Examination of the Relationship Between Customizable Heads-up-displays, Difficulty, and Player Satisfaction

by

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ABSTRACT

This paper documents a study of the relationship between heads up display (HUDs) customization and player performance. Additional measures capture satisfaction and prior gaming experience. The goal of this study was to develop a framework on which future Human Systems Engineering studies could create games that are tailor made to examine a given area of interest. This study utilized a two-by-two design, where participants play a two-dimensional (2D) platformer game with a mechanic that incentivizes attention to the HUD. This study successfully developed a framework and was moderately successful in uncovering limitations and demonstrating areas for improvement in follow-on studies. Specifically, this study illuminated issues with the low amount of usable data caused by design issues, participant apathy, and reliance on self-reporting data collection. Extensions of this study can utilize this framework and should look to recruit beyond crowdsourcing platforms, collect more diverse data, reduce participant effort, and address other considerations that were found during execution.

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Video games have grown from technical demonstrations of computing power and graphics (Smithsonian, n.d.) to an $85 billion dollar industry the United States in 2021 (Clemet, 2021). This development has sparked academic investigation of video games from a wide range of disciplines, from economics (Castronova, 2002) to philosophy (Schulzke, 2014).

The way games direct attention and engage players makes them incredibly interesting to the field of Human Systems Engineering (HSE). A particular area of interest in games centers on the examination of heads up displays (HUDs) that serve information to players about the current game state, resources, and other mechanics. Often, this information is presented through graphical means and are projected on top of the gameplay frame. These elements are of particular interest as they need to perform their function without drawing significant attention away from the gameplay (Zammitto, 2008).

Another area of interest is that of player satisfaction. Satisfaction is an incredibly board term, and so is the ways that players experience satisfaction. The diversity of games matches players' goals and preferences, making it difficult to directly compare player satisfaction across games (Phan et al., 2016). One game element that can also directly impact player satisfaction is that of difficulty. Games must be difficult enough to constitute a challenge, however, a game that is too easy does not engage players (Klimmt et al., 2009).

This paper provides the background literature on prior HSE examinations of player satisfaction and HUDs, then outlines the creation of a gaming framework that can be used to quickly develop and deploy games with mechanics that highlight a desired

variable, then relays the results of a proof-of-concept study on the relationship between HUD customization and player performance. Participants were asked to play through a two-dimensional (2D) platformer, with the ability to move elements of their HUDs. The paper then covers some takeaways from the study and proposes a number of changes be made to further extend the work.

Prior Works

As Ng and Khong (2008) outlined, several human computer interaction (HCI) principles apply to gaming. However, video games have features that make them unique. For example, video games are usually played for enjoyment and satisfaction, whereas other software is utilized through necessity. As such, elements like reward and difficulty are examined, elements that would not be as essential in a piece of productivity software (Pagulayan et al., 2002). Federoff (2002) provides a framework of heuristics to examine usability and satisfaction inside video games. Ten of these heuristics examine game interfaces and emphasize non-intrusive interfaces, clarity of information, and consistency, among a few others.

Game mechanics are "methods invoked by agents for interacting with the game world" (Sicart, 2008). Through this definition, we can see that players engage with games through mechanics that change the state of the game. For example, jumping and other player movements are mechanics, and more complex systems such as weather or crafting are mechanics.

HUDs are a form of video game interface overlayed on top of gameplay views that relays essential information to the player (Zammitto, 2008). While the visual language and information provided differ between genres, they are common feature of

games. Furthermore, there is a dichotomy between HUDs that are diegetic or non-diegetic (Peacocke et al., 2015; Wilson. 2006; Iacovides et al., 2015). Interfaces that provide HUD information through in-game contexts are diegetic. Non-diegetic interfaces, by contrast, are 'projected' onto the screen and exist outside of the game context.

One key element when discussing HUDs in video games is that of the genre. Games, much like movies, have a wide range of experiences that are loosely grouped into genres (Apperley, 2006). As a result, there is usually some difference in the HUDs with each genre. For example, a dense information HUD with many resource trackers and a mini-map is more desired in a strategy-focused game genre. In contrast, it may be seen as a distraction serving redundant information inside of a first-person shooter (FPS) (Peacocke et al., 2018).

