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Investigating Player Experience of Displays in First-Person Shooter Horror Game Design

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ABSTRACT

Displays in games can be used to relay information in games and their design, and the granularity of information can vary and impact the player's experience. 5 displays of differing granularity were implemented within a custom horror FPS game, and a user study (N=20) was conducted to investigate their different effects on the player experience, immersion, anxiety, and performance. Recommendations and resulting impacts were presented to inform designers on what displays may achieve a certain experience. Results showed reducing the granularity of information can reduce readability, but also increase immersion, anxiety, and the perceived suitability for a horror game. Past research is criticised, suggesting it does not make sense to present the "best" display and is better to find the impact(s) it has on the experience so designers may choose what suits their game context.

1. INTRODUCTION

1.1 Motivation

Video games must provide feedback to players so they know what is happening within the game and react accordingly [21]. Feedback can communicate information such as resource amounts, successful actions, taking damage etc. [21], and is provided through various modalities (audio, visual and haptic) which impact the player experience [26, 11]. One crucial feedback type is game *displays*, which convey relevant information to the player, such as health, whilst playing the game [51, 26]. How these displays, and their information, are implemented within a game has been demonstrated to affect a player's experience, immersion, and performance [12, 47, 51].

One widely used *display* type is the Heads-Up Display (HUD), which is an overlay on the game itself. This allows players to read information persistently, existing outwith the fiction and virtual space of the game world and is often used to relay important data such as the player's health, resources, and progression [26, 51].

Alternative approaches also exist, including spatial representations, where information is represented spatially in the game world, meta perceptions, where information exists in the game fiction but not the game world (usually as an overlay), and diegetic displays, where information is represented spatially within the game world and fiction (e.g. an ammunition counter being displayed on a gun itself) [51, 26].

As video games vary considerably by genre and gameplay type, there exists no one-size-fits *display* applicable to all games across all genres [66]. The game genre can affect how players respond to different displays and other design elements, such as immersion or readability, but also what information is relevant to the player during gameplay [66]. As such, it is necessary to focus on both a specific genre of game and gameplay type when conducting games user research[65, 41, 53], to provide designers with clear insights into the consequences of using one display over another.

1.2 Problem Description

This project aimed to collate and provide empirically-backed information on how game displays, that communicate a player's health and ammunition, may affect the player experience and performance within the context of a horror first-person shooter (FPS) game. The aim was to investigate how changing the granularity of information, and display type itself, impacted the player experience as a whole, as well as immersion, anxiety, and stress. Additionally, the usability of the differing displays was explored through factors of perceived interpretability, and suitability for a horror FPS game.

This investigation did not aim to discover a *"definitive best display"* to be used in horror FPS games. Instead, it aimed to present the displays and any differences between them, so future designers can make informed decisions about which display best suits the needs of a specific experience. This approach was built upon the work of Peacocke et al.[51], which presented performance metrics of different displays within a specific game genre, and revised it to provide a more refined approach that gives more insight to designers.

To this end, a custom horror FPS game was built, and 5 display types were evaluated in a user study (N=20) which investigated the impacts of changing information granularity on the player experience. Results showed generally that reducing the amount of information can reduce readability, but also increase immersion and anxiety in a horror game. Finally, an overview of each display and its recommendations/effects was presented within the context of a horror FPS.

2. BACKGROUND

2.1 Games User Research

While research on games may focus on interaction[28], sound design[31] or aesthetic[44], this study focuses on player experience of game displays. Often referred to as *games user research* (GUR)[46, 29], this paper attempts to understand the impact of game design decisions in a particular context and utilises HCI research methods to do this. However, it is important to note the results are interpreted differently from traditional HCI studies, where high anxiety or stress may indicate poor UX design, but within GUR this just describes the effect of a particular design that a designer can intentionally use. For example, a designer may obfuscate a health display to increase players' stress, as they won't know how damaged they are or if the are close to death.

2.2 Player Experience & Immersion

It was necessary to select a measure of player experience and immersion for this project, but due to being a broad concept there are numerous methods, and several relevant examples have been detailed here. One widely used method of measuring player experience in previous research is the Player Experience Inventory (PXI) which is a questionnaire that can aid in understanding "how players experience your game", but also help provide insight into how game design decisions may impact player actions and emotional responses[10, 6, 34]. The PXI uses several constructs including immersion, ease of control, mastery and several others, measured each from the average of three Likert scale questions of agreement/disagreement.

More specifically within the context of horror games, researchers will often measure more intense emotional responses to games such as stress and anxiety. Measuring such responses can be done by recording physiological responses such as heart rate, electrical brain signals, facial expression analysis, and machine learning solutions [48]. Ferreira et al. measured physiological signals to research how horror game interaction can affect anxiety[28]. These solutions usually require additional equipment and time, so interviews and self-reporting can also be used to gain insight into a player's emotional responses[48]. The Beck Anxiety Inventory (BAI) is used most commonly for investigating symptoms of anxiety as a whole but can be adapted and used within the context of a game experience to gather results on how stressful or anxiety-inducing the player experience may be[1].

Players also tend to experience some level of immersion whilst playing a game, which can imply a "deep and positive game experience" that causes people to use their "real world perception and reasoning skills or emotions", or perhaps even "voluntarily adopt the game world" as a real one[26]. Increased immersion can imply a highly engaging game, that allows players to emotionally invest in it[14].

2.3 Player Performance

Player performance is another important aspect that can be measured when investigating different game design decisions and can be measured in various ways. What constitutes as relevant or "good" performance metrics can often depend on the context of the game and the objectives and gameplay aspects being investigated. In past studies, a broader definition has been given as "a quantitative outcome to a given task", and metrics such as completion time, failure counts, in-game score, progress, and reaction times have been used[20, 51, 22, 56]. This ambiguity of performance is even more present when in the context of a horror game, compared to a more competitive FPS for example. Therefore, when approaching it for this study it was deemed more relevant to use performance measures in terms of cause and effect, and the insight they can give alongside the player experience.

Hicks et al. utilised performance measures including *kills, deaths, levels completed, attack accuracy,* and *score*, while investigating game visual embellishments and found performance was unaffected[34]. Another paper investigated different FPS displays via measures such as *error rates*, *completion times*, and other bespoke metrics specific to the experiment(s) context, finding performance was affected by different properties of displays[51]. Both of these examples relied on the specific context of the user study, so the performance measures in this project were considered relative to the experiment and displays.

2.4 Game Displays

Games use a range of different displays to present relevant data to the player through information visualisation and play an integral role in games [40, 66].

One of the most relevant studies is an article which compared player performance across several different FPS information displays[51]. The displays included traditional HUDs, diegetic displays, and spatial representations. They conducted a series of experiments on them within common FPS task contexts including monitoring weapon ammunition and player health, matching a weapon to a certain situation, and navigating a level. The results suggested that specific properties of a display's information technique such as "word, icon, number, bar" as well as its position (to a "lesser extent"), can impact the player performance providing that the display is related to the "task at hand"[51]. It suggests that when considering performance and preference, the "game world and tasks" should be the main considerations when designing a display method[51]. This is being examined primarily within the context of performance and does not consider aspects of the player experience.

A game display can be altered/changed, including the display type, but also the technique by which information is presented. These different techniques can often differ in the granularity of information, where different methods may be more or less granular depending on how specific or vague they are. For example, a health display may utilise a numerical display that offers a higher and more precise level of granularity than a health bar, which gives a more ambiguous representation of remaining health. This idea of granularity of displays has not been isolated and researched concerning the player experience, and this project aimed to garner a better understanding of any possible implications and effects it may have.

With fewer display elements (and potentially less granularity) there may be less for the player to focus on "at the expense of lack of information", compared to increased display elements reducing "the player's focus on the game" [50]. Some have said that traditional HUD interferes with the immersion of players when compared to alternative diegetic displays[27, 5], but traditional HUD is also often considered necessary in providing the player with information and does not always affect immersion[26, 3].

2.5 Horror Game Design

It is especially relevant for horror game designers to know and predict the effects of game design decisions on the player experience, as horror games usually rely on specific emotional reactions as a core element of the game experience[39]. Horror games are inherently well-suited to researching aspects of the player experience such as anxiety and immersion, as the genre commonly provides some form of emotional, stressful and immersive game experience to players[31].

There is a range of differing games that can be considered a part of the horror genre, from cinematic linear games like P.T and Outlast [43][54], to more action-oriented shooters like the Resident Evil and Doom franchises[15][36], and even horror-lite titles like Luigis Mansion[49]. Horror games make use of different design techniques to create emotional experiences for players, including sound design, lighting, non-playable characters (NPCs), perspective, and visuals [28, 32]. Despite this, there is minimal work investigating game displays concerning the player experience in horror games, and how they may affect players' reactions and interactions within them.

Game displays in a horror context do not follow one set of conventions, and the types and information techniques used vary across different games in the genre. For example, when comparing two recent horror games, Resident Evil 4 (2023)[18] and Dead Space (2023)[24], several differences between their information displays can be observed despite the two games both being third-person horror shooters. Resident Evil 4 uses a minimal and traditional HUD to display player health and ammunition and uses numbers for ammunition but a bar for health. Alternatively, Dead Space opts for a spatially diegetic display approach that uses a gun-mounted "hologram" display with numbers once again for ammunition, and also uses a bar to represent health but in the form of lights on the player character's armour.

3. GAME DESIGN

A custom horror FPS, *"Crimson Undead"*, was designed and created to investigate the effect of differing information granularity of game displays on the player experience. In *Crimson Undead*, players are tasked with hunting and killing zombies within a fixed time limit inside a mansion. The creation game was necessary due to a lack of open-source games meeting the criteria for the study.

