Exploring How Different HUD Orientations Affect Players' Eye Movement Patterns While Playing a Video Game

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1 ABSTRACT

This study investigates how different Heads-Up Display (HUD) orientations affect players' eye movement patterns while playing a fast-paced first-person shooter (FPS) video game. By using Gazepoint eye-tracking technology, we tracked participants' visual attention as they interacted with two different HUD orientations in which the health bar was placed on either the bottom-left or bottom-right corner of the screen. Participants played through one linear game level, with the HUD location being randomly chosen at the start of the level. After the level, they completed a survey assessing HUD readability. Eye-tracking data, including fixation duration and saccades, were analyzed to determine how HUD positioning influences players' ability to process game-critical information and maintain situational awareness. No statistically significant differences were found between the mean Area of Fixation (AOI) fixation durations of those who had the health bar placed on the bottom-left and those who had the health bar placed on the bottom-right. These results indicate that intentional fixations towards a dynamic user interface (UI) are minimally influenced by the positional arrangement of elements within the HUD.

2 INTRODUCTION

In the past 30 plus years, the popularity of video games has grown at an astonishing rate, and there are now few in today's society who can say they have never played one. Video games have become far more than a simple recreational activity, and there are now many who would even call them sports. Many video games require impressive hand-eye coordination and split-second decision making in order for one to be successful. While playing the game, players need to be simultaneously keeping track of information such as health, ammo, items, or a variety of other things depending on the game. This information is generally displayed on the screen during game-play in the form of a heads-up display (HUD). Knowing this, we wanted to find out how the positions of different HUD elements affect players' ability to easily find information while playing a fast-paced first-person-shooter (FPS) style of game. Research into how user interface (UI) design affects how players experience a game already exists, but much of this research is centered around educational games that are far slower-paced than the average FPS. This research aims not only to aid game developers in designing their own UIs, but also to shed light onto how humans quickly and precisely use their eyes to process information in high pressure situations.

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3 BACKGROUND

Helen Fricker's "Game User-Interface Guidelines: Creating a set of Usability Design Guidelines for the FPS Game User-Interface,"[Fricker 2012] offers valuable insights into UI placement strategies, particularly for studies incorporating eye-tracking data. The research highlights the importance of balancing cognitive, visual, and motor loads in UI design to avoid overwhelming users and maintaining an intuitive gameplay experience. By adhering to the "Magical Number Seven" principle, designers can limit on-screen elements to facilitate better information processing. The study underscores the significance of visual feedback, clarity, and consistent design through grouped elements and clear hierarchies, which eye-tracking data can validate by assessing gaze patterns and attention flow. Furthermore, Fricker's exploration of integrated HUD elements versus traditional overlays provides a basis for examining player immersion and focus, with eye-tracking serving as a tool to measure these effects. Finally, the research emphasizes sustaining player flow through thoughtfully designed UI, with disruptions in gaze patterns offering insights into areas for improvement. These findings provide a robust framework for integrating eye-tracking analysis into UI design evaluation, optimizing usability and player engagement in gaming contexts. The paper also emphasizes the importance of consistency across UI, both within a game and across game genres.

In "Find the Difference! Eye Tracking Study on Information Seeking Behavior Using an Online Game"[Józsa and Hámornik 2011] researchers used a classic "Find the Difference!" game in conjunction with an eye tracker in order to gain insight into how people gather information in an attempt to complete a task. In the game, participants went through 4 different levels in which each half of the screen contained the same picture apart from a few differences which they were tasked with finding. These 4 levels were then repeated with the differences changed, making a total of 8 levels. The bottom of the screen also showed feedback telling the participant how many differences remained in the two pictures. The researchers analyzed 4 different Areas of Interest (AOIs): each of the two images separately, the distance to completion feedback at the bottom of the screen, and the entirety of the screen as a whole. They analyzed the total visit duration of the AOI representing the entire screen as a measure of the total task completion time and separated the data between the male and female participants. They found no significant differences in task completion time between genders except for during the second phase of the experiment when the 4 levels were completed. In this phase, male participants completed the task on average slower than females, possibly because the male participants were more frustrated at having to repeat the same levels than female participants were. They also examined the fixation count and duration for each side of the image separately and found that participants had no significant preference as to which side of the image they preferred to look at. Finally, analysis of the AOI for the distance to completion feedback showed that during easier tasks, participants looked at the feedback far less, and several participants barely fixated on the feedback at all. As a whole, comparing the completion times between the first and second phases of the experiment revealed that there were no significant changes time to completion. They concluded that changing the locations of the differences from one phase to the next was able to suppress the effect of learning, and familiarity with the pictures was not enough to overcome the changing of the differences. While the genre of game used in this study significantly differs from our own, this study is relevant in that it similarly tackles the question of how people interact with UI elements while playing a video game. Particularly, the finding that level completion feedback was ignored during easier levels and completely ignored by some participants gave us insight into how we should design the UI that we test in this study.