While there have been some investigations on the link between HUDs and user experience, Caroux and Isbister (2016) conducted a thorough examination of existing literature. Within their literature review, they conducted two studies to examine the connection. The first they conducted examined the impact of genre and player experience on eye movement, the perceived value of HUDs, and player satisfaction. Participants found HUDs more valuable in a real-time strategy (RTS) game than in FPS games, and participants tended to fixate their gaze on the RTS HUD more frequently. Novice players also stated that they tended to use the HUD less frequently but still used it. The second study they conducted examined HUD composition and organization. They found a strong link between spatial organization and composition on player experience. Furthermore, there was a difference between those with extensive experience playing games and novices regarding HUD preferences. These findings demonstrate the impact genre has on

HUD composition and utilization and the relationship between player experience and HUD utilization.

The study of player taxonomy looks to classify and define players into categories based on their goals and preferences inside video games. Studies on this topic date as far back as 1996, when players of Multi-User Dungeons (MUDs) were observed and surveyed about what they enjoyed doing the most when playing a MUD (Bartle, 1996). Bartle proposed four categories: killers, achievers, socializers, and explorers. Killers interacted most with game mechanics that put them in adversary roles with other players, such as player vs. player combat. Socializers also looked to interact with other players; however, they took to forms of socialization such as chatting or cooperating. Achievers engaged with and responded to mechanics that showed completion and mastery over games. Finally, explores also enjoyed interactions with the game world, looking to find new areas to explore. As games increased in scope and complexity, future studies looked to extend Bartle's work in-game taxonomy to fit the modern gaming environment (Kahn et al., 2015). Studies have also been conducted to taxonomize players based on personality traits (Quick et al., 2012) and structural equation models (Patzer, Chaparro & Keebler, 2020). These taxonomies are vital tools in understanding the differences between players and the types of activities or genres they enjoy. Therefore, it can be inferred that players' satisfaction increase when interacting with a game system that suits them; however, no study was uncovered that directly examines the relationship between taxonomy and player satisfaction.

Due to differences in player taxonomy and game genre, it can be challenging to measure player satisfaction. The Gamer User Experience Satisfaction Scale (GUESS) is a

psychometric scale that provides items to discover player satisfaction during playtesting sessions (Phan et al., 2016). While this scale is not the only tool to measure player satisfaction (Shelstad et al., 2019), it has grown popular due to its completeness and validity. Furthermore, there have been efforts to combine this scale with player taxonomy (Patzer et al., 2020) and apply it to more novel game genres such as virtual reality (Shelstad et al., 2017). This tool can be valuable in measuring player satisfaction and providing a list of items that can be utilized in study surveys.

Targett et al.'s (2011) work on HUD modifications inside of World of Warcraft (WoW) was most closely related to this study. Researchers surveyed players of WoW and interviewed players who create modifications. They found that those who modify HUDs tend to do so to meet their playstyle better, include additional information than the default interface, and generally modify the HUD significantly. Those who develop and create interface modifications are highly computer competent. Players had a generally positive perception of these modifications (Targett et al., 2011).

Study

These studies highlight many areas of interest for HSE to examine inside video games; however, there is some difficulty in isolating and manipulating gameplay mechanics. This difficulty is due to studies generally relying on existing games for analysis where they do not have the flexibility to modify the game to suit a given study. HSE could benefit from creating a framework through which games with unique game mechanics could be easily created and modified. This framework would allow future studies to home in a particular area of interest by modifying mechanics to suit a given study.

This proof-of-concept study, documented in this paper, was conducted to implement this framework, and exhibit its value. Examination of the link between HUD customizability and player performance was determined to be a valuable avenue of exploration. Such exploration would require the creation of a complex game that would also implement a game mechanic that could be easily and visibly demonstrated.

The framework was based on an already existing library that focused on two-dimensional (2D) arcade games, Phaser 3 (Phaser, n.d.). Phaser 3 is built upon hyper-text markup language (HTML) and JavaScript, two well-known and widely implemented web development languages. The online nature of these languages provides another benefit. By hosting the games online, researchers can recruit through online platforms, eliminating the need for in-person recruitment.

2D platformers are games in which players must navigate through levels of obstacles such as enemies, spikes, and other game mechanics while jumping and using platforms to reach a goalpost. 2D platformer games also suit the framework's goals as it was relatively simple to explain to those without gaming experience and possessed easy asset modification and programmability. In addition, the smaller nature of platformers, compared to other genres, allowed for a game to be created by only one developer rather than through a team, which would create significant additional complexity in management and collaboration. The study also benefited from the genre because it could be hosted through web browsers, allowing off-site data collection and global recruitment.

The present study looked to create a game through this framework that focused on HUDs and player performance. Therefore, mechanics and interfaces were generated to emphasize the best elements that would lead to an examination of the desired variables.