Horror settings vary considerably aesthetically, from space stations[24] to spooky mansions[16], and spatially from small, self-contained locations to wide open spaces[55]. For *Crimson Undead*, the interior of a large mansion with an American Gothic aesthetic was chosen. The mansion consisted of multiple rooms and corridors to increase tension via restricted movement and tight spaces (e.g. narrow hallways and dead ends) and an overview of the level map and layout can be seen in Figure 1. The layout takes inspiration from existing games in the horror genre such as Resident Evil 7[16], which is set within a large house with a dense assortment of rooms. An American Gothic aesthetic was used throughout the game, for the architecture, interior design, and general art direction, and is also present in Resident Evil 7 [44, 64, 33]

Games used within GUR often vary in the fidelity of their implementation, from placeholder low-quality environments to more polished experiences[61]. Within the context of a horror game, it is important that the game would still create an atmospheric experience for participants to properly engage them within the study [42]. For example, suppose a low-fidelity prototype was created with grey box environments and characters. In that case, participants may focus their feedback of the horror experience onto the reduced fidelity, instead of the evaluated displays. Therefore it was decided it was necessary to create a higher-fidelity prototype for the user study, that participants would find more authentic and believable as a horror game, thus providing more reliable and generalisable results. To achieve this, important aspects of game design that needed to be considered concerning the game's authenticity, including sounds, textures, visual effects, animations, and overall feel.

Figure 1: The map layout and level design.

3.1 Player Information

The game needed to include 2 player resources integral to horror and FPS games as a whole, player health and weapon ammunition[66, 13, 30]. This is the information to be relayed to the player through the different game displays being investigated (see Section 4). In *Crimson Undead*, health was measured out of 100 health points (HP), as is common in FPS games (e.g. [62]), and when the health reached 0 HP the player would die and subsequently respawn in a fixed player spawn location. For ammunition, the player's weapon (a pistol) held 10 bullets per magazine with a reserve of 60 bullets. While health only required one item of information, the ammunition required two when relaying the bullets in both the current magazine and the total reserve.

3.2 Enemies

Zombies were chosen as the main enemy/threat that the player faced during the gameplay, due to their longstanding usage within the horror genre[23]. The zombies were designed to roam the map and pursue the player to attack them once close enough. To achieve this, three main states were used: a passive "roaming" state where the enemy will randomly walk around to anywhere they can reach, an active "attacking"/"pursuing" state where the enemy can see the player and will actively try to chase them and attack them when close enough, and a "searching" state where the enemy was pursuing the player but can no longer see them they will be able to move towards the player's location for a few seconds before giving up and returning to their "roaming" state.

The zombies move at the same speed as the player when they are walking, allowing the player to distance themselves by using the player's sprint functionality. To ensure it was not too easy to escape a zombie's pursuit, a zombie will start to run when the player is far enough away, but upon getting closer will slow down again. This design was created to increase the pressure and tension of being chased during gameplay, a common method of creating pressure and tension in horror games such as Outlast[54].

When close enough to the player the zombies attempt to damage the player using a melee attack, and if successful in hitting the player, 20 HP of damage is dealt to their total health. 20 HP of damage was chosen so that players would be able to survive 5 hits from full health before dying; ensuring players had sufficient scope to engage with the health display relaying varying amounts of health to the player. The ability to survive 5 hits before dying also provided a challenging but fair experience for the player, one where they could be overwhelmed if not cautious but could succeed if careful.

3.3 Combat & Movement

Although many shooter games provide the player with various weapons and methods for defeating enemies and defending themselves, it is common for the opening levels to start with a basic weapon like a pistol. This is especially true in the horror genre of games, e.g. games including Resident Evil 2[17], Doom 3[37], and BioShock[9]. Therefore, the decision was made to restrict players to only one weapon, a pistol, in the game. This ensured that all participants were exposed to the same combat system throughout the study, reducing any potential noise from players using different weapons across conditions, and allowing for easier comparisons of displays. The pistol was designed to be easy to use, and let players aim and shoot with a crosshair in the centre of the screen (using the mouse), without any additional aiming down sights mechanics, similar to Doom[38], and Left 4 Dead 2[63].

The pistol's ammunition held 10 bullets per magazine with the zombies requiring 5 bullets of damage to be eliminated, meaning a player with perfect aim can defeat 2 enemies before needing to reload. This requirement for perfect aim to eliminate 2 enemies in combat was chosen to lead to tenser situations during combat where players would be forced to reload if a shot was missed.

Players could reload by pressing "R" if 9 or fewer bullets remained in the magazine, provided there was sufficient ammunition in reserve to reload with. Players were given a reserve of 60 bullets which allowed for eliminating 12 enemies with perfect aim before needing to pick up more bullets.

Though the focus of the gameplay was based on shooting, its design was intended to be slower-paced. For example, similar to the combat speed of Resident Evil 7[16], where a slower movement speed makes the game more tense and stressful compared to the faster-paced Doom franchise that focuses more on the action[36]. Therefore, the player's movement speed was controlled to be slow-paced to allow for more tension and atmosphere to build. Players were provided with a means of escaping a group of enemies to avoid being overwhelmed and so were provided with the ability to sprint. However, to further create suspense, players' actions while sprinting were limited such that they were unable to shoot their gun or reload whilst sprinting, forcing them to either run away, or slow down and fight.

3.4 Interactions

Players were provided with the ability to refill their health and reserve ammunition via pickup med-kits and ammo boxes scattered throughout the level. These interactions related directly to the game displays, as it meant players were forced to pay closer attention to their health and ammunition by needing to consider when to heal/refill their resources.

Additionally, most rooms within the level had doors that could be opened or closed by the player. This provided players with the ability to control zombies, who could not open doors, but also provided an element of suspense from opening a door to a room without knowing what, if anything, was inside.

All interactions (picking up health/ammo or opening/closing doors) used contextual prompts on-screen to inform the player when they could interact with an object. The input key of "E" was used to interact with all objects within the game.

3.5 Gameplay & User Study Considerations

The gameplay tasked players with hunting and killing zombies located throughout the level. This provided participants with a task that required them to interact with the display conditions being evaluated by managing their health and ammunition during gameplay.

To ensure participants experienced equal exposure to each condition during the study, a timer-controlled, "survival mode" gameplay design[8] was chosen, inspired by the wave-based Call of Duty Zombies mode[60]. This tasked the player with defeating as many "waves" of enemies within a 4-minute time limit for each condition being evaluated. This ensured participants of differing skill levels would experience the conditions for the same amount of time. Each enemy wave consisted of 10 zombies. Upon defeating all 10 enemies within a wave, a short countdown alert notified players that another "wave" of enemies would spawn. To ensure players did not learn the enemies' spawn locations, the zombie spawn points were distributed semi-randomly from a set of possible spawn configurations each time a wave of enemies was spawned. These configurations were designed so that zombies could spawn in different rooms in groups of different sizes ranging from 1 to 3.

Finally, upon starting each condition participants were spawned in a small introduction room where through on-screen text instructions: the display type being evaluated was explained to the participant, and players were familiarised with the relevant gameplay mechanics (e.g. *refill ammunition from ammo box*, *reload gun*, *shoot a target*, and *heal using a med-kit* (after being artificially damaged)). Upon completing this introduction, the door of the small room players began each condition in was opened and the 4-minute condition timer started.

4. DISPLAY CONDITION DESIGN

To investigate the effect of differing display granularity on the player experience, 5 displays were designed to convey both health and ammunition to the player. Health and ammunition, in practice, relay varying amounts of information to the player, with health being *one* important piece of information and ammunition including the current magazine *and* the reserve bullet counts.

The five displays were designed to differ based on the level of granularity of information present in each display's information representation technique. The final designs were inspired by existing industry display techniques, as well as novel alternative solutions, and the two display types present were: traditional HUDs and diegetic displays.

Three of the designs took the form of a traditional HUD overlay display, with granular differences in their design relaying the health/ammunition information, including the use of numbers, continuous bars, and discrete icons. A fourth display utilised a diegetic display type to better fit a lower granularity, making use of colour within the fiction of the game world. The fifth display provided no additional visual information to the player at all and thus does not have a definitive display type.

The 5 different display conditions (descending in order of granularity from the most information to least) are as follows for both health and ammunition information: ***Numerical*** (Traditional HUD), ***Discrete*** (Traditional HUD), ***Continuous*** (Traditional HUD), ***Hue*** (Diegetic Display), and ***None*** (No Health or Ammunition Display Whatsoever).

Screenshots of all displays can be seen in Figure 2, and a demo reel showcasing the different displays is provided on YouTube[1].

4.1 Traditional HUDs

The ***numerical*** display condition makes use of whole numbers to visualise the health and ammunition information *numerically* and has the highest granularity of player information out of all the displays. When the player is damaged by an enemy in this condition the health display would change from "100/100" to "80/100". For ammunition, if the player shoots once, the magazine display would change from "10/10" to "9/10", and if the player reloads the magazine would change from "0/10" to "10/10", and the reserve would change from "60" to "50".

The ***discrete*** display visualises health and ammo with individual or *discrete* heart and bullet icons respectively, taking a slightly less granular approach. When damaged, the *discrete* display would reflect this by changing from 5 full heart icons to 4 full heart icons. When shooting, the display would change from 10 bullet icons to 9 bullet icons, and when reloading the bullet icons would refill to 10 from 0 and the reserve would change from 6 magazine icons to 5. Additionally, "spare bullets" in the reserve that wouldn't fill a magazine were represented at the end of the magazine icons as smaller bullet icons.

