

Performance of HUDs and Diegetic Displays in FPS Games

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ABSTRACT

We present an experiment comparing several commonly used heads-up display (HUD) based options to diegetic (in-game) displays. Participants played a custom-developed FPS game, and were tasked with shooting enemies while monitoring remaining ammunition. Results of the experiment indicate that the diegetic condition “number in game” performed best overall.

Keywords: HUDs, first-person shooter games, diegetic displays.

Index Terms: H.5.2 [Information interfaces and presentation (e.g., HCI)]: User Interfaces; K.8.0 [Personal Computing]: Games.

1 INTRODUCTION

First-person shooter (FPS) games task players with completing missions while shooting enemies from a first-person viewpoint. This is a popular and profitable game genre [1]. They are interesting platforms for empirical research, as numerous design considerations go into developing the UI for such a game. Our work investigates methods of displaying status information to the player in FPS games. Broadly speaking, two classes of information displays are prevalent in FPS games. The first is heads-up displays, (HUDs) which show game information in meters, bars, on-screen icons, or numeric displays. Sample HUDs representing this range of options are shown in Figure 1.



Figure 1. Example HUD displays. (a) *Call of Duty: Strike Team*, depicting controls (soft buttons, left-side), health (variation of bar), and ammunition as a number and bar; (b) *Tom Clancy's Rainbow Six: Vegas*, depicting ammunition numerically; (c) *Call of Duty: Ghosts* depicting ammunition both numerically and as a bar/meter.

The second class of displays is referred to as “diegetic”, see Figure 2 for examples. These incorporate the information display into the game world, i.e., they appear as an element that the character (in the game fiction) is aware of and can “see”.

Our research investigates the most effective means of presenting information to FPS players. To address this question, we conducted an experiment comparing several diegetic and HUD options for displaying ammunition information. We chose to study this in the context of ammunition, as it is a critical display in FPS games [2]. Future studies will look at similar options for other information displays (e.g., health).



Figure 2. Diegetic game displays. (a) *Metro 2033*. (b) *Dead Space* displays the health meter (blue bar mounted on player's back) diegetically. The in-game inventory is also presented like an augmented reality/holographic display floating in front of the player.

2 RELATED WORK

There is relatively little empirical work on the effectiveness of diegetic displays, particularly compared to HUDs. Most research in this area is qualitative, and relates to user experience, such as preference toward one display or another [3, 4]. Other work investigated issues such as level of immersion experienced by players [4-6]. There is evidence that players are more immersed in games that employ primarily diegetic UIs [6]. There is also work suggesting design guidelines for using diegetic UIs. Fagerholt and Lorentzon [3] recommend employing diegetic UIs instead of HUD-based options wherever possible. In the absence of empirical studies, however, it is unclear if this would enhance or detract from player performance. For example, Frago [5] suggests that the most important element is the effectiveness of the information display - participants reported that they felt their gameplay suffered from an absence of meaningful feedback. In contrast to the recommendation of Fagerholt and Lorentzon, Frago reports that HUD-based UI elements were less disruptive than their diegetic counterparts, and hence more preferred by participants. Our work complements this research by studying user performance rather than user experience with these different classes of displays.

3 METHODOLOGY

We conducted a user study to compare performance between different types of information displays. Here we focus exclusively on ammunition display. Ten paid participants took part; all were regular gamers, and reported playing FPS games every week.

The experiment was conducted on a desktop PC with a 3.4 GHz quad-core Intel Core i7 processor. The computer had 8 GB of RAM, and was running the Windows 7 OS. A 75 in. Samsung Series 7 7100 Smart TV (1920 x 1080 pixel resolution) was used for the display. Participants were seated on a couch approximately 15 ft. from the screen, see Figure 3. Figure 4 depicts the five ammunition displays studied. We used a custom game for the study, made using the Unity 4.5 game engine. See Figure 3.

Participants were asked to play the FPS game in a single level, and to shoot all 25 enemy soldiers as quickly and accurately as possible. They had an unlimited amount of ammunition, but a finite number (random between 7 and 16) of shots per clip. This necessitated reloading upon running out of ammunition, and hence required participants to attend to the ammunition display. The ammunition display varied between conditions.

