Work-in-Progress: Enhancing Player Experience in Asymmetric Virtual Reality Gameplay

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Abstract— Interest in multiplayer games that allow players to connect and play with different technologies, such as virtual or augmented reality (VR/AR) has increased. Research has shown that in asymmetric gaming experiences (eg. where there are differences between the players' abilities or interfaces) it is possible to achieve an enhanced player experience (PX) through various interdependencies. However, most of the previous work focuses on co-located scenarios, where the space and proximity of the players are local and utilized. With this study, we investigate a remote asymmetric game setup, and we explore how asymmetries of space, user interface (UI), interaction design, role and abilities, and information access impact the PX and performance for users of different technologies (eg. VR, AR, PC).

Index Terms—Virtual reality, mixed/augmented reality, gameplay, narrative, multiplayer, asymmetric, cross-reality, VR, AR, MR

Introduction

Due to the current pandemic context, there has been a surge in interest in technology that allows people to connect, play, and collaborate, despite physical distance and restrictions. A technology area that has seen growth during the pandemic is multiplayer games [1]. Immersive technologies such as VR and AR have also seen an increase in adoption, as people were looking for ways to connect during the lockdowns and beyond [2]. Despite their immersive qualities, head mounted displays (HMDs) have also received criticism for their isolating characteristics, both socially and technologically [3] and for the discomfort they sometimes induce [4]. As a result of these limitations, VR research and design has started to look more and more into leveraging different systems for the design of novel interactions, which include bystanders and co-players. In this context, various types of asymmetries were considered from the asymmetry of player interfaces (rooted asymmetric multiplayer VR is relatively novel with only 25 relevant papers identified by a recent systematic review conducted by Rogers et al. [5], which proposes a framework based on the types of asymmetries designed in multiplayer VR games and on their impact on the player experience. The authors identified a set of opportunities for future work such as asymmetric VR games with more than two players, alternative interfaces, mirrored and unidirectional interdependence between players, remote play, or the need for more investigation of the social factors of player experience. With this study, our aim is to address some of these existing gaps by developing an asymmetric VR game that connects remote VR, AR, and PC users in a shared virtual environment. The application will be designed following the best practices recommended in [5], [6], [7], and [8]. This work-in-progress paper focuses on the workflow process of the development of the asymmetric VR game and provides some initial observations.

1 Related Work

Asymmetric VR gameplay has had significant research and development over the years [5]. Pereira et al. [8] proposed a et al. [6] provide guidelines when designing asymmetric interactions. The importance of asymmetry in interaction design is validated by Karaosmanoglu et al. [9]. Smilovitch and Lachman [10] developed an asymmetric game that focuses on interdependence and communication. Piumsomboon et al. [11] included in their research a collaborative interaction requiring both participants to interact with an object to reveal hidden information. Some of these related works will inform the design of my game, while others have uncovered some research gaps.

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2 Research Gaps

In their extensive systematic review of asymmetric gameplay in multiplayer VR games, Rogers et al. [5] identified a number of gaps and opportunities in this area. In existing studies, players are often co-located. Understanding how remote setups would influence the different aspects of PX is highlighted as an important direction as this creates new possibilities for increasing access. Therefore, with our system and experimental design we want to explore the challenges brought by space asymmetry in communication and social presence. Player experience in collaborative asymmetric VR games is greatly influenced by team dynamics and communication, but very few studies addressed this factor. This study will analyze the effectiveness of team communication as it relates to player experience and performance. According to [12], player experience is shaped by mechanics (the "rules of the game and interaction options), context (the device that is used, the physical setting, presence of others), and narrative (the story, plot, events, and characters). Unfortunately, player experience as it relates to narrative were not included in any of the papers reviewed in [5].

Our research questions aim to address these gaps by investigating:

- **RQ1:** How are different elements of the PX (team dynamics, communication, and performance) affected in a remote asymmetric game setup?
- **RQ2:** How are different elements of the PX (team dynamics, communication, and performance) affected by the embodiment and interactions afforded by VR, AR, and PC devices?

