary in their response to the game elements. We wanted to develop the game so that when it is run on the HoloLens, the facilitator can quickly select features and settings needed for the study without having to rebuild the game each time. In the current version, the system supports varying the enemy NPCs, their size, speed, position and movement characteristics.

3.2 Root Of Guilt: AR Adaptation

We developed an AR escape room game for the Microsoft HoloLens 2, using Unity and the MRTK toolkit. The game was designed to be site specific, taking advantage of two rooms with an adjoining window. We built a mesh of this space by scanning the rooms, which we then populated with assets previously developed for the *Root Of Guilt* [2] project and the Unity Asset Store. We used Azure spatial anchors to align and fix our virtual content to the physical world. In order to facilitate rapid iterative development, we also implemented an administrative console so that settings could be changed easily, as shown in Figure 2.

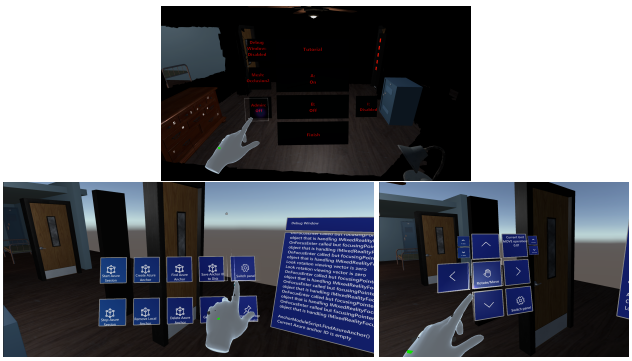

Figure 2: Administrative console. *(left)* game settings, *(center and right)* utility for aligning position of mesh in the physical space.

The administrative console supports quick adjustments and configuration choices varying aspects of the experience including enemy choice, speed of character, among others as shown in Figure 2 (left). We conducted pilot studies exploring player responses to various configuration options, yet it became apparent that the surprise factor of the appearing enemy NPC and the fear caused by the urgent escape diminished after playing a few times. As a result of the pilot studies we made refinements to the environment by adjusting the ambient lighting and increase the scary atmosphere of the game. We also simplified parts of the escape room task to ensure that players could finish the puzzles in a reasonable amount of time.

[2]https://dadiu.itch.io/root-of-guilt

3.3 AR Escape Room Game

Our game puts the player in the role of a kid who is trying to retrieve their teddy bear from the school without being noticed and captured by the NPC enemy, which is in the form of either a janitor or robot. There are eight tasks that need to be completed in order to win the game. These are described below and shown in Figure 3 (left) where the numbers of each task are mapped to the corresponding space and movement in the room.

(1) Pickup the key to enter the room.
(2) Open door and collect the light bulb from drawer. The enemy enters the adjacent room (purple area) and can be seen by the player looking through the window.
(3) Install the light bulb in the lamp which reveals a code in the cast light.
(4) Remember the code and use it to open the drawers to get the key to the locker.
(5) Unlock the locker and grab the teddy.
(6) Try to exit the room with the teddy (the door is locked), alarm goes off, the enemy is alerted and buttons appear on the wall.
(7) Player needs to activate all buttons on the wall by tapping them as quickly as possible.
(8) Once all buttons are activated, the door is unlocked and the player exits the room escaping the enemy. (If the player delays too long, the enemy enters and captures the player, ending the game.)

4 EVALUATION

We conducted a within subjects experiment in which players played against both enemies, once with the janitor and once with the robot. The play studies were conducted in a controlled room as shown in Figure 3 (Right).

4.1 Participants

In total 6 people (1 female) took part in the experiment between the ages of 24 to 62 years *(M = 31, SD = 13)*. None of the participants owned an AR or VR-supporting headset, and in general the participants had less experience with AR than VR. Four of the six participants had experience with escape rooms. In the pre-game questionnaire, participants were asked to select up to three of their preferred game genres. One of the participants chose not to answer this question and one answered that they did not play videogames. The remaining four particpants all preferred *puzzle* games the most. *Role-playing games* received the votes from 3 of the 4 players while *shooter* and *racing* games received 2 votes each. *Horror* and *sport* games received only one vote each.

