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Abstract. In user interface design, spatial proximity between areas of interest is considered beneficial for user's performance. This study aimed at investigating the impact of split visual attention on players' performance in a video game. The first experiment showed that closer proximity of an important element of a video game user interface, namely the score, with the most watched area of the game screen did not lead to significantly better performance. The second experiment showed that the players' performance was actually better when the score was displayed below the game screen, though the scattering of eye fixations was larger than in the other conditions. For video games user interface, spatial sharing of visual attention may lead to better players' performance.

Keywords: Eye movements, proximity compatibility principle, video game, video game-player interface, usability

1 Related works

Numerous scientific studies have been published about video games, but relatively few of them were devoted to experimental research on the interaction between the computer or video game system and the player [1]. Yet, results from such experiments could help game designers to improve the usability of their products. Indeed, most of the usability guidelines and heuristics used nowadays in the video game industry are directly adapted from the ones used for more classic human-computer interfaces (e.g. web pages, software) like Nielsen's design heuristics [2].

The problem is that video game-player interfaces must be handled differently than other human-computer interfaces for at least two reasons. First, video games are entertainment products, and hence their interfaces cannot be designed using the same criteria as for more classic interfaces [3]. For example, the level of optimization of the effectiveness or efficiency of the user that must be reached for a classic human-computer interface might not be pertinent for game-player interactions. Second, most of the current video games offer complex graphic environments, which include dynamic backgrounds and/or moving objects. Because of these dynamic elements, the visual perception of video games scenes might obey different rules than that of static scenes.

In user interface design, spatial proximity between areas of interest is considered beneficial for user's performance because it favors spatial integration and should reduce visual attention sharing. For instance, Wickens used this concept to formulate the "proximity compatibility principle", which specifies that displays relevant to a common task or mental operation should be rendered close together in perceptual space [4]. Two experiments were conducted to investigate the validity of this principle and the impact of split visual attention on players' performance in a video game situation.

Eye-tracking is now commonly used in human-computer interaction studies to help understand the user's behavior (see for examples [5] [6] [7]). Here, eye movements were recorded to assess how participants explored different versions of the video game visual display and to understand their differential impact on players' performance.

2 Experiment 1

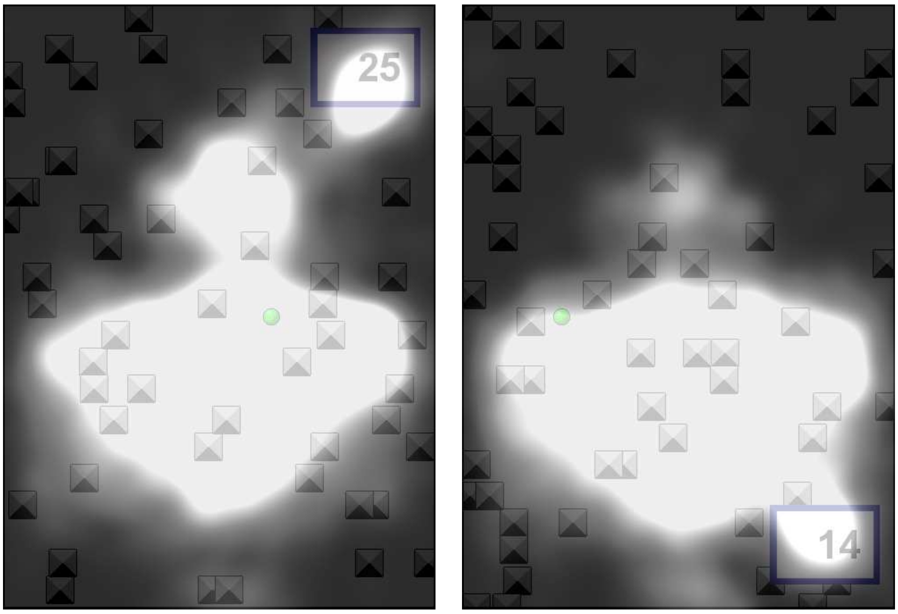
The first experiment examined the impact on players' performance and eye movements of different locations of the score display. The hypothesis was that reducing the split attention by moving closer together the important visual elements of a video game would increase the player's performance. Putting the score closer to the most watched area of the screen (i.e., the horizontal quarter screen located just below the ball) was expected to favor spatial integration and reduce visual attention sharing.