The ***continuous*** display reduces the granularity even further by making use of continuous bars to represent both health and ammunition. When taking damage, the *continuous* condition would communicate this via the health bar changing from being 100% full to 80% full. When shooting, the current magazine bar would go from 100% full to 90% full, and when reloading the current magazine bar would go from 0% fill to 100% fill, while the reserve magazine icons would change from 6 full magazines to 5. Extra reserve bullets were represented by the last magazine icon being only partially full (e.g. 4 extra bullets = 40% full magazine in the reserve).

All these displays were implemented using an overlay traditional HUD type. In terms of the layout, multiple other FPS games' HUDs were examined and the most common

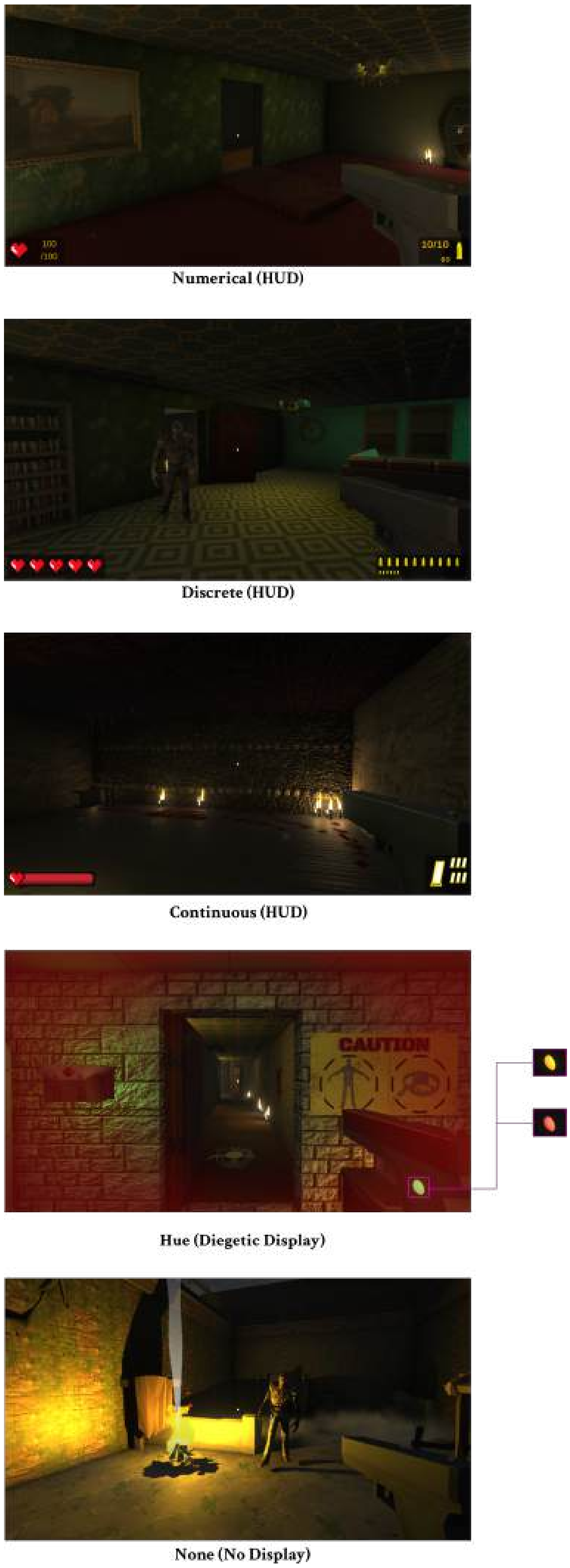

Figure 2: All five display conditions in order of granularity descending. NOTE: The *hue* diegetic display is shown when the player has low health, and low ammunition in their current magazine, with a nearly full reserve.

[1]https://www.youtube.com/watch?v=SsdlVVLu4g0

convention when it came to ammunition and health seemed to be to display the health in the bottom left and the ammunition on the bottom right. Additionally, all the traditional HUDs used the same colour scheme and shared similar iconography. The colours and layout were inspired by existing FPS HUDs like the one used in Half-Life 2[62], and Doom (2016)[38] due to their simplicity and adaptability.

4.2 Hue Diegetic Display

The granularity of information was once again decreased by using colour intensity and hue to represent health and ammunition. For the hue display a slightly different approach was taken compared to the traditional HUD. It was decided to create a diegetic display with spatial elements and meta perceptions for ammunition and health, both because the low granularity was deemed well suited to a more minimal, stripped back, and diegetic display, but also due to the popularity of alternative display types within commercial games, especially horror.

For the health information, a meta perception screen overlay is used via a red-hued vignette that increases in intensity (and decreases in transparency) proportionally to the player's remaining health and is initially fully transparent when at full health. This was informed by the common practice of using a "blood splatter" or red overlay for health in games such as the Call of Duty franchise[60] and once again Resident Evil 7[16]. When the player takes 20HP damage at full health, the health vignette goes from 0% opacity (cannot be seen at all) to 20% opacity, increasing in intensity as player health decreases.

The ammunition information was represented spatially directly on the gun model, and just like the other conditions, it was necessary to represent the current magazine *and* the reserve amount. The top, or "slide", of the pistol increases in its red hue proportional to how many bullets have been shot from the current magazine, and similarly to the health, there is no visible red hue at all when the magazine is full. The reserve ammunition display is located on the gun handle and is represented by a small LED light, and instead of a single hue increasing in intensity, a traffic light encoding was utilised in which: *green* = mostly full or full, *yellow* = a roughly half full, and *red* = mostly empty or empty. When a player shoots a bullet with a full magazine, the red texture on the gun increases from 0% opacity (completely invisible) to 10% opacity, and when reloading the slide goes from 100% opacity (fully red) to 0% opacity and the reserve LED goes from green to yellow (assuming reserve was 40 and reloaded to 30).

4.3 None Display

The ***none*** display condition was designed to embody the extreme minimal possible display granularity experienced by a player. That is, no information about the health or ammo being displayed to them at any time in any way. Instead, players are required to manually track any change in their health/ammo during gameplay, e.g. a player would be required to remember if they had taken 20HP of damage and decreased from 100 HP to 80 HP.

Although less common, this has been done for displays in games such as Outlast and Inside[54, 52].

5. IMPLEMENTATION

The game and display conditions were implemented using the Unity game engine (Version 2021.3.8f1). The Unity game engine was chosen due to its wide range of development options and documentation, and it is widely used by developers and researchers alike. Most of the game's functionality is driven by C# scripts that manage everything from player health and ammunition and their corresponding displays, to how the player can control and interact with the game. Unity has built-in tools for AI and a NavMesh Agent[58] was used as a foundation for all the enemies to be able to navigate the map, with additional required states being built on top. Another key element was RayCasts[59], which aided in the aiming and shooting of the player's gun as well as checking if enemies could see the player.

The *numerical, discrete, continuous* displays (health and ammo), and *hue* display (health only), were implemented as an overlay using the Unity Canvas and UI system. Artwork using recognisable iconography for health and ammo was created using Figma[4]. The *hue* ammunition display effect was implemented by modifying the 3D model of the pistol itself. *None* was just implemented by disabling all displayed information.

To create a sufficiently high-fidelity and atmospheric experience, models, textures, animations, lighting, and sound were utilised. An array of assets (e.g. the zombie models) were acquired from the Unity Asset Store[7], under a Creative Commons 0 license[2], but many game elements were handmade as well.

Animations were created/utilised throughout the game to create a fluid gameplay experience. This included animations for shooting, reloading, running, idling, and dying, as well as enemy walking, running, attacking, death animations, and doors opening/closing.

Lighting and visual effects were used across the level to create a more suspenseful horror atmosphere. The game was set at night and dimly lit with the use of many real-time light sources (e.g. candles) that would cast shadows of enemies against walls. Rain and fog effects were used in the outside area, with dust particle effects used inside. Unity post-processing effects such as ambient occlusion, bloom, and film grain were added to solidify a cinematic aesthetic.

Sound design was also important so that the visuals were reinforced with equally atmospheric audio, and background music and sound effects were utilised. Spatial audio was used for all sound effects and ambience to increase immersion and tension and allow players to determine sound direction. These sound effects included (but were not limited to): zombie noises, footsteps, gun sounds, and ambient environmental sounds like rain and thunder, clocks ticking, and TV static when near certain areas. Several ambient music tracks suited to the genre were implemented to play as background music during the gameplay to add to the overall tone.

As a contribution of this paper, and in the interest of encouraging replicability of future GUR, the source code is available on GitHub[2] and the final build is available to download and play on itch.io[3].

6. STUDY DESIGN

A user study was designed to investigate the five designed

[2] `https://github.com/harvey240/CrimsonUndeadFPSHorrorGame`
[3] `https://harvee.itch.io/crimson-undead`

display types within a horror game context to investigate what impact, if any, the different displays would have on player experience and performance. A within-subjects design allowed for direct comparisons between the display conditions and condition order was counterbalanced using a perfect Latin Square. The study was designed and conducted within the ethics checklist of the University of Glasgow (included in full in Appendix A.

6.1 Questionnaire Measures

A questionnaire was designed for the study to evaluate the player experience per display condition, as well as their preferences and thoughts after experiencing all conditions. All the per-condition questions made use of a 7-point Likert scale in terms of agreement with statements (-3=Strongly Disagree, 0=Neither Disagree nor Agree, 3=Strongly Agree).

It was decided that not all of the constructs measured in the PXI[6] were relevant to this study, and therefore only relevant constructs and their corresponding questions were kept when including them in the questionnaire; creating a variant of the PXI. Each construct consists of three related questions from which the mean represents the corresponding construct, and for brevity, the individual questions have not been listed here. It is common practice within existing research to use constructs most relevant to the investigation[34].