3 System Design

To answer our research questions, we have designed and developed *LabXscape*, a cross-reality escape room type experience where remote players cooperate using different technologies. To understand how the affordances of different technologies impact the PX, we implemented interactions for VR, AR, and PC. The affordances and limitations of each device have been considered when developing the asymmetric game.

The game is a narrative-based experience where each player needs to work together to prevent a catastrophic meltdown in a laboratory. The VR player has the role of the scientist, ultimately responsible for preventing the meltdown. The VR player cannot accomplish this without support from the other players. The AR player has the role of the robot that that supports the VR player, but unlike other studies [5, p. 11], the AR player has an active role which requires movement and interacting with the environment. The position and rotation of the AR player is based on the physical movement and rotation of the mobile device, resulting in the device acting as a window into the virtual environment. Due the potential of limited physical space, artificial locomotion has been included for both the VR and AR players. The PC player is in a security office observing the VR and AR players through security cameras. They are the holder of information on how the VR player can prevent the meltdown, but the information that they share will be based on what the VR and AR players see in the virtual environment, creating interdependence. Each player is physically separated and experiencing the game in a remote setting.

Each device has an avatar that creates a sense of embodiment and social presence. The VR player's avatar has full motion tracking and auditory and visual feedback when they talk (see Figure 1a). While the PC player does not have an avatar in the traditional sense, the sense of social presence is created as they scan and communicate through the security cameras. When the PC player rotates the cameras, this is seen and heard by the other players. When they are viewing through a particular camera, the red "record" light is on (see Figure 1b). The AR player's avatar is a hovering robot, which plays to the absence of hand-tracking on a mobile device. When the AR player talks, the others can hear and get visual feedback in the form of a light blinking (see Figure 1c). In both cases, the PC and AR players are not present in the virtual space, but through the devices are creating a window into the virtual environment. This window is diegetic, leverages the limitations of the devices, and ultimately draws the player into the experience.

The scenario is timed and has three specific tasks, requiring involvement from all the players. Each player will have access to information and abilities required for the tasks to be completed. Failure to communicate, follow instructions from team members, and work together will impact the outcome of the game and may cause the team to fail the challenge.

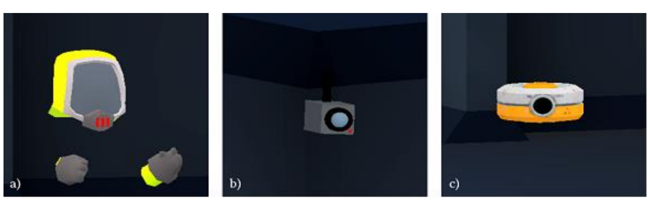

Fig 1. Visual representation of players using different devices. VR player (a), PC player (b), and AR player (c).

Task 1: Exit the Correct Door: There are three doors, but only one door is the correct one. The PC player can switch between security cameras and scan the corridors for obstructions (either a security drone or debris) as shown in Figure 2a. Once the correct door is identified and communicated to the VR and AR players in the lab, they will need work together to override the security lock on the door.

Task 2: Lower the Reactor Shield: Once the VR player can leave the lab, they will travel to the power grid panel (Figure 2b). There are a levers and buttons that need to be pulled and pressed in the correct configuration. The PC player has access to the required information. The configuration depends on the color of the reactor and the reactor shield. The color is communicated by the AR player to the PC player. With this information, the PC player can convey the correct configuration to the VR player. Once the VR player has made the correct adjustments, the reactor shield and glass are lowered (Figure 2c), which will be communicated by the AR player (as the reactor is out of the view of the PC player).

Task 3: Replace the Power Crystal: There is a table of many crystals to choose from (Figure 2d), but only one crystal is correct. The crystal that is used in the reactor will depend on the color of the reactor. Some of the crystals are depleted and will not work in the reactor, even if they are the correct color. The AR player can scan each crystal to see if it has energy, but they should only scan the color of crystal that is communicated by the PC player. Once the correct crystal has been identified, the VR player can grab it and insert it in the reactor, averting the critical meltdown.