4.2 Measures

The participants completed two questionnaires one prior to the experience and another after the game. The pre-game questionnaire gathered information about participants demographics: gender, age, and additional relevant information such as participants level of

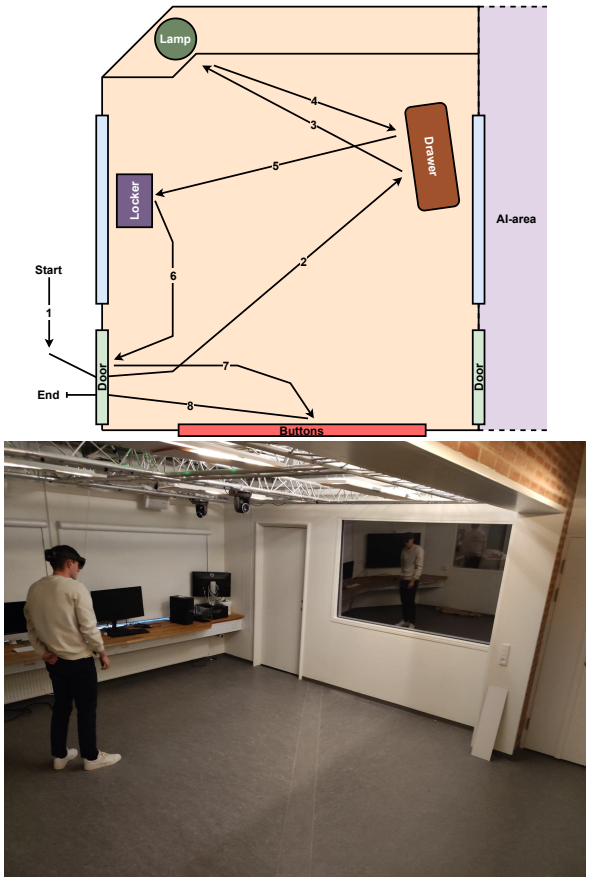

Figure 3: (Left) Plan view of the experimental setup with arrows indicating the required movement of the participant to complete each sub task. (Right) The game was situated in a room with a window looking into an adjoining room. Participants entered it and then had to solve puzzles to escape. Shortly after the beginning, an enemy would enter the second room and peek into the players' space. Upon spotting the player it then tried to break down the door leading into the room and, once successful, would attack the player and end the game.

experience with both AR, VR and escape-rooms. The post game questionnaire included the forced choice question about which of the two models they found more intimidating. Participants were also asked:

Q1 What made the chosen character more intimidating to you?
Q2 What is your general opinion about the experience?
Q3 Do you have any ideas for improvement or additional comments?

4.3 Experimental Procedure

We first obtained informed consent and then had participants fill out the pre-study questionnaire. We then calibrated the HoloLens for each participant and guided them through a tutorial that familiarized them with the device and the interactions possible during the game.During this stage participants could already explore the escape room, albeit with no sound or monster present. We instructed them that during subsequent plays there would be an enemy who would try to capture them, thus they should try to complete the game as quickly as possible.

Participants then played a first round of the game, after which they took a short break of 5 minutes. The participants then played another round with the other monster model present. The order of presentation was balanced and randomized so that half experienced the human janitor first and half experienced the robot janitor first. After the second run, we asked participants to complete the post-study questionnaire. The entire session for one participant took about 45 minutes.

5 RESULTS

In total, our participants completed 12 playthroughs, of which 10 were successful escapes while in 2 cases, the enemy captured the player. Participants 4 and 6 were captured on their first session, yet were successful on the second session. The Average completion time across all participants was *(M = 202 seconds, SD = 78s)*. All participants had an improved completion time comparing first and second playthrough. The average of the first playthrough was 245 seconds. Participants improved by an averages of 162 seconds in the second playthrough with average time to complete *M = 81s, SD = 73s.*

5.1 Which janitor was most intimidating?

Five of the six participants picked the human janitor model as the more intimidating option. Only one participant (P4) chose the robot model instead, which also was the first enemy they experienced and explained that the voice affected their choice. The robot was the first enemy they experienced, and some who had the first encounter with the human also claimed the first encountered character might affect their choice. Thus it remains an open question how much the effects of order play on their impression. Participants choosing the human as the more intimidating enemy claimed it was more relatable and realistic. The participant explanations for their choices provide additional insights (highlighting by us):

P1: "The human was personally the most intimidating due to me feeling like an intruder. It was somewhat due to it being the first character together with the unknowingness of what would happen if I was caught. The human seemed very upset that I was in that room. The fact that it was a robot and knowing that it had a lack of common human attributes, made it feel like it was less of a 'crime' of some sort."

*P2: "The human was the most intimidating, since I found it **more relatable**. However at the first try, I got more scared, since it was the first time. Thus the second time, I got more used to the system."*

*P3: "The human was more intimidating because he was **more animated**. He moved his arms and legs as he walked around the room, so it feels like he would be more intimidating if he came in to my room. Moreover, his face made it clear when he looked at you. He was more alive. The robot's face was less prominent than the rest of its body."*

*P4: "The **voice** from the robot had an effect on how much I stressed. The robot was harder to ignore at the end of the game than the man."*
*P5: "I found the man more intimidating as he was **very human-like** which I think made him more creepy than the robot."*
P6: "He was fat and bald and looked quite scary."