To investigate participants' stress, fear, and anxiety overall it was decided that several questions from the BAI[1] would be suitable, with some slight rewording to pivot the context to experiences within a video game instead of real life. Likert-scale display-specific questions were also asked to isolate the display conditions specifically and investigate how players' stress managing resources, readability, visual appeal, and horror suitability were changed across them, and between health and ammunition too. Ranking questions were also devised for general preference, immersion, and readability, to give insight into other results and explore how player preference may differ across conditions. Finally, open-ended questions were included to explore the opinions and justifications of participants in the context of game displays.

(A) PXI (Variant) Questions: The constructs that were kept for use in the questionnaire were: (1) *"Meaning"*, (2) *"Mastery"*, (3) *"Immersion"*, (4) "Autonomy", (5) *"Ease of Control"*, (6) *"Challenge"*, (7) *"Audiovisual Appeal"*, and (8) *"Enjoyment"*.

(B) BAI (Variant) Questions: 6 questions adapted from the BAI concerning stress and fear (1) *"I felt that my heart was pounding/racing"*, (2) *"I felt a sense of urgency"*, (3) *"I felt unsteady"*, (4) *"I felt scared"*, (5) *"I felt afraid of dying in-game"*, and (6) *"I felt comfortable"*.

(C) Display Specific Questions: 8 questions that directly reference the health and ammunition displays were used to evaluate stress managing resources, readability, visual appeal, and suitability for horror, for the displays specifically: (1) *"The ammunition information was clearly readable"*, (2) *"The ammunition display was visually pleasing"*, (3) *"The ammunition display is well suited to a horror game"*, (4) *"The health information was clearly readable"*, (5) *"The health display was visually pleasing"*, and (6) *"The health display is well suited to a horror game"*, (7) *"I felt stressed about managing my health"*, and (8) *"I felt stressed about managing my ammunition"*.

(D) Ranking Questions: After experiencing all 5 conditions participants are then prompted to rank the different displays from most to least preferred (1=most preferred, 5=least preferred) separately for ammunition and health in the following ways: (*Health*) *"Please rank the different health display conditions that you played with in terms of "* (1) *"your general preference"*, (2) *"how easily readable you found them"*, (3) *how immersive you found them"*, and (*Ammunition*) *"Please rank the different ammunition display conditions that you played with in terms of "* (4) *"your general preference"*, (5) *"how easily readable you found them"*, (6) *how immersive you found them"*.

(E) Open-Ended Questions: Finally, at the end of the questionnaire 2 final open-ended questions are included to ask: (1) *"Would you like games to offer options for a game's display or would you prefer designers to make these decisions exclusively? Why?"*, and (2) *"What kind of Information Displays/HUD do you think is best suited to a horror game context? Why? (This could be a combination of things if you prefer)"*.

6.2 Performance Measures

Although the main focus was to investigate the player experience, several performance measures were gathered automatically for each participant and each condition. Due to the fixed time for each condition, it was not possible to include any completion time metrics, so several counts were gathered: *death count*, *kill count*, *reload count*, and *heal count.*

Additionally, 2 novel performance metrics were created and proposed as part of the study's contribution for use in future research as a measure that provides an indication of player performance and how aware the player is of a resource. The *wastage* of player resources was calculated as a percentage value that indicates how much of a resource is "wasted" when performing an action such as healing or reloading and builds on the idea that healing/reloading with more health/bullets is less efficient and more "wastage" may indicate less awareness of resources. *Health wastage*(1) is calculated when a player uses a med-kit to heal, where n is the amount of health recovered by a med-kit (80HP), and r_{health} is the amount of remaining health (greater than $100 - 80 = 20$) at the time of healing. *Ammunition wastage*(2) is calculated when a player reloads their magazine, where n is the number of bullets in a magazine (10), and r_{ammo} is the number of bullets remaining in the gun when reloading. For both metrics the mean value is calculated and saved per condition playthrough.

$$wastage_{health} = (r_{health}/n) \times 100 \tag{1}$$

$$wastage_{ammo} = (r_{ammo}/n) \times 100 \tag{2}$$

6.3 Procedure

Upon arriving at the experiment, it was explained to participants that the study aimed to investigate their experience using different representations of health and ammunition information within a horror FPS game. Participants were then given an intro sheet, provided informed consent, their demographic information was captured, and the controls of the game were explained to them (see Figure B1). Participants were instructed to play the game as they normally would any other and were told their objective within the game was to explore and hunt down zombies but to ensure they paid attention to their health and ammunition whilst playing. Participants were then told to begin the study and loaded into the tutorial room for the first display being evaluated. The experimenter then briefly explained the functionality of the health and ammunition system as the participant completed the tutorial tasks.

When completing the first condition, participants then completed a questionnaire containing the *PXI (Variant) Questions, BAI (Variant) Questions*, and the *Display Specific Questions*. Participants were instructed to think aloud while doing this and to provide their opinion of the experienced condition and the experimenter recorded any comments made. A game script collected the performance measures associated with the condition and exported these in a text format for later analysis. Upon completing this evaluation, the process was repeated for the remaining conditions. After all conditions were evaluated participants completed a questionnaire containing the *Ranking* and *Open-Ended* Questions.

The experiment took approximately 45 minutes to complete. Participants gave informed consent. A PC with a mouse and keyboard was used to conduct the study. Headphones were also provided to the participants to take full advantage of the game's sound design and atmosphere.

7. RESULTS

7.1 Analysis

For the PXI, BAI, and display-specific Likert-scale questions, the mean and standard deviation values were calculated, and then a Friedman test was used to find any significant differences between display conditions. Finally, pairwise comparisons were conducted using Wilcoxon Signed Rank tests with Bonferroni corrected p-values (p=0.005 as there are 5 display conditions). The weighted average ranking score for each ranking question for health and ammunition displays was calculated to find overall rankings. For the think aloud comments and open-ended questions, participants' comments were coded using initial coding[57] and broken up into emergent codes via repeated cycles and the codes were grouped using a thematic approach. For the performance results, mean and standard deviation values were calculated for all metrics, as well as additional ratios that were calculated based on mean count values. The *kill/death* ratio aimed to measure a player's combat effectiveness, the *reload/kill* ratio aimed to give insight into players' decision-making surrounding ammunition, and the *heal/death* ratio aimed to reflect players' decision-making surrounding health management.

7.2 Participant Demographic Data

Participants were recruited through social media. 20 participants completed the study (17 men, 2 women, and 1 Non-Binary Individual) aged between 22 and 42 (M=24.45, SD=5.78). Prior experience/familiarity was measured via a 5-point Likert scale (1=Very Familiar, 5=Not Familiar At All), in terms of horror games (M=2.45, SD=0.94), FPS games (M=2.05, SD=1.23), and using a mouse and keyboard as a game input method (M=2.3, SD=1.26). Additionally, participants were asked how often they played video games from the following options: *Daily* (n=2), *Several times a week* (n=12), *Several times a month* (n=3), *Several times a year* (n=3), and *Never* (n=0).

7.3 PXI (Variant) Results

Psychological PXI Consequences Mean (Std) Values	Meaning	Mastery	Immersion	Autonomy
(1)Numerical	1.6 (1.2)	2.05 (1.11)	1.85 (1.02)	1.97 (1.16)
(2)Discrete	1.55 (1.16)	2.07 (0.95)	2 (0.79)	1.78 (1.39)
(3)Continuous	1.68 (1.14)	1.92 (1.11)	2.02 (0.91)	1.87 (1.03)
(4)Hue	1.63 (1.25)	1.75 (1.28)	2.03 (0.83)	1.95 (0.91)
(5)None	1.47 (1.22)	1.7 (1.31)	2.12 (0.94)	1.72 (0.83)
Friedman Test	$\chi^2(5) = 1.74$, $p = 0.78$	$\chi^2(5) = 9.35$, $p = 0.05$	$\chi^2(5) = 2.14$, $p = 0.71$	$\chi^2(5) = 4.40$, $p = 0.35$
Wilcoxon Post-hoc ($p < 0.005$)	N/A	N/A	N/A	N/A

Table 1: Mean (standard deviation) values for the PXI Psychological Consequences (-3=strongly disagree, 3=strongly agree). A heatmap ranges from red (lowest) to green (highest) for the mean values *per condition.* Note: each construct is calculated from 3 the mean of the means of 3 relevant questions from the PXI questionnaire

Functional & Enjoyment PXI Consequences Mean (Std) Values	Ease of Control	Challenge	AudioVisual Appeal	Enjoyment
(1)Numerical	2.38 (0.62)	1.13 (1.51)	2.2 (0.9)	2.35 (0.72)
(2)Discrete	2.37 (0.54)	1.35 (1.48)	2.18 (0.99)	2.27 (0.71)
(3)Continuous	2.28 (0.73)	1.47 (1.28)	2.13 (0.89)	2.32 (0.7)
(4)Hue	2.35 (0.7)	1.57 (1.1)	2.18 (0.87)	2.27 (0.88)
(5)None	2.22 (0.84)	1.43 (1.3)	2.18 (0.87)	2.33 (0.61)
Friedman Test	$\chi^2(5) = 1.07$, $p = 0.90$	$\chi^2(5) = 3.77$, $p = 0.44$	$\chi^2(5) = 2.33$, $p = 0.68$	$\chi^2(5) = 1.06$, $p = 0.90$
Wilcoxon Post-hoc ($p < 0.005$)	N/A	N/A	N/A	N/A

Table 2: Mean (standard deviation) values for the PXI Functional Consequences (-3=strongly disagree, 3=strongly agree). A heatmap ranges from red (lowest) to green (highest) for the mean values *per condition.* Note: each construct is calculated from 3 the mean of the means of 3 relevant questions from the PXI questionnaire

The PXI constructs' mean, standard deviation values and statistical differences between pairwise comparisons are summarised in Table 1 (Psychological Consequences) and Table 2 (Functional and Enjoyment Consequences). There were no statistically significant differences between conditions for *all* the PXI constructs, likely due to the questionnaire being a broader measure of the sum of all the game's parts.