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Figure 3. Participant performing the study. The game can be seen on the display.



Figure 4. The displays studied. (a) Bar, (b) Icon Bar, (c) Icon in Game, (d) Number on HUD, (e) Number in Game. Bar, Icon Bar, and Number on HUD appeared at the bottom right corner of the screen, fixed in the game HUD. Icon in Game and Number in Game were diegetic options that appeared co-located with the player's gun (and were thus subject to player rotation/viewpoint control).

Enemies started in a semi-circle around the participant, and slowly advanced inward. The participant was unable to move, but could rotate the viewpoint in typical FPS fashion.

Participants completed 15 trials for each of the five ammunition display methods, for a total of 75 trials each. The study thus employed a 5x15 within-subjects design. The independent variables were ammunition display (bar, number on HUD, icon bar, number in game, icon in game), and trial (1..15). Each trial took 30 to 45 seconds to complete.

The dependent variables were number of shots before reload (count of shots “fired” after running out of ammunition, but before reloading), and time before reload (seconds before reloading after running out of ammunition).

4 RESULTS AND DISCUSSION

There was a significant main effect for ammunition display on shots before reload ($F_{4,9} = 3.04, p < .05$). Tukey-Kramer analysis revealed that only *number on HUD* and *number in game* were significantly different. See Figure 5. Trial was not significant ($F_{14,9} = 1.19, p = .29$), nor was the interaction effect between ammunition display and trial ($F_{56,9} = 1.00, p = .47$).

Ammunition display did not significantly affect time before reload ($F_{4,9} = 1.46, p = .23$). However, there was a significant effect for trial on time before reload ($F_{14,9} = 2.13, p < .05$). See Figure 6. The interaction effect was not significant ($F_{56,9} = 0.97, ns$). This suggests that while participants improved their time before reload throughout the experiment, there was no difference in their improvement between the different ammunition displays.

Overall, these results suggest that there are indeed performance differences between these displays. The strongest difference was between the two numeric presentation options: one diegetic (number in game) and one a HUD presentation (number on HUD). This may be in part due to the extra and longer saccades required to view the HUD-based option. The number in game option presented the remaining ammunition right in front of the gun, and likely necessitated less glancing at the display.

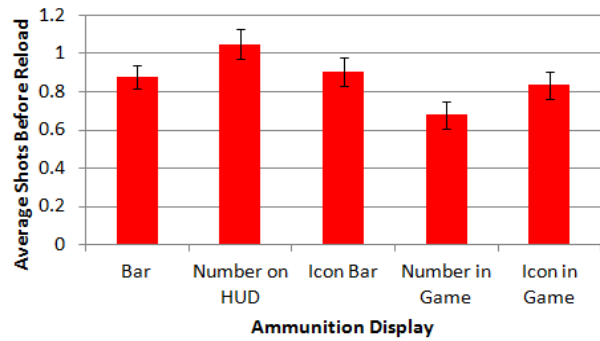


Figure 5. Average shots before reload for each ammunition display. Error bars show $\pm 1 SE$.

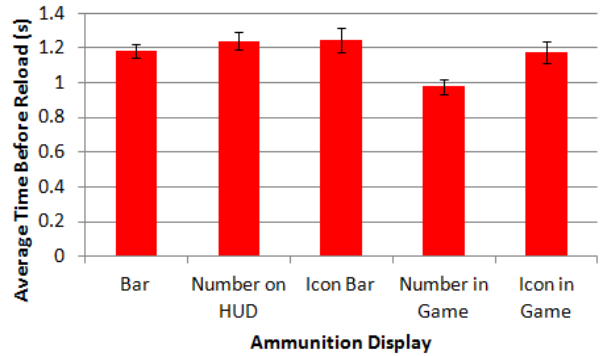


Figure 6. Average time before reload for each ammunition display. Error bars show $\pm 1 SE$.

However, the icon in game option also presented the display beside the gun, but was not substantially better than the HUD-based options. The minor (but not significant) differences between the HUD-based displays (bar, number on HUD, icon bar) suggest that there may be inherent advantages to one presentation style over the other. This is difficult to state with certainty though, due to the relatively small participant pool used in the study. Hence we intend to continue this work with additional participants to better isolate any differences.

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