5.2 Additional comments/suggestions about the game

Participants were also asked about their general opinion about the experience as well as suggestions they had for improving the game. Participants gave only few specific ideas for the game, mostly providing ideas for new puzzles that relate to their previous escape room experiences. Players generally enjoyed the game and explained aspects that were particularly exciting and fun:

P1: "I love escape rooms so this was a huge hit for me. It felt like an intimidating experience, also pressing the lamp power button was very satisfying.".
P2: "Very funny, challenging and engaging".
P3: "It was especially stressful accessing the drawers without being noticed and pressing the red buttons, It worked surprisingly well, when I compare to my previous experiences. I can easily see the idea behind it, and really I just wish that it was longer. I really wanted to try a longer version with more puzzles.".
P4: "Funny and exciting, comprehensible yet challenging".
P5: "The music and design supported a creepy atmosphere and it was stressing pressing the buttons to avoid being captured".
P6: "Very fun experience, the music made me feel more stressed".

6 DISCUSSION

In order to utilize the outcomes of our work, we provide implications for the design of AR horror games to assist designers and researchers. It is also important to discuss the limitations and future work.

6.1 Implications for design

While the reported study involves few players, we propose intermediate level knowledge in the form of three implications for design [**?**] in order to share the lessons we have learned and challenges we faced to provide useful insights to other designers or researchers who are interested in working with AR horror games.

Sound is especially important: Good game design takes into consideration what is seen and what is heard. This is well-known and has been discussed in related research on sound and atmospheres in games [13]. In the horror genre, sound seems to play an especially prominent role in building tension, providing an unsettling atmosphere, and elevating the scary moments. Nearly all of the players in our study discussed how the sound affected the experience–while we designed the sound carefully with foreboding background music and sound effects such as creaking doors and footsteps, we are reminded about how crucial it is to building an exciting game and inciting visceral emotions.

Consider how lighting builds a scary atmosphere: In previous research, lighting has been emphasized for its influence on motivation [2], performance[10], attention[12], and for eliciting emotions[15]. The feedback from the participants confirms how important lighting was for them. For the scary atmosphere of the school, we designed for a dark and dreary game world, yet this was especially difficult to accomplish because we needed to provide enough visible light so that the HoloLens hand tracking worked well, but at the same time, support the relatively dark holograms and virtual content provided in the HoloLens display. In order to achieve convincing and effective lighting, we masked off most of the overhead LED lights in both rooms and in the adjoining room where the enemy emerged, we set up 3 studio lights to provide wall washing to draw attention to the physical room and to ensure that the bright holograms of the enemy seemed to be at the same relative brightness level. This required much experimentation and iteration – we would recommend setting aside plenty of time for designing the light of the space and asking new participants to enter the space and provide feedback.

Dealing with novelty and learning: Games are often designed to maintain a level of challenge and novelty to ensure that a player remains engaged. Research has explored ways to sustain interest in games by designing characters that users identify with or by providing in-game rewards to combat waning interest over time [1]. In the horror game we designed, it became clear that surprise and novelty were critical to providing an intimidating, scary experience on the first play-through. In order to provide a sustained experience of fear and intimidation, we are working to develop additional variation and content. Procedural content generation and AI techniques were used in the original Root of Guilt desktop game, which may be explored further in iterations of the AR adaptation.

6.2 Limitations and future work

There are various limitations of this work, some of these include the size of the study, possible learning effect, lack of novelty across the conditions, design of the enemy NPCs, and data gathering. In terms of study size, we conducted many pilot studies as we iterated and refined the game, yet the study reported involved six participants. Although we intend to conduct additional studies with a larger number of participants, there were recurring patterns of participant claims and feedback, thus we believe and important next step is to first address the limitations of the study design first. In our study, we wanted participants to be able to compare across two conditions, yet the novelty diminished after the first condition and the participants learned how to complete the game very quickly. We are currently designing additional escape room environments with various puzzles to ensure the novelty of each play through is maintained and to reduce the learning effect. We also intend to run a larger study in a between subjects design in order understand the first impressions. Further refinement of the enemy NPCs are an important next step. While we strove for comparably scary enemies, we intend to explore many additional designs and then select more comparable characters perhaps through crowd-sourced ratings of each. In future studies we intend to gather physiological measures and first person video recordings to enable deeper analysis of the player experience and behaviors. There are examples of biofeedback used to adjust the game dynamically as in the zombie game, [5]. Recent research focused on adapting the horror game in realtime using advanced biofeedback. [3]

[3] https://cc.au.dk/en/recreational-fear-lab/

7 CONCLUSION

We set out to learn more about how players respond to intimidating game experiences in AR. In order to study this, we developed an escape room game with a supporting research platform that enabled us to explore various settings. We conducted a study in which participants raced against time under the threat of being captured by an enemy NPC in the form of a janitor or a robot. The findings suggest that the human-looking janitor was the most intimidating and additional feedback provided by the participants provides useful directions for refining the game and future studies.

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