For all conditions, mean score values were positive and around 2, implying a unanimous level of agreement with the constructs. Notably *immersion*, *audiovisual appeal*, and *enjoyment* scoring highly across the displays highlight that an immersive, and sufficiently detailed game was successfully achieved as intended.

For *Meaning*, all conditions had similar scores of agreement. *Mastery* notably decreased as the granularity of information decreased through each condition from *numerical* to *none*. Conversely, *immersion* increased as granularity decreased and the greatest difference was between *numerical* and *none* displays. *Autonomy* had similar scores for all conditions.

Ease of control generally appeared to decrease as granularity decreased, with a slight increase for *hue*. *Challenge* generally appeared to increase along with the decrease in granularity. The *audiovisual appeal* was all fairly similar scores. *Enjoyment*, similarly, had similar scores.

7.4 BAI (Variant) Results

BAI Questions Mean (Std) Values	Heart Pounding	Urgency	Unsteadiness	Scaredness/Fear	Fear of Dying In-Game	Comfort
(1)Numerical	-0.25 (1.62)	0.35 (1.9)	-0.3 (1.89)	-0.05 (1.76)	0.15 (1.87)	1.25 (1.29)
(2)Discrete	0 (1.59)	0.5 (1.88)	-0.1 (1.48)	0.3 (1.34)	0.5 (1.7)	1.5 (1.28)
(3)Continuous	0.1 (1.86)	0.45 (1.61)	-0.25 (1.65)	0.1 (1.8)	0.55 (1.85)	1.25 (1.21)
(4)Hue	0.4 (1.57)	1.5 (0.95)	0.2 (1.44)	0.45 (1.54)	1.7 (0.86)	1 (1.49)
(5)None	0.1 (1.68)	0.95 (1.36)	0.35 (1.57)	0.55 (1.5)	1.05 (1.64)	0.45 (1.64)
Friedman Test	$\chi^2(5) = 3.05$, $p = 0.55$	$\chi^2(5) = 10.57$, $p = 0.03$	$\chi^2(5) = 3.47$, $p = 0.48$	$\chi^2(5) = 7.03$, $p = 0.13$	$\chi^2(5) = 13.34$, $p < 0.005$	$\chi^2(5) = 9.39$, $p = 0.05$
Wilcoxon Post-hoc ($p < 0.005$)	N/A	3-4	N/A	N/A	1-4, 2-4, 3-4	N/A

Table 3: Mean (standard deviation) values for the BAI Variant Questions (-3=strongly disagree, 3=strongly agree). A heatmap ranges from red (lowest) to green (highest) for the mean values *per condition*.

The BAI questions' mean standard deviation values and statistical differences between pairwise comparisons can be seen in Table 3.

For *heart pounding,* most values were similar but *numerical* scored lowest (mean=-0.25) while *hue* scored highest, and there were no significant differences. For *urgency*, it seemed to increase with granularity up until *hue* and then decreased slightly again for *none*, and there was one significant difference between the granularity adjacent *continuous* and *hue* conditions. For *unsteadiness*, it generally increased as granularity decreased, but there were no significant differences. For *Scaredness/Fear*, it generally increased as granularity decreased, with no significant differences. The *fear of dying in-game* appeared to increase as granularity decreased, and there were significant differences between *hue* and *numerical*, *discrete*, *continuous*. For *comfort*, most values are similar but *none* and *discrete* had the lowest and highest values repsectively.

7.5 Display Specific Question Results

Health Display-Specific Questions Mean (Std) Values	Stress Managing Health	Readability	Visual Appeal	Suitability for Horror
(1)Numerical	-0.15 (2.03)	2.45 (1.15)	0.55 (1.93)	-0.3 (1.98)
(2)Discrete	0.2 (1.64)	2.5 (1.15)	1.75 (1.45)	0 (2.1)
(3)Continuous	0.55 (1.47)	2.25 (0.91)	2.1 (0.72)	0.65 (1.81)
(4)Hue	1.65 (0.81)	1.15 (1.53)	2.05 (1.28)	2.65 (0.75)
(5)None	1.35 (1.57)	-1.95 (1.57)	-0.95 (2.28)	0.15 (1.76)
Friedman Test	$\chi^2(5) = 29.20$, $p < 0.005$	$\chi^2(5) = 52.20$, $p < 0.005$	$\chi^2(5) = 29.20$, $p < 0.005$	$\chi^2(5) = 33.34$, $p < 0.005$
Wilcoxon Post-hoc ($p < 0.005$)	1-4, 2-4, 3-4	1-5, 2-4, 2-5, 3-5, 4-5	1-3, 2-5, 3-5, 4-5	1-4, 2-4, 3-4, 4-5

Table 4: Mean (standard deviation) values for the *Health* display-specific questions (-3=strongly disagree, 3=strongly agree). A heatmap ranges from red (lowest) to green (highest) for the mean values *per condition*.

The display-specific questions' mean standard deviation values and statistical differences between pairwise comparisons can be seen in Table 4 for the ammunition displays and Table 4 for the health displays.

7.5.1 Health Display Results

Stress managing health generally increased as granularity decreased, and significant differences were found between *hue* and *numerical*, *discrete*, *continuous*. For the *readability*,

Ammo Display-Specific Questions Mean (Std) Values	Stress Managing Ammo	Readability	Visual Appeal	Suitability for Horror
(1)Numerical	0.05 (2.19)	2.55 (1.71)	1.35 (1.35)	0.15 (-0.3)
(2)Discrete	0.25 (1.86)	2.25 (1.67)	1.7 (1.7)	1.1 (0)
(3)Continuous	0.4 (1.6)	2.35 (1.3)	2.15 (2.15)	1.15 (0.65)
(4)Hue	1.2 (1.4)	0.15 (1.91)	1.6 (1.6)	1.6 (2.65)
(5)None	1.35 (1.73)	-1.5 (2.16)	-0.25 (-0.25)	1.6 (0.15)
Friedman Test	$\chi^2(5) = 18.70$, $p < 0.005$	$\chi^2(5) = 52.06$, $p < 0.005$	$\chi^2(5) = 16.73$, $p < 0.005$	$\chi^2(5) = 8.88$, $p = 0.06$
Wilcoxon Post-hoc ($p < 0.005$)	N/A	1-4, 1-5, 2-4, 2-5, 3-4, 3-5, 4-5	3-5, 4-5	N/A

Table 5: Mean (standard deviation) values for the *Ammunition* display-specific questions (-3=strongly disagree, 3=strongly agree). A heatmap ranges from red (lowest) to green (highest) for the mean values *per condition*.

it generally decreased as granularity decreased, with significant differences between *none* and *numerical*, *discrete*, *continuous*, *hue*, and between *discrete* and *hue*. For *visual appeal*, it generally increased as granularity decreased and then decreased when it came to *none*, and significant differences between *none* and *discrete*, *continuous*, *hue*, and between *numerical* and *continuous*. For *Suitability for Horror*, it similarly increased as granularity decreased, but decreased for *none*. Significant differences were found between *hue* and *numerical*, *discrete*, *continuous*, *none*.

7.5.2 Ammunition Display Results

Stress managing ammo increased as granularity decreased, and no significant differences were found. *Readability* generally decreased as granularity also decreased, and significant differences were found between *hue* and *numerical*, *discrete*, *continuous*, *none*, and between *none* and *numerical*, *discrete*, *continuous*, *hue*. For *visual appeal*, significant differences between *none* and *continuous*, *hue*. For *suitability for horror*, it increased as granularity decreased, but there were no significant differences.

7.6 Ranking Question Results

Ranking/Condition	Numerical	Discrete	Continuous	Hue	None
1st	1	2	5	11	1
2nd	4	6	2	5	3
3rd	3	3	8	3	3
4th	8	7	4	1	0
5th	4	2	1	0	13
Weighted Average Ranking	2.5	2.95	3.3	4.3	1.95

Table 6: *Health* display general preference ranking counts and weighted average rankings.

Ranking/Condition	Numerical	Discrete	Continuous	Hue	None
1st	10	3	3	4	0
2nd	3	10	7	0	0
3rd	3	6	9	1	1
4th	3	1	1	15	0
5th	1	0	0	0	19
Weighted Average Ranking	3.9	3.75	3.6	2.65	1.1

Table 7: *Health* display readability ranking counts and weighted average rankings.

Ranking/Condition	Numerical	Discrete	Continuous	Hue	None
1st	0	0	1	17	2
2nd	1	2	3	2	12
3rd	5	3	9	1	2
4th	3	11	6	0	0
5th	11	4	1	0	4
Weighted Average Ranking	1.8	2.15	2.85	4.8	3.4

Table 8: *Health* display immersion ranking counts and weighted average rankings.

Ranking/Condition	Numerical	Discrete	Continuous	Hue	None
1st	5	1	7	5	2
2nd	3	8	3	2	4
3rd	2	2	6	5	5
4th	4	5	3	4	4
5th	6	4	1	4	5
Weighted Average Ranking	2.85	2.85	3.6	3	2.7

Table 9: *Ammunition* display general preference ranking counts and weighted average rankings.

Ranking/Condition	Numerical	Discrete	Continuous	Hue	None
1st	10	2	6	1	1
2nd	5	5	8	2	0
3rd	3	9	5	3	0
4th	1	4	1	12	2
5th	1	0	0	2	17
Weighted Average Ranking	4.1	3.25	3.95	2.4	1.3

Table 10: *Ammunition* display readability ranking counts and weighted average rankings.