In "Eye Tracking in Educational Games Environment: Evaluating User Interface Design through Eye Tracking Patterns"[Mat Zain et al. 2011] researchers used an eye tracking device to evaluate fixation areas of 6 participants while they played an educational video game. Within the game there were 3 main tasks: collecting keys to access the "scholar" character, answering quiz questions, and accessing the school location. They analyzed participants eye movements by using heat maps and gaze plots. They found that participants mainly focused on the center of the screen and the top left where the quiz questions and game instructions were displayed. The authors of the paper described some common issues users encountered with the UI and gave some recommendations for how these issues should be addressed. Similar to the paper mentioned above, multiple participants in this study either ignored completely or rarely looked at the scoreboard. Additionally, the authors note that some players had difficulty figuring out where they should go within the game. They recommend that important objects or locations should be marked in some way, for example by highlighting them or making them blink. The authors also recommend ensuring that game instructions are prominently placed in the center of the screen with a contrasting background and font to ensure ease of readability by the player. These findings aided us significantly in the design of our User Interface by giving us insights into what aspects of UI will draw the attention of players the most.

In "Evaluating Educational Game via User Experience (UX) and User Interface (UI) Elements"[Zamri and Tan 2022] researchers gathered 35 students and divided them into 5 groups to examine 10 different educational games and give each of them a score of 1 to 5 based on 10 different UI elements. These 10 elements were: connectivity, simplicity, directional, informative, interactivity, user-friendliness, comprehensiveness, continuity, personalization, and internal use. The average ratings for each element across all 10 games was between 3.1 and 4.2, and the elements of simplicity and user-friendliness were both particularly high with ratings of 4.2 and 4 respectively. The paper goes into detail describing what each element is why it is important for keeping the player interested and improving the effectiveness of the educational game. While this study did not use eye tracking and is based only on the subjective evaluations of 35 students, it still aided us in the design of our UI as it, similar to the study above, gave us valuable insights into what effective User Interface design looks like. This study was also helpful in that it examined and compared 10 games rather than just one, and this larger sample size was helpful to us as we looked for inspiration in designing the UI for our study.

4 METHODOLOGY

4.1 Apparatus

We tracked the individual's fixations and saccades using a Gazepoint eye-tracker (GP3 HD), a binocular pupil-corneal reflection eye tracker. The participants are sat approximately 20 inches from the eye-tracker, which was affixed below a 22 inch Monitor with a resolution of 1920 x 1080 and a refresh rate of 60Hz.

4.2 Stimulus

The stimulus for this experiment utilized a linear level of a first person video game. The game runs using the Unity game engine and is controlled via mouse and keyboard. The controls for the game are as follows:
pressing the "w" key will move you forward
pressing the "s" key will move you backwards
pressing the "a" key will move you to the left
pressing the "d" key will move you to the right
pressing the "r" key will let you reload your weapon
pressing the spacebar will allow you to jump
moving the mouse will adjust where you are aiming
left-clicking on the mouse will shoot your weapon
right-clicking on the mouse will aim down the sights

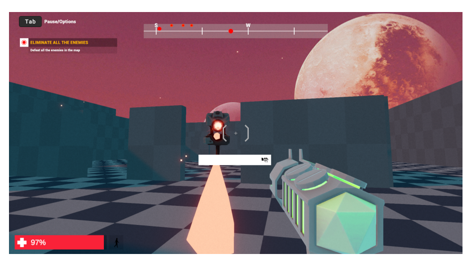

Figure 1: Screenshot of the Stimulus with the Health Bar on the Left Side of the Screen

4.3 Subjects

The participants were 10 undergraduate college students at Clemson University aged 21 to 23. The average age of the participants was 21.6 years. The participants were composed of 9 male students and 1 female student. None of the participants reported having any eye conditions.

Figure 2: Screenshot of the Stimulus with the Health Bar on the Right Side of the Screen

Figure 3: Aggregated Eye-Tracking Gaze Paths Overlaid on Participant Gameplay

Figure 4: Aggregated Eye-Tracking Gaze Paths Overlaid on High-Intensity Gameplay

4.4 Experimental Design

Prior to the start of the experiment, participants were given a survey in which they answered basic demographic questions regarding their age, gender, whether they wore glasses/contact lenses, whether they had any eye conditions such as cataracts, glaucoma, eye implants, or permanent dilation, and their experience playing both video games in general and first-person-shooter games specifically. This experiment utilized a between-subjects design in which each participant had the health bar placed on either the bottom-left or bottom-right side of the screen. The participants went through one level of a first-person-shooter game in which the goal was to defeat all of the enemies. Upon completion of the level, participants were asked to answer a post-experiment questionnaire which asked how often they play games of a style similar to this one, how easy/difficult it was to complete the level, and how easy/difficult it was to find information using the heads-up-display. After completing this questionnaire, the experiment was finished.