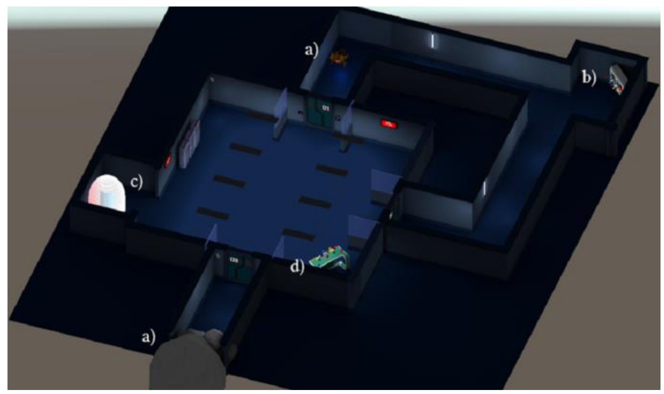

Fig. 2. Birds-eye view showing the layout of the asymmetric game

4 System Implementation

The game was developed using the Unity game engine (version 2020.3.9) with the following additional packages: XR Interaction Toolkit (VR) AR Foundation (AR), and Normcore (multiplayer). The VR device setup used an Oculus Quest 2 standalone device. The AR device setup used a Lenovo P11 Plus 11" tablet. The PC device setup used a Dell computer with a NVIDIA 2070 Super GPU and a 27" monitor. All players used over-the-ear headphones for spatialized audio and to improve immersion.

Players can verbally communicate with each other, despite virtual distances. Interaction and feedback sound effects are spatialized, which means that if a player does an interaction that causes a sound effect to be played as a response (eg. pulling a lever, which results in a click sound), only the player that is near the source of the sound will hear it.

5 User Study

The goal of this study is to determine how PX is affected when three players participate, each with a device with different affordances and limitations, in a remotely located asymmetric VR game. They study will be conducted with 24 participants. They will participate in groups of three. The device that they are assigned will be randomly selected using a simple random sampling approach [13].

5.1 Methodology

A mixed design was used for the study, with device (VR, AR, PC) as the independent variable. Sessions will be recorded for review and to conduct participant observation to identify non-verbal cues, such as facial expressions, as well as team dynamics, communication, and performance. Additional information on player experience that may not be volunteered during the other data collection methods can be gained during observation [14]. Following each gameplay session, each participant completed a survey which is a combination of a short version of the Game User Experience Satisfaction Scale (GUESS-18) [15] and a subset of the Multimodal Presence Scale (MPS) [16]. After the survey, a short semi-structured interview was conducted with each participant.

5.2 Participants

The study was conducted with 24 participants (15 male, 9 female) with the majority (37.5%) in the 35 – 44 age range. 87% of PC players were familiar or very familiar with computers, 50% of AR players had used AR 10 times or more, and 50% of VR players had used VR 10 times or more.

5.3 Procedure

At the beginning of the study, participants were provided a brief introduction to the overall research, the game scenario, and asked to sign a consent form. They were then provided with a role card that provided unique information about their role within the asymmetric game. Participants were then loaded into the game on the randomly assigned device. When all players were in the game, they could begin, and the video recording was started. Participants had 20 minutes to complete the three tasks and finish the game.

6 RESULTS

As this is a work-in-progress, comprehensive data analysis is currently in progress to understand if PC players and AR players felt as engaged and immersed in the asymmetric VR game, despite the limitations of their randomly assigned device.

Preliminary observations of participant interview data uncovered some enlightening quotes such as:

- "Even though I was in here *[referring to a computer lab],* I actually completely disengaged from most of it. I'm lucky I didn't run into one of the computers." – AR player
- "I also have a vivid imagination, so putting myself into a security officer role. This is my station. I can just for it." – PC player

Further thematic analysis will be conducted to identify patterns and factors that contribute to PX.

7 CONCLUSION

Asymmetric VR games is a growing industry. There are opportunities for these types of games beyond co-located gameplay and two devices. This study aims to identify how PX is affected when three devices, each with their own affordances and limitations, are introduced into a remote asymmetric VR game. As a result of this research, the intent is to develop a best practices document for developing remote asymmetric VR games and experiences. This best practices document will provide insights into avatar, environment, interaction, and narrative considerations required to improve PX in asymmetric VR games.x

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