Design

This study implemented a 2-by-2 design. The two independent variables were difficulty and the ability to move the HUD. The difficulty independent variable levels were easy or hard, and the HUD variable levels were movable or not movable.

The difficulty independent variable was determined to be of particular interest as prior works noted that difficulty is a unique feature of video games that impacts player satisfaction (Klimmt et al., 2009). In the game outlined here, the difficulty is related to the frequency of color platforms, which add additional difficulty by requiring more intense engagement in the game. Hard treatments had more platforms than easy, which had neutral platforms that did not require additional effort to interact with during game play. Therefore, it was hypothesized that there would be a relationship between the hard treatments and utilization of the HUD that would have some impact on player satisfaction.

For the ability to move the HUD independent variable, while interface modification is a broad topic, prior works (Caroux & Isbister, 2016) demonstrated that position would have the most impact on player experience. The ability to move the HUD elements was also easier to implement than other forms of modification, such as substitution, which would have required integrating features that would have significantly weighed down the framework, impacting rendering performance and creating additional programming complexity. For treatments with not movable, the HUD elements were placed at the top and could not be moved. For the movable, these elements could be dragged to any position, and the game notified participants that they could move HUD items.

The treatments at the cross-section of the independent variables were assigned to numerical values and were automatically assigned by the game (See Table 1).

Table 1

2-by-2 Design and Treatment Numbers

Independent Variables	Non-Moveable HUD	Movable HUD
Easy Difficulty	Treatment 1	Treatment 2
Hard Difficulty	Treatment 3	Treatment 4

Materials

The Game

As mentioned before, the game's foundation of HTML and JavaScript framework meant that the game was accessible through web browsers. The web-based delivery method also reduced the effort and removed installation requirements for participants. Using Apache Virtual Host, the domain of www.xgwallace.com served the game.

The game was a 2D platformer based on an existing copyright-free Phaser template from Ourcade (2021). This template was extended to include additional elements such as the moveable HUD components. Players controlled a koala using the arrow keys to move and the spacebar to jump. The game's goal was to collect cookies

while navigating the obstacle course avoiding spikes and enemies by jumping, moving, and utilizing the platforms to reach the end flag (Figure 1).

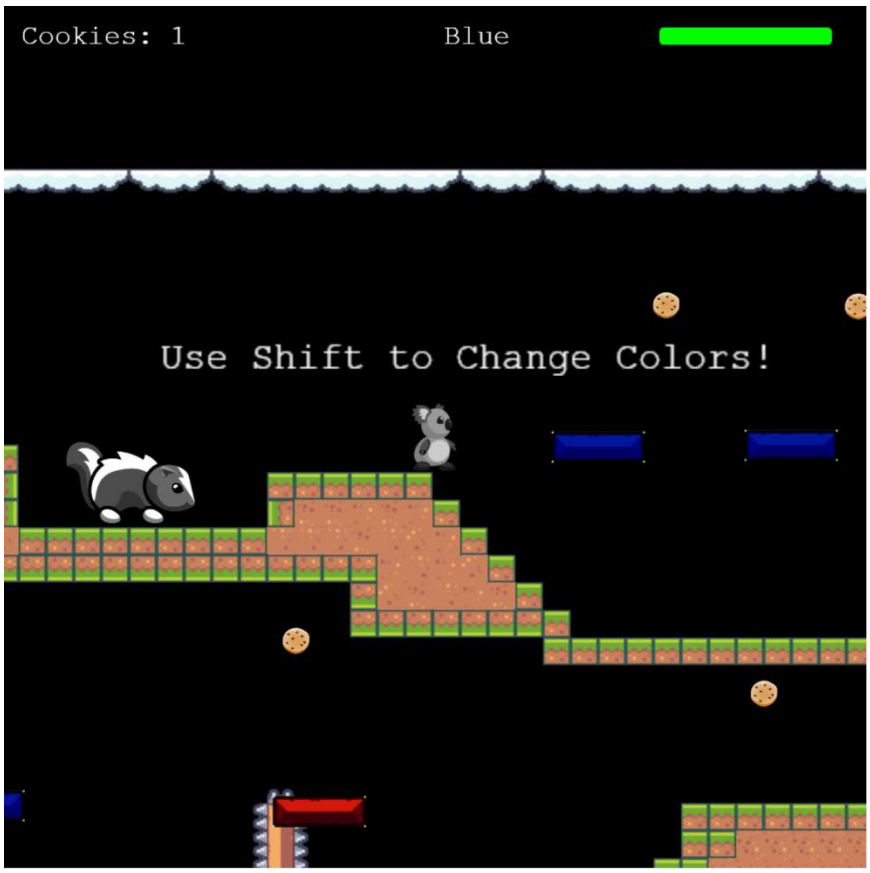

Figure 1. The users controlled the koala through the maze of enemies and obstacles.