Ranking/Condition	Numerical	Discrete	Continuous	Hue	None
1st	1	0	3	4	12
2nd	2	2	3	10	3
3rd	2	7	10	0	1
4th	3	10	4	2	1
5th	12	1	0	4	3
Weighted Average Ranking	1.85	2.5	3.25	3.4	4

Table 11: *Ammunition* display immersion ranking counts and weighted average rankings.

The ranking questions' counts and weighted average rankings can be seen in Table 6.. and Table 9 for the health and ammunition general preference, in Table 7 and Table 10 for the health and ammunition readability, and in Table 8 and Table 11 for the health and ammunition immersion.

7.6.1 General Preference

Health: *Hue* scored highest (4.3/5), and was ranked 1st by 55% of participants. *None* interestingly scored lowest (1.95/5) with 65% of participants ranking it 5th, despite the rankings having steadily increased as granularity decreased up until *hue*. *Numerical*, *discrete*, and *continuous* scored similarly with somewhat uniform distributions.

Ammunition: *Continuous* scored highest (3.6/5) and was 1st choice for 35% of participants, while *none* scored lowest (2.7/5) but was more uniformly distributed with only 25% of participants ranking it 5th. The other conditions shared similar values, and *numerical* and *discrete* shared the same score (2.85/5) but *discrete* had 40% of participants that ranked it 2nd whereas *numerical* had a more uniform distribution. *Hue* scored second highest (3/5) but was more uniform than *continuous*.

7.6.2 Readability

Health: *Numerical* scored highest (3.9/5) with 50% of participants ranking it first, and *none* scored lowest (1.1/5) with 95% of participants ranking it 5th. All scores decreased as granularity also decreased which made sense in the context of readability. The two biggest jumps are between *continuous* and *hue*, and then between *hue* and *none*.

Ammunition: Similarly, *numerical* scored highest (4.1/5) with 50% of participants ranking it 1st, and *none* scored lowest (1.3/5) with 85% of participants ranking it 5th. Generally, the rankings decrease as granularity decreases once again, and similarly there are large gaps between the first 3 *HUDs* to the *diegetic hue* display, and between *hue* and *none*.

7.6.3 Immersion

Health: *Hue* scored highest (4.8/5) with 85% of participants ranking it 1st, and *numerical* scored lowest (1.8/5) with 55% of participants ranking it 5th. Interestingly, immersion scores increased as granularity decreased, except for a slight decrease for *none*.

Ammunition: Interestingly for ammunition, *none* scored highest (4/5) with 60% of participants ranking it 1st, and *numerical* once again scored lowest (1.85/5) with 60% of participants ranking it 5th. Scores increased as granularity decreased.

7.7 Think Aloud Results

7.7.1 Health Display Interpretability

Numerical: 7 participants commented on the interpretability of the health display, with 6 mentioning that they found it *P5: "very readable"* and easy to understand, whereas only 1 participant mentioned it *P6: "wasn't as easy"* to read.

Discrete: 5 participants mentioned the health being readable and *P3: "easy to understand"*, but 2 participants expressed the health was *P0: "harder to read"*.

Continuous: 7 participants described the health as being readable, *P1: "easier to glance at and read"*, and 2 participants described the opposite opinion, *P0: was still not completely clear on the exact health value.*

Hue: 11 participants commented on health being more vague and *P16: "more difficult to read"*, and only 3 participants mentioned the health being readable, *P11: "the red is helpful to have"*.

None: 13 participants express the health being hard to read and *P5: "harder as there is no indication at all"*.

7.7.2 Ammunition Display Interpretability

Numerical: 11 participants commented on the ammunition being *P16: "obviously more clear"* due to the exact amount being displayed. However, 2 participants mentioned difficulty in reading and understanding the reserve ammunition specifically, *P0: "the reserve is less clear"*.

Discrete: 6 participants described the discrete ammunition as being *P11: "easy to see and really clear"*, but 4 participants expressed it as less readable and *P1: "over-*

whelming" when having to count the bullets. Additionally, 4 participants mentioned difficulty interpreting the reserve ammunition being *P3: "hard to recognise"*.

Continuous: 8 participants found this condition readable and made it *P8: "easier to to keep track of everything"*, 3 participants expressed difficulty in understanding it. There was 1 participant who found this condition easier to interpret their reserve ammunition, *P0: "felt a lot more easy to keep track of"*, and 2 participants who expressed difficulty with the reserve.

Hue: Similarly to health, this condition sees more participants having difficulty with readability, with 11 participants commenting on it being *P11: "hard to interpret"* especially when it came to reading the red hue on the gun, 3 participants did however indicate the display being easy due to being *P1: "forced to look at it all the time"* and the traffic-light LED. Interestingly, 5 participants said the reserve was easier to understand in this condition and only 1 person found it harder.

None: 8 participants said the ammunition was hard to read and more ambiguous, *P16: "too little knowledge"*, but 3 people mentioned it being okay as they could count the bullets or rely on the built-in *P12: "click sound feedback"* to know when it was empty.

7.7.3 Immersion and Suitability for Horror

Numerical: 8 participants indicated that the display was overall not suitable for horror, and *P5: "doesn't match horror aesthetically and functionally"* and reduced immersion. For health specifically, 7 people said it was *P16: "ineffective for horror"* due to being too confident, but 2 people thought the opposite. For ammunition, 4 people said it was not suited to horror and was *P5: "less stressful/scary"*, but 1 person said it was.

Discrete: For health, 13 participants expressed it *P18: "didn't suit horror aesthetics"* and *P4: "ruined immersion slightly"*, but 1 person said they were *P10: "less confident with the health"* overall. For ammunition, however, 5 participants said the ammo felt well suited for horror and was *P0: "more realistic"*, and 3 people said it was not suitable, *P19: "I wasn't as immersed"*.

Continuous: 4 participants commented that this condition was better suited to horror, *P9: "a good combination of having information and ambiguity that creates unease"*, and 3 participants said the opposite. For health, only 2 people mentioned it being good for horror, and 4 people said it did not suit horror and commented on the aesthetics, *P11: "heart icons do not fit the horror game"*. For ammunition, 3 participants indicated it was unsuitable, but 2 stated the opposite.

Hue: 4 participants stated that this condition suited horror overall and was *P4: "the most immersive"*. For health, 13 participants said it was well suited to horror and *P0: "got a stronger reaction out of me"*, and only 3 participants said it was unsuitable. For ammunition, 6 people said it was suited to horror and *P12: "not knowing how much ammo makes it more stressful"*, but 2 people said it was not suitable aesthetically.

None: 7 participants said this condition was overall well suited to horror and was *P7: "definitely more scary as it's more uncertain"*, but 2 people said it was not suited. For health, 4 people mentioned it being unsuitable for horror due to being *P1: "totally removed"*, and 1 person stated the opposite. For ammunition, however, 7 participants liked it for horror as it *P8: "increased tension and was grounded"*.

7.7.4 Impact on Difficulty

Numerical: 3 participants expressed the game feeling easier and having more control, *P2: "found it the easiest out of all conditions"*.

Discrete: 2 participants said the game was easier and they were *P9: "less scared and more confident"*.

Continuous: Just 1 participant mentioned feeling *P10: "less stressed"*.

Hue: 2 participants mentioned the game feeling harder and being *P1: "quite challenging but I liked it"*.

None: Finally, 5 participants expressed difficulty in this condition and mentioned it *P6: "felt harder and felt like I had to pay more attention"*.

7.8 Open Ended Question Results

7.8.1 Game Display Options

10 participants expressed that they would want the option to change their game display in the interest of *freedom of choice* and *player preference*, *P0: "more player choice is always better"*, and 7 participants mentioned there should be display options in the interest of *accessibility*. Conversely, 8 participants said that players should *not* be able to change displays and thus interfere with the designer's intended experience. 5 participants mentioned that being able to change the display could impact the *immersion* of the game, *P12: "it takes away from the immersion and the intended experience"*. Finally, 2 participants indicated that changing displays could impact the *difficulty* and to *P9: "not to make the game so customisable the game becomes too easy"*.

7.8.2 Preferred Horror Display

General Preference: 5 participants mention preferring the *hue* display and more specifically the *diegetic* aspect of it for horror games. Just 1 participant mentioned preferring the *continuous* display.

Health Display: 14 participants indicated they would prefer the *hue* diegetic display for a horror game, *P5: "I would prefer hue-based health for horror games to feel more immersed"*. 3 people indicated they preferred the *continuous* display as it *P0: "created a bit of tension whilst still being clear"*, and only 1 participant per *numerical*, *discrete*, and *none* display conditions respectively.

Ammunition Display: 5 participants preferred the *hue* display for a horror game and *P1: "liked the immersive feel of the slide and the light"*, 5 participants preferred the *numerical* display, and 5 participants said they liked the *none* display. 5 participants also said they preferred the *continuous* display, and 3 participants preferred the *discrete* display.

Combination: 8 participants stated they would like a combination of different display techniques for a horror display, *P19: "for ammo I like the idea of integrating the numerical count onto the gun itself"*.

7.9 Performance Results

The performance data results' mean standard deviation values can be seen in Table 12 for the counts, Table 13 for the *wastage* metrics, and Table 14 for the calculated ratios.

The *death count*s were similarly low, but *none* was the highest value while *hue* was the lowest. The *kill count* ap-

Performance Counts Mean (Std) Values	Death Count	Kill Count	Reload Count	Heal Count
Numerical	0.6 (1.14)	16.3 (5.3)	14.5 (4.15)	2.65 (0.81)
Discrete	0.5 (0.89)	15.05 (5.4)	13.7 (5.14)	2.8 (1.32)
Continuous	0.7 (0.92)	16 (7.71)	13.95 (6.08)	3.05 (1.05)
Hue	0.3 (0.57)	14.25 (4.04)	13.9 (3.51)	3.7 (1.72)
None	0.75 (0.85)	14.9 (5.91)	14.1 (5.31)	2.9 (1.37)

Table 12: Mean (standard deviation) values for the performance counts (-3=strongly disagree, 3=strongly agree). A heatmap ranges from red (lowest) to green (highest) for the mean values *per condition*.