Twenty-nine right-handed participants played an experimental video game. They had to control the left-right movements of a green ball placed in the middle of the game screen. The grey background game screen was framed and slightly smaller than the computer screen. The principle of the game was to avoid obstacles (black and grey squares) that appeared at random locations at the bottom of the game screen and moved up towards the top.

The score was displayed in a blue background rectangle in either one of two different locations within the game screen. The first location, at the top-right corner of the screen ("top" condition), was further away from the most watched area of the screen than the second one, at the bottom-right corner of the game screen ("bottom" condition). The game was over as soon as an obstacle was touched. The score was set to 0 and increased by 1 point for each line of obstacles that was avoided. The objective of each participant was to hit a threshold score in one trial. The number of trials was not limited, but the time of effective play was limited to 6 minutes. The participants were asked to give their score after each trial to incite them to regularly look at the score display. The score location was manipulated between-participants. It was located at the top right corner of the game screen for half of them (15 participants), and at the bottom right for the other half (14 participants).

Eye movements were recorded to assess the distribution of eye fixations on the game screen using a Tobii 1750 eye-tracker linked to a PC-compatible computer, which collected the data and ran the video game program. A non-invasive eye-tracker was used to mimic as much as possible natural game conditions.

Figure 1 presents the cumulative distributions of eye fixations made on the game screen by each group of participants. The results supported the hypothesis that closer proximity of the score with the most watched area of the game ("bottom" condition) reduced the split attention, but did not support the hypothesis that this would increase the players' performance.



"top" condition "bottom" condition

Fig. 1. Hotspots of the total number of eye fixations (6 minutes of effective play plus inter-trials) made on the game screen by each group of participants. The grey scale represents the number of fixations that were made at or near specific areas of the game screen. The white color corresponds to areas where 100 or more fixations were made, whereas and the black color indicates the areas where no fixation occurred.

3 Experiment 2

A second experiment was done to replicate the observations of the first experiment in slightly different conditions, and to investigate how performance and eye movements were modified when two more extreme score locations were used. It was designed using a within-participant experimental design. In addition, another difference was that the participants were not asked to give their score after each trial anymore as they had to in the first experiment.

Twenty-four right-handed participants were recruited as unpaid volunteers. The experimental video game was the same as the one used in the first experiment, but two more possible locations of the score display were added. The third location was on the middle of the right side of the game screen, just above the horizontal axis of movement of the ball ("just above the ball" condition). This was supposed to be the closest possible location from the most watched area of the game that would not hide some of the upward moving obstacles from view. The fourth location was at the bottom right corner of the computer screen, outside and below the game screen ("below" condition), and was thus even further away from the most watched area of the game than the top right corner of the game screen used in the "top" condition. The participants' goal was the same as in the first experiment. Participants played for a longer time (20 minutes), but only the 15 last minutes were analyzed. The apparatus was the same as in the first experiment.

The hypothesis was that adding these two extreme locations would reveal a significant effect of the score display location on players' performance not seen in Experiment 1. The "just above the ball" condition was expected to minimize split attention and to lead to better performance than the "below condition", which would maximize visual attention sharing.

Again, the results did not support this hypothesis. Player's performance was not better when the score was displayed "just above the ball" than in the other three locations. In contrast, players' performance was better when the score was displayed "below" the game screen than in the "top" and "bottom" locations, even though the vertical scattering of eye fixations was larger in this condition than in those in which the score was displayed nearer from the most watched area of the game ("just above" and "bottom" conditions). Hence, displaying the score near the most watched area of the game led to worst performance than displaying it further away in the direction where players had to look to anticipate the movement of obstacles. For video games user interface, more spatial sharing of visual attention may lead to better players' performance, in contradiction with the proximity compatibility principle.

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