The game features three HUD elements, the cookie number, player color, and the health bar, as seen at the top of Figure 1 from left to right.

The player had a color, indicated through a simple HUD element consisting of a line of text stating the player's current color (Figure 2). They could toggle between red and blue color states by pressing the shift button. This mechanic was decoupled from any diegetic cues, ensuring that players had to check the HUD. Some platforms were color platforms (Figure 1). After playing a short blinking animation, these platforms would

swap between being colored red or blue. On those with the hard treatments, these platforms were more frequent and required greater attention to ensure the proper color. Upon colliding with these platforms, the game would check if the player's color matched the current platform color. If they were mismatched, the player would take damage and be launched into the air, giving them feedback and time to swap to the proper color.

Figure 2. The HUD consisted of three elements. The Cookie Number, The Player Color, and The Health Bar.

The HUD contained a health bar, which indicated their current health. Players started with 100 units of health. Enemies dealt 10 damage, spikes dealt 30, and color platforms dealt 30. A bar was chosen as opposed to a simple numerical value which would not be as illustrative as a bar that quickly conveys percentage.

The final HUD element is the cookie number, which conveys the number of cookies the player collected through their playthrough. The number of cookies collected had no impact on the game. The game included this element to see if players moved this less valuable information to a low-priority attention area.

Post-Treatment Survey

The post-treatment survey consisted of 11 questions: one screening, three demographic, and seven Likert Scale questions.

The screening question asked participants to enter their randomly generated 4-digit identification number that was output on the game's final screen. The number was not the one used to identify their data but rather served as proof of completion of the

game and to link their survey response with the screenshot data. Therefore, any response that had a number that was not four digits was removed from the data pool, as it could not be tied to a screenshot nor provide sufficient evidence of completion of the game portion of the study.

The demographics consisted of three items: please report your current age in years, please describe your gender, and please describe your ethnicity. These items were kept as an open field, allowing for a broader range of gender and race identities to be reported, which may slip away under traditional check all that apply demographic items.

The remaining seven items were Likert Scale questions centering on participant satisfaction and mastery of the game and their general prior gaming experiences. One item, the game was difficult, gauged participants perceived difficulty. One item, I enjoyed mastering the game, examined player satisfaction. Two items, I consider myself good at video games, and I frequently play video games, gauged prior gaming experience.

The final three items: the HUD elements (color shifter, health, cookies) were easy to read, I frequently looked at the HUD, and the HUD elements were already in a good location from the start of the game, examined the participant's utilization and perception of the HUD.

Participants

Three batches of participants were recruited for 129 total (*n = 129*). Two batches were recruited through Amazon's Mechanical Turk (MTurk) crowdsourcing platform. $1 was provided as compensation for the task, which was determined to be at an appropriate

standard for MTurk. There were no qualifying requirements beyond the ability to read English and the establishment of an MTurk account.

The third batch was recruited through word-of-mouth networking and messages posted in large group chats. These participants were compensated $1 as well.

Procedures

A link to the Qualtrics page was posted, which provided the informed consent document, then participants were presented with the game's URL and a post-treatment survey. The game and survey were expected to take around 10 minutes to complete. Upon completion of the informed consent document, the participants then navigated to the game's website, where they would then start the game. Under the hood, participants were assigned to treatment through a random number generator. Participants were then provided instruction through in-game text, describing the controls and general objective of the game. For the conditions with moveable HUDs, they were informed that they could move these elements also through text boxes. After encountering a color platform, participants were then informed of their ability to change their player color.

After reaching the end goal, participants were asked to take a screenshot of the end game screen, which provided the final location of the HUD elements, randomized ID number, the treatment number, and the number of deaths. Participants would then return to the Qualtrics page and upload their screenshots. They were then led to the post-treatment survey. To validate their completion, participants recruited through MTurk were then prompted to return to the listing and reenter the ID number. After its completion, the participants were thanked for their responses.