Resource Wastage Metrics Mean (Std) Values	Ammo Wastage (%)	Health Wastage (%)
Numerical	27.29 (10.23)	27.6 (12.5)
Discrete	26.67 (13)	28.74 (19.24)
Continuous	24.75 (12.8)	31.01 (14.12)
Hue	30.19 (11.76)	39.09 (11.61)
None	28.49 (13.35)	27.9 (20.35)

Table 13: Mean (standard deviation) values for the ammunition and health wastage metrics (-3=strongly disagree, 3=strongly agree). A heatmap ranges from red (lowest) to green (highest) for the mean values *per condition*.

Count Ratio Metrics Mean (Std) Values	Kill/Death Ratio	Reload/Kill Ratio	Heal/Death Ratio
Numerical	15.86 (6.07)	0.91 (0.14)	2.57 (0.95)
Discrete	14.16 (6.46)	0.93 (0.22)	2.69 (1.46)
Continuous	14.72 (8.65)	0.93 (0.23)	2.67 (1.08)
Hue	13.85 (4.25)	1.01 (0.2)	3.63 (1.78)
None	13.83 (6.56)	0.99 (0.26)	2.63 (1.38)

Table 14: Mean (standard deviation) values for the ratio metrics (-3=strongly disagree, 3=strongly agree). A heatmap ranges from red (lowest) to green (highest) for the mean values *per condition*.

peared to decrease as granularity decreased but with similarly high standard deviations across all conditions. The *reload count* had mostly similar values for all conditions. The *heal count* seemed to increase slightly as granularity decreased but decreased again for *none*. The *kill/death ratio* generally decreased with granularity. The *reload/kill ratio* remained mostly similar with a slight increase as granularity decreased. The *heal/death ratio* generally increased as granularity decreased, with a large increase between the *HUDs* and the *diegetic hue* display.

For the *ammunition wastage* metric, there appeared to be less wastage for the 3 *HUDs* compared to the *diegetic hue* display and the *none* display. For *health wastage*, it seemed to increase as granularity decreased with the largest percentage belonging to *hue*, and decreased again for *none*.

8. DISCUSSION

8.1 Overview

Despite the PXI's frequent use in past research [25], the results indicate it may not be the most applicable measure for this type of study.

This may be because of participants answering the questions while reflecting on their experience of each condition as a whole, rather than reflecting on the changes in display type. As the differences between the conditions were intentionally granular, this may explain why no statistically significant differences were found between the PXI components across conditions, while the targeted questions gave clearer insights into differences between the conditions.

Despite the PXI not yielding any significant differences, several general insights were still found. *Mastery*, for example, decreased alongside granularity suggesting players may feel less competent playing when presented with less display information. This is also indicated through *ease of control* decreasing, and *challenge* increasing as granularity of display decreased. Additionally, *immersion* increased slightly with the decrease in granularity, suggesting that removing/reducing overlay information may immerse the player more, an insight also reported within the literature[27, 26, 5].

The BAI questions reported several significant differences. The *fear of dying in-game* had significant differences between the *hue* display and the 3 traditional *HUDs*, and increased as display information decreased. This makes sense as, regarding the health player resource, it indicates players became more afraid of failing/dying as less health information was presented to them. For *urgency*, a significant difference was found between *continuous* and *hue*, where *urgency* increased as granularity decreased. The mean results of *unsteadiness*, *scaredness/fear*, and participants' qualitative comments follow this pattern too; as information granularity was reduced, player anxiety and stress increased.

These concepts align with existing research, where it has been suggested that removing aspects of the display can increase immersion and tension, as well as increase game difficulty[35, 45].

For the targeted Likert-scale questions, *stress managing health* generally increased as granularity decreased, and there were significant differences between *hue* and the 3 traditional *HUDs*, further reinforcing that as health information decreases, player stress increases. A similar trend was also found for *stress managing ammunition*, where less information was found to increase player stress although no significant difference was found in this case.

8.2 Display Specific Insights

8.2.1 Numerical HUD

Numerical HUD, in general preference with participants, ranked as the second worst health display and joint third ammunition display, despite ranking highest for both health and ammunition in terms of information readability. That the *numerical* display had the highest readability makes sense as it had the highest level of information granularity of the conditions evaluated in the experiment. This clarity of readability is reinforced by the display-specific questions where the ammunition had the highest readability, and health had the second highest readability. It is further reflected by players being the least stressed about managing their health and ammunition in this condition also.

Numerical was also ranked by participants as the least immersive display overall for health and ammunition, suggesting too much information granularity can negatively impacts immersion. This is reinforced by having the lowest *im-*

mersion in the PXI results, and within the display-specific questions, it was the least *suitable for horror* for both health and ammunition. Aspects relevant to horror other than immersion such as *urgency*, *unsteadiness*, *scaredness/fear*, and *fear of dying in-game* were all at their lowest for this display as well, highlighting that too much information granularity may hinder displays within a horror context.

Of note also is that players found the game easiest when playing this condition, seen in the PXI *ease of control* scoring highest, *challenge* scoring lowest, and the most participant comments identifying the game feeling easier whilst playing this condition. This suggests the *numerical* display may be good for making an accessible and lower-difficulty experience.

Overall, the *numerical* display is recommended when designers want to maximise the readability and ease of use of their game, perhaps within the context of a competitive However, this display is not recommended for a horror game, especially when designers want to create an immersive and scary experience.

8.2.2 Discrete HUD

The *discrete* display was ranked 2nd choice most often for general preference for ammunition and health, with health being slightly less preferred. Readability was ranked 2nd for health, and 3rd for ammunition, roughly aligning with *discrete* being the second highest in information granularity. The display-specific results also showed health had the highest readability, but ammunition had the 3rd highest. Players' stress managing health and ammunition was low, scoring second lowest.

Players ranked the immersion second lowest for ammunition and health and second lowest for *immersion* in the PXI. This lower immersion is also backed up by lower *suitability for horror* scores, as well as mostly neutral aspects of anxiety from the BAI results, with this condition being the most comfortable overall.

The game was found to be second easiest in this condition, with a relatively low *challenge* and participants mentioning the game feeling easier too.

This display was similar to *numerical*, and would be useful when prioritising readability and reducing player stress. It is a slightly more neutral option in the context of a horror game so is hard to recommend for maximising immersion and anxiety.

8.2.3 Continuous HUD

The *continuous* display was generally received the most neutrally by participants, and it had the most people that ranked it 3rd for general preference for health and ammunition, but for the average ranking, it was the most preferred for ammunition. The information was 3rd most granular and predictably ranked 3rd for health readability, but 2nd for ammunition. The same result was found in the display-specific questions. This may suggest that continuous bars may be slightly better suited for displaying ammunition than health concerning readability. Players' stress managing their health and ammunition scored third highest but was still relatively low, suggesting the readability is only slightly reduced than higher granularity conditions

Continuous was also ranked neutrally in 3rd place for immersion of health and ammunition. Similarly, aspects of anxiety remain mostly neutral in this condition as well.

The game was regarded as slightly more challenging overall in this condition, with less mastery and increased challenge compared to the first two conditions.

Overall, this display seemed a little more neutral in its effect on the player experience and is therefore recommended for designers who want a balance of readability, immersion, and difficulty, while none of those aspects are particularly higher than the other.

8.2.4 Hue Diegetic Display

Notably, the *hue* display was ranked by participants as their favourite health display, but second favourite for ammunition. Interestingly, the *hue* display had the second worst for readability overall, for both health and ammunition. This suggests that players do not inherently desire the highest level of granularity for displays, and in this case prefer a minimal amount of information; to a greater extent for player health. Players were most stressed about managing health with this display, and second most stressed about managing ammunition.

This condition was the most immersive display for health, but interestingly the second most immersive for ammunition. Suggesting that preference may be correlated to how immersive a display is. The BAI aspects of *heart pounding*, *urgency*, and *fear of dying in-game* were all at their highest for the *hue* display, reinforcing player stress and immersion with minimal information granularity. This display was the most suitable for a horror game for health and ammunition (joint 1st with *none*). This display type was also diegetic which may be a contributor to immersion and horror suitability as a whole.

The difficulty was mostly higher compared to the first 3 conditions, with the highest challenge second lowest feelings of mastery and ease of control. Participants also mentioned the game feeling harder.

Overall, this display is recommended strongly for a horror game context where designers want to limit readability and maximise immersion, anxiety and fear. It may also be useful for any immersive game experience where ambiguity is permissible.

8.2.5 None Display

This display was ranked lowest for both general preference *and* readability. This may imply that, although reducing granularity does not inherently impact preference, when completely removing the display information players may not prefer it to others.

Even more interestingly, considering the low readability and preference, the *none* display was ranked most immersive for ammunition, but second highest for health. Despite having the lowest granularity of all conditions, it may imply that removing the display completely makes it easier for players to immerse themselves in the game. However, the reason the *none* condition is not as immersive for health as for ammunition could be due to health being more directly relevant to the player character, therefore having no form of display to show how damaged the character is may impact immersion and make the player *P1: "totally removed"*. Ammunition however is more related to the character's pistol, and as pointed out by several participants it was *P5: "more realistic and had to count"*; which players might expect in a real-life situation. The *urgency* and *fear of dying in-game* was also only second highest to *hue*, and third highest for *heart pounding*, suggesting that no display at all may reduce aspects of immersion and fear.