4.5 Procedures

The study utilized a classroom equipped with Gazepoint eye-trackers. Participants were read a simple synopsis of how the experiment will be run and then asked to provide written consent of their voluntary agreement to participate in the study, along with a rating of their familiarity with video games. Participants were also given the opportunity to ask any questions they may have had about the procedures of the experiment or the equipment used. The study began with the calibration of the Gazepoint eye-tracker, and one successfully calibrated, the video game program was run. Upon clicking "play game" the HUD appeared in a random location and participants proceeded to play through the linear game level, with the game HUD in a random location of 2 possible positions. Upon completion of the level, the participant was be directed to complete a standardized survey on readability of the HUD values. Each study session lasted approximately 10 to 15 minutes.

4.6 Analysis

To analyze the data we used custom written code to run independent samples t-tests in order to determine if a significant difference existed between the mean AOI fixation durations of those who had the health bar on the left side of the screen vs. those who had the health bar on the right side of the screen and those who wore glasses/contacts vs. those who did not wear glasses/contacts.

5 RESULTS

To determine if any significant differences in AOI fixation duration between participants who had the AOI on the left and on the right existed, an independent samples t-test was conducted with a significance level of $\alpha = 0.5$. The average fixation duration for those who had the health bar on the left (M = 56.26 ms, SD = 13.69 ms) was longer than for those who had the health bar on the right (M = 50.31 ms, SD = 15.16 ms) but the difference was not statistically significant, with a t-value of 0.58 and a p-value of 0.58. A t-test was also conducted analyzing AOI fixation duration between those wearing glasses/contacts and those not wearing glasses/contacts with a significance level of $\alpha = 0.5$. The average fixation duration for those wearing glasses/contacts (M = 50.06 ms, SD = 13.24 ms) was lower than for those not wearing glasses/contacts (M = 60.80 ms, SD = 15.34 ms), but this difference was once again not statistically significant with a t-value of -0.89 and a p-value of 0.44. Among the 10 participants, only 1 stated that they had no prior experience playing video games, and among those that did have experience, all stated that they had experience playing first-person-shooter games with a keyboard and mouse. Because there was only one participant who did not have experience with video games, a t-test was unable to be conducted between these two groups. However, it is interesting to note that the participant without prior experience did have a much lower mean fixation duration (M = 31.13 ms) than those with prior experience (M = 55.75 ms). Moving to the results of the post-experiment questionnaire, 6 of the participants responded that the level was at least "quite easy" to complete, while 3 participants responded that the level was "quite difficult," "difficult," or "very difficult." Among those 3 participants, two had the health bar placed on the right side of the screen while 1 had the health bar placed on the left. Just 1 participant responded that the level was "neither easy nor difficult." All but one of the participants responded that it was either "quite easy," "easy," or "very easy" to obtain information about their health using the HUD. The one participant who responded that it was "difficult" to obtain information using the HUD was also the participant without prior video game experience, which could suggest that the difficulty was caused more by lack of experience than the HUD pattern itself.

6 DISCUSSION

Future research should expand on these findings by exploring a broader range of UI element positions and implementing more controlled methodologies to minimize extraneous variables. While this study provided valuable insights, several areas warrant further investigation. Suggested improvements for subsequent studies include increasing the sample size to enhance the statistical power of findings and testing additional UI configurations beyond the two examined here. Exploring different types of gameplay, including various genres and levels of complexity, could provide a richer understanding of how UI placement interacts with user attention across diverse contexts.

Longer play sessions with varying intensity in gameplay should also be considered to allow participants to become fully acclimated to the game's mechanics. This would mitigate potential biases arising from participants' unfamiliarity with the controls or mechanics during shorter sessions and provide a more accurate assessment of attention distribution and user experience. Incorporating gameplay segments of different pacing—such as moments of high action versus slower exploration—could further clarify how UI placement influences attention under varying cognitive loads.

Moreover, utilizing advanced eye-tracking systems capable of accommodating greater head movement would enhance data reliability, especially in dynamic gameplay settings. These systems could capture more precise gaze patterns and allow for a broader range of natural player movements, ensuring that the findings are applicable to real-world gaming scenarios.

Finally, the research findings conclude that there is no significant difference in user attention between the two UI placements tested. This supports [Fricker 2012] assertion that consistency in UI design across game genres may hold greater significance for the overall user experience than specific positional adjustments. Future research could explore how maintaining consistent design principles across genres affects user satisfaction, engagement, and ease of transition between different games. By addressing these gaps, subsequent studies could yield deeper insights into the interplay between UI design and user attention, contributing to the refinement of usability guidelines for game design.

7 CONCLUSION

There is a limited body of research on eye movement analysis aimed at improving dynamic user interfaces (UIs), particularly in the context of video games. While the current study did not yield statistically significant findings, it provides valuable insights, indicating that intentional fixations towards a dynamic UI are minimally influenced by the positional arrangement of elements within the Heads-Up Display (HUD). This contributes to the understanding of eye movement dynamics in UI design.

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