Results

Of the 129 participants recruited, 27 provided valid ID numbers, leaving the pool of valid results at 27. Furthermore, of those 27, only 14 provided an ideal screenshot that included the treatment number. Therefore, the number of adequately completed treatments and responses was insufficient for statistical significance. For this reason, statistical analysis was not performed. However, some descriptive statistics were performed and will be reported.

From the ethnographic data of those who completed the task, the group was predominately white. While the group had several women and non-binary, the group was primarily men. The group's average age was 39.

The responses to the Likert Scale questions were converted to numerical values to make analysis easier. Strongly Disagree was converted to a value of 1, Somewhat Disagree was converted to 2, Somewhat Agree was converted to 3, and "Strongly Agreewas converted to 4. Items can be seen as more agreeable the closer to 4 and less agreeable the closer they are to 1.

The satisfaction item, "I enjoyed mastering the game," had an average of 3.38 across all participants. Those with hard treatments rated this item with a 3.50 average, while those with easy treatments rated it 3.20.

As for the difficulty item, The game was difficult, it averaged a score of 2.65. Those who received easy treatments rated the item 2.80, while hard rated the item 2.50.

For the prior experience items, I consider myself good at games and I frequently play games, they both scored high with 3.69 and 3.54, respectively, across all treatments.

The item about default placement, The HUD elements were in a good place from the start, averaged 3.0 across all categories, including movable or not moveable HUD treatments. As shown in the screenshots, none of the 7 who received the treatments with moveable HUDs moved the HUD elements.

The remaining two HUD items, The HUD elements (color shifter, health, stars) were easy to read, and I frequently looked at the HUD, were rated 3.15 and 3.08 across all treatments. For the item I frequently look at the HUD, easy treatments rated this item a 2.80, whereas hard treatments rated this item 3.25.

It is important to note that it is dangerous to make assumptions based on these results alone with this small usable sample size. These findings should act as indicators for the present study's state, not as definitive conclusions.

Discussion

The ethnographic data revealed that most of those who provided complete results were white men, with an age average of 39. The open-ended fields also provided additional insight in that non-binary individuals were able to report their gender.

The qualifying item served its purpose of eliminating invalid responses. Most of the invalid responses were in the form of MTurk ID numbers. Many of these respondents were either confused by the item or intentionally entered this to complete the form enough to submit.

The difficulty item was rated with an overall average of 2.62, through which it can be assumed that the participants found the game moderately difficult but not overly. An interesting finding is that easy treatments rated this item with 2.80, whereas the hard treatments rated this item 2.50. This is unexpected as it was assumed that the participants

would perceive the game as more difficult due to the increase in obstacles with higher difficulty. Future studies should examine the relationship between this item and the items relating to prior experience and satisfaction.

The satisfaction item rated higher on those with hard treatments, 3.50, than those with easy, 3.20. It can be concluded that participants who received harder treatment found the game more enjoyable than those who received easier treatments. Again, future studies should look for a link between this item and prior experience through statistical analysis.

The items relating to prior experience were high across all treatments. It can be inferred that this may have to do with the online recruitment methods drawing in those who already have experience in computer technology, which can lend itself to prior exposure to video games. Further, another possible conclusion to the high rating of the item, I consider myself good at video games, can be attributed to overconfidence on the participant's part regarding their gaming skills. Future studies should expand these items to get a fuller view of participants' prior gaming experience and skills.

Of the items relating to the HUD, there was a large discrepancy between the easy and hard treatments regarding the frequency of use of the HUD, 2.80 against 3.25, respectively. From this, it can be inferred that the harder difficulty treatments did incentivize more extensive usage of the HUD. This finding was expected as the color swapping mechanic that was more present in difficult treatments incentivized the careful examination of the current player color state that was only relayed to players through a HUD element. It can be inferred from this preliminary finding that the color swapping mechanic did incentive engagement with the HUD elements. However, the item relating

to default HUD element positioning reveals that participants did not feel enticed to move these elements as their initial placement was sufficient. Future studies should look to place the default HUD elements in more unfavorable places or require the player to place these elements themselves at the start of the game. Furthermore, a statical analysis should look for a link between the utilization of these elements and prior experience as the binary nature of the color-shifting mechanic can lead to simple memorization of the current state rather than active engagement of the HUD elements.

Limitations

The most extensive limitation is the quantity of complete data entries. Of the 129 participants recruited, only 14 provided complete data, resulting in a failure rate of 88%. The two batches of 50, for a total of100 MTurk participants, provided very few verifiable and complete data points. It cannot be understated how impactful the number of usable data points is on statistical significance. This lack of statistical significance makes finding relationships between the variables difficult. More rigorous statistical evaluation methods such as T-Tests or ANOVA analysis would be able to deliver more concrete relationships between the items and treatments; however, they could not be utilized due to the lack of usable data.