BAI elements of *unsteadiness* and *scaredness/fear* were highest in this condition, as well as scoring the lowest for participants' comfort. This may indicate that reducing granularity to the point of no display may increase certain aspects of general discomfort and stress.

The game was generally the most difficult in this condition, with players experiencing the lowest mastery and ease of control, and participants mentioning it was more demanding.

Overall, this display is recommended for designers who want maximum immersion and minimal readability in a horror game context, but only for the ammunition condition. For health, it is hard to recommend this display due to the frustration and negative impact it had on immersion.

8.3 The Evaluation of Game Displays

A typical approach of prior works investigating game displays will often implement novel displays within a particular genre and perform a within-subjects evaluation, concluding an *"optimal"* display type in terms of measures surrounding player experience or performance[51, 27, 19, 30]. However, such an approach does not fully account for the wide range of possible game experiences and ignores the game designer's intentions within the game creation process. Instead, research should not strive to identify a singular *"best"* display from study results, but rather provide designers with a clear overview of how players responded; in terms of player experience, immersion, or performance in response to different displays.

Where Peacocke et al. argued for a more neutral presentation of display recommendations based on player performance metrics [51], this paper argues that such a presentation of design recommendations and insights should take a more holistic approach that includes information on general player experience, immersion, anxiety and tension, difficulty, and relevant performance metrics. This gives designers a more cohesive understanding of including a given display within a chosen game genre/context.

For example, in the context of a horror game, following Peacocke et al.'s performance-oriented approach a designer may conclude that the performance differences between the three traditional HUD conditions are negligible, and thus opt for the *numerical* display. However, as the results show, this display was considered by participants to be unsuitable for a horror FPS game. Additionally, by providing designers with a more complete understanding of different display types, designers may be able to identify novel display-driven gameplay experiences. For example, in a horror FPS which uses this study's *hue* diegetic display for health, a designer may want to temporarily increase player stress within a certain level, and could therefore switch to using the *none* display. This design decision relies on the designer's understanding of the role different displays have in altering player stress within gameplay, and cannot be derived from quantitative performance metrics alone.

These insights motivate future work that aims to create a cohesive and comprehensive resource of displays across genres that would enable designers to find appropriate design solutions for their specific needs when creating novel experiences. This would help to organise recommendations that are currently disjointed across papers, with varying degrees of comparability and sometimes even stuck behind paywalls.

8.4 Limitations and Future Work

Using a broad questionnaire like the PXI to measure player experience concerning a specific aspect of game design, such as game displays, can result in noise and a more general experience consisting of the sum of the parts of a game. Isolating the element(s) being investigated in GUR is important, and in future work, more targeted questions and measures should be used to garner more targeted results.

The BAI had to be slightly adapted to be relevant within a video game context due to a lack of existing anxiety measures within GUR, and future work would benefit from creating and validating such a questionnaire. Physiological measures were unable to be collected to investigate elements of fear from players due to time, ethics, and equipment limitations, but it would be valuable for future work to make use of measures such as galvanic skin response[31] to gain quantitative insight into emotional player responses.

Elements of diegesis were investigated, but future work would value isolating research purely on diegetic game design in horror and across all genres.

Finally, results indicated there may be a trade-off between immersion and readability of displays but further work on the specifics of this observation is needed.

9. CONCLUSIONS

This paper investigated and implemented 5 different horror FPS game displays with differing levels of information, and different display types, and investigated their impact on the player experience, immersion, anxiety, and performance. Via a custom-made horror FPS and user study (N=20), recommendations and effects of the different displays were discovered and presented individually and on a general level. It was found that reducing the amount of information in displays may reduce readability and cause player stress, but also increase immersion, difficulty, and overall suitability for horror. Specifically, the *hue* diegetic display was generally most suited to a horror FPS and had a low level of information granularity compared to the *numerical* and *discrete* displays which were less suitable for horror and had a higher level of granularity. However, reducing granularity to *none* can break immersion in the context of the health display specifically, but not ammunition.

Existing research was criticised on how displays should be evaluated. Where past work has taken a more objective approach to what displays are "best" in terms of performance, this paper suggests a more refined approach in which displays and their effects are presented and recommended so designers can use them for a range of different intended game experiences.

Finally, the paper presented the FPS horror game, *Crimson Undead*, as an open-source contribution for replicability and future research, as well as the novel performance metric of resource *wastage*.

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APPENDIX

A. ETHICS CHECKLIST

School of Computing Science
University of Glasgow

Ethics checklist form for 3rd/4th/5th year, and taught MSc projects

This form is only applicable for projects that use other people ('participants') for the collection of information, typically in getting comments about a system or a system design, getting information about how a system could be used, or evaluating a working system.

If no other people have been involved in the collection of information, then you do not need to complete this form.

If your evaluation does not comply with any one or more of the points below, please contact the Chair of the School of Computing Science Ethics Committee (matthew.chalmers@glasgow.ac.uk) for advice.

If your evaluation does comply with all the points below, please sign this form and submit it with your project.

---

1. Participants were not exposed to any risks greater than those encountered in their normal working life.
   Investigators have a responsibility to protect participants from physical and mental harm during the investigation. The risk of harm must be no greater than in ordinary life. Areas of potential risk that require ethical approval include, but are not limited to, investigations that occur outside usual laboratory areas, or that require participant mobility (e.g. walking, running, use of public transport), unusual or repetitive activity or movement, that use sensory deprivation (e.g. ear plugs or blindfolds), bright or flashing lights, loud or disorienting noises, smell, taste, vibration, or force feedback

2. The experimental materials were paper-based, or comprised software running on standard hardware.
   Participants should not be exposed to any risks associated with the use of non-standard equipment: anything other than pen-and-paper, standard PCs, laptops, iPads, mobile phones and common hand-held devices is considered non-standard.

3. All participants explicitly stated that they agreed to take part, and that their data could be used in the project.
   If the results of the evaluation are likely to be used beyond the term of the project (for example, the software is to be deployed, or the data is to be published), then signed consent is necessary. A separate consent form should be signed by each participant.

   Otherwise, verbal consent is sufficient, and should be explicitly requested in the introductory script.

4. No incentives were offered to the participants.
   The payment of participants must not be used to induce them to risk harm beyond that which they risk without payment in their normal lifestyle.

5. No information about the evaluation or materials was intentionally withheld from the participants.
   Withholding information or misleading participants is unacceptable if participants are likely to object or show unease when debriefed.

6. No participant was under the age of 16.
   Parental consent is required for participants under the age of 16.

7. No participant has an impairment that may limit their understanding or communication.
   Additional consent is required for participants with impairments.

8. Neither I nor my supervisor is in a position of authority or influence over any of the participants.
   A position of authority or influence over any participant must not be allowed to pressurise participants to take part in, or remain in, any experiment.

9. All participants were informed that they could withdraw at any time.
   All participants have the right to withdraw at any time during the investigation. They should be told this in the introductory script.

10. All participants have been informed of my contact details.
    All participants must be able to contact the investigator after the investigation. They should be given the details of both student and module co-ordinator or supervisor as part of the debriefing.

11. The evaluation was discussed with all the participants at the end of the session, and all participants had the opportunity to ask questions.
    The student must provide the participants with sufficient information in the debriefing to enable them to understand the nature of the investigation. In cases where remote participants may withdraw from the experiment early and it is not possible to debrief them, the fact that doing so will result in their not being debriefed should be mentioned in the introductory text.

12. All the data collected from the participants is stored in an anonymous form.
    All participant data (hard-copy and soft-copy) should be stored securely, and in anonymous form.

Project title Investigating Player Experience in First-Person Shooter Horror Game Design

Student's Name Harvey Russell

Student Number 2461525R

Student's Signature Harvey Russell

Supervisor's Signature Joseph O'Hagan

Date 04/03/2024

Ethics checklist for projects

B. CONTROL SCHEME

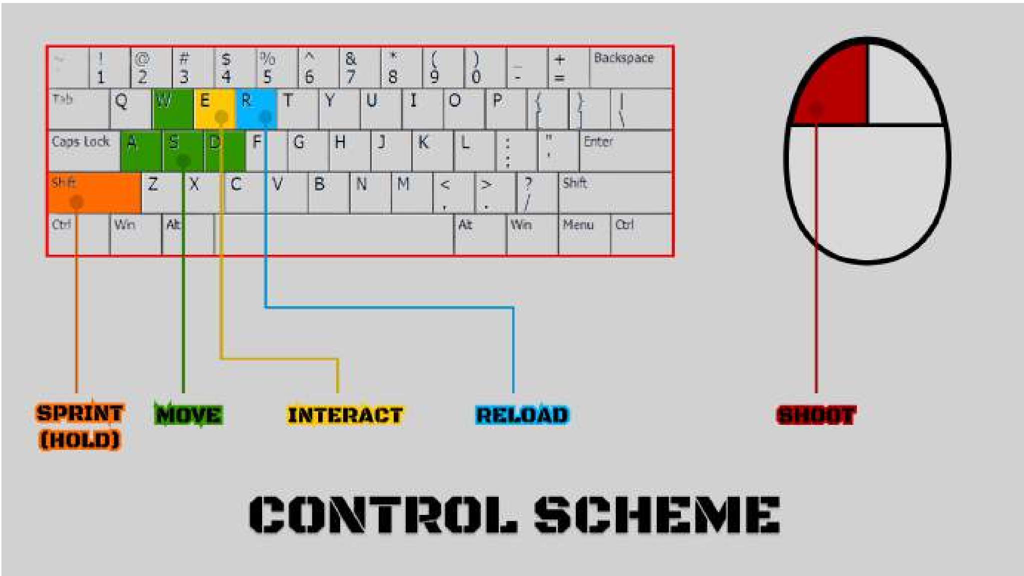

Figure B1: Control Scheme for *Crimson Undead*, provided to participants.