Discovered through the testimony of a participant, an unintended mechanic that arose was that of wall sticking whereby pressing their character against surfaces, players could avoid falling, and from there, they could jump onto other platforms or surfaces. However, it was determined that this mechanic displayed mastery and engagement with the game and was maintained.

The central color mechanic of color had only two states: red and blue. Due to this binary nature, players could likely have remembered the state they were on, making them less likely to look at the HUD.

Reflections

This was a self-funded study that accomplished the goal of developing a framework for future studies aimed at advancing research into video games by creating a flexible framework in which game mechanics can be easily implemented. This framework successfully demonstrated its value through this proof-of-concept study. While it did not provide statistically significant results, it did find some potential relations between difficulty and engagement with HUD elements. Further, this study illuminated shortcomings with self-reported data and online recruitment through crowdsourcing platforms such as MTurk.

Future versions of the 2D platformer utilized in the study will need to include elements designed to automatically collect data instead of relying on the participant to capture and self-report. The original design for the game framework had a networking component that was invisible to participants and would report when and where participants moved their HUD elements, player deaths, time to complete, and other game variables. Due to the complexity involved in programming the data collection elements, specifically issues with the communication between the game and servers, this component was removed. The results of this study demonstrate the need for automatic in-game data collection.

The damage players received for being the wrong color when touching a color platform was relatively low. Due to the low damage and bounce provided when taking

damage, it is possible that players accepted the damage in exchange for the bounce to progress farther. While this was not an intended mechanic, it was decided that this strategy showed significant enough mastery in the game and was kept. Future versions of the game should increase the penalty for disregarding the mechanic, increasing the chances that the players will rely on the information in the HUD to determine the safety elements in the game.

Regarding compensation, ethical considerations of research state that researchers are obligated to provide compensation to all who agree to participate in the study; in this case, agreement to participate was given by simply clicking on the MTurk listing. MTurk incentivizes workers to complete tasks as quickly as possible. The fastest way to complete this task and receive compensation was to agree to the informed consent and submit anything in the form. This meant that participants could be as dishonest as possible in stating their task completion. Based on guidance provided by MTurk, the compensation amount was believed to be adequate for the study. This speed over quality incentive was likely one of the driving forces behind the low-quality data.

In contrast, the third recruitment pool consisting of word-of-mouth networked individuals provided much higher usable data rates for the same compensation amount. There is likely a difference in motivation between these pools. Future studies must consider this difference when recruiting. Future studies relying on crowdsourced participants should look to add controls, higher incentives, and qualifiers to the posting to ensure quality data collected from trusted individuals. Assuming these conditions could implement, there should still be further testing to see if crowdsourcing is a viable recruitment method. There is a limitation on the maximum number of participants one

can reasonably expect to recruit with word-of-mouth recruitment. The average person only knows so many people. Future studies might utilize the HSE/PSY 101 pool for qualified participants.

The self-funded nature of the study meant that there was an upper limit on the number of participants that could be recruited as recruitment necessitated that compensation was provided. While designing this experiment, no significant issues were uncovered to suggest that there would be such a significant disparity between participants and usable data. The initial design assumed the honest completion of the task with minimal data discarded for an incompletion. This assumption did not hold when crowdsourcing participants via MTurk. Networked recruits provided acceptable data completion rates; however, this pool was quickly exhausted. The self-funded nature of this study combined with suboptimal data return rates from MTurk resulted in the termination of the study.

Conclusion

This study was intended to act as a proof-of-concept for a game framework with a secondary goal of analyzing the relationship between HUD customizability, the ability to move the position of HUD elements, and difficulty. This pilot study demonstrated the usefulness of the 2D platformer game framework that was developed for this and future HSE investigational purposes. While this study experiences significant difficulty with the secondary goal of analyzing relationships due to the inability to collect enough data points for statically sound analysis, it uncovered some tentative links between difficulty and HUD utilization. Further, the study provided insight into the prior works performed in this field, evaluations of player satisfaction, including player taxonomy, the computer

programming required to create and deploy a game through the created framework, game design, HUD element design and layout, participant recruitment, overall study execution, as well as exposure on conducting a study through crowdsourcing platforms. In terms of providing learning opportunities and demonstrating the value of the game framework, this study was successful.

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