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Influence of head-up displays' characteristics on user experience in video games

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ABSTRACT

Head-up displays (HUD) are important parts of visual interfaces of virtual environments such as video games. However, few studies have investigated their role in player–video game interactions. Two experiments were designed to investigate the influence of HUDs on player experience according to player expertise and game genre. Experiment 1 used eye-tracking and interviews to understand how and to what extent players use and experience HUDs in two types of commercial games: first-person shooter and real-time strategy games. Results showed that displaying a permanent HUD within the visual interface may improve the understanding of this environment by players. They also revealed that two HUD characteristics, namely composition and spatial organization, have particular influence on player experience. These critical characteristics were manipulated in experiment 2 to study more precisely the influence of HUD design choices on player experience. Results showed that manipulation of design of these HUD characteristics influences player experience in different ways according to player expertise and game genre. For games with HUDs that are perceived as very useful, the higher player expertise is, the more player experience is influenced. Recommendations for video game design based on these results are proposed.

1. Introduction

Virtual environments such as video games, are environments simulating the physical presence of a user in a place that imitates the real world, or represents an imaginary world (Stanney et al., 1998). Two elements must be taken into account to describe the interface of this type of environment: the way that the user can interact with the environment, and information displayed by the interface that allows interaction with the user (Stanney et al., 2003). This information can be displayed according to different sensorial modalities, but the visual mode is generally the most used (Stanney et al., 2003).

The visual interfaces of video games generally consist of a main action scene containing objects with which the player can interact (e.g. avatars, enemies or targets) and a complex, moving background (e.g. interiors, landscapes). Traditionally, a *head-up display* (HUD) is often superimposed on the main action scene (see Caroux et al., 2015a for a review). This display provides contextual information associated with the current situation in the form of words, word lists, numbers or symbols (Brooksby, 2008). In most cases, the more-or-less permanent information is arranged around the edge of the screen (e.g., score, life points, map of the virtual world). In contrast, the non-permanent information is often displayed in the central area (e.g., warning messages). HUDs vary as a function of context. Some of them augment the user's perception of the game environment by superimposing context information over a real scene. HUDs can be used in real environments to assist, for example, piloting or driving activities (e.g., Charissis and Papanastasiou, 2008; Crawford and Neal, 2006). However, in contrast with HUDs in planes or cars, most of the elements used in head-up displays in video games could be opaque and have no real association with the part of the screen on which they are superimposed. They may therefore hide elements present in the game's main scene (Caroux et al., 2011).

The influence of specific elements of the video game visual interfaces, such as point of view or background characteristics, on player performance or experience has been investigated in several studies (e.g., Bae et al., 2012; Browne and Anand, 2012; Caroux et al., 2015b, 2013, 2011; Dyson, 2010; Hou et al., 2012; Jie and Clark, 2008; Knez and Niedenthal, 2008; Sabri et al., 2007; Takatalo et al., 2011; Wolfson and Case, 2000; Yannakakis et al.,

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2010). However, only a few of them investigated the influence of HUDs on player behavior, and more specifically on player experience.

The aim of the present research was to understand how HUD design choices influence player experience and to propose solutions to optimize player–video game interaction. The present study was composed of two experiments. Experiment 1 aimed to understand how and to what extent players use and experience HUDs in existing commercial games. Experiment 2 aimed to understand more precisely the influence of the most essential HUD characteristics on player experience by manipulating them.

The current state of knowledge about HUDs in player–video game interaction is introduced in the following paragraphs. Then, user-centered theoretical frameworks useful to design HUDs are presented.

1.1. Influence of HUD design choices on player performance and experience

HUDs are important parts of video game visual interfaces. They provide contextual information to the player, such as a score or health bar (Brooksby, 2008). However, few scientific studies have investigated the benefits of HUDs to player–video game interaction. Actually, this issue has been mostly debated in the industrial community. For example, Wilson (2006) proposed several reasons to abandon classical HUDs. This game designer claimed that HUDs decrease player immersion in the game environment and increase unnecessarily the amount of information to be processed by the player, particularly by a beginner. He suggested integrating all contextual information within the main action area. Elements would be displayed in a "diegetic" way. In such a way, contextual information would be directly integrated within the game world, and not superimposed on, as if virtual characters could see and use it. For example, in a shooter game, remaining ammunition could be displayed directly on the gun used by the virtual character (and the player). In contrast, Breda (2008), suggested that these arguments are not valid because HUDs have always been a conventional way to display contextual information in a game. However, these opinions were not proven with empirical results.

More recently, researchers conducted scientific studies about HUDs in video games. Jørgensen(2012)investigated the acceptance of HUDs in games by players. Contrary to certain game designer opinions, the author showed that HUDs are accepted, and even desired. That was true for all kinds of HUDs, even the most intrusive. In contrast, HUDs entirely integrated within the action scene or invisible are not always desired. The author also showed that the main condition for high acceptance is that displayed information should be useful for the player. Other studies investigated the influence of isolated characteristics of HUDs on the player performance and experience. Sabri et al. (2007) and Caroux et al. (2011) studied the effects of the spatial organization of contextual information in video games.Sabri et al. (2007) have shown that in the interfaces of high-resolution video games, spread across several monitors, the important context information that is most frequently consulted or used should be as close as possible to the cursor controlled by the player. In multi-monitor configurations, players have been found to perform their best when the context information is displayed on the monitor that is actually used. Caroux et al. (2011) studied the influence of the screen position of important context information (the score) on players' performance in a game requiring the visual anticipation of moving obstacles. The authors showed that positioning the score close to the area in which the obstacles were expected to move did facilitate the anticipation of these movements. Furthermore, players' performance was better when the score was positioned just outside, rather than even partially superimposed on, the area of anticipation.

In sum, there are still rather few findings from scientific research. It would be difficult for game designers to know what they have to do exactly to design a perfect HUD from these results only. Thus, it may also be useful to take into account general user-centered theoretical frameworks for interface design that exist in the HCI literature.

1.2. User-centered theoretical frameworks for the design of visual interfaces and head-up displays

Several theoretical frameworks for interface design exist in the HCI literature. These models are based on the fact that users must, to realize their tasks, divide their attention between the different sources of information, acquire the necessary information, and integrate that information. Two frameworks are especially relevant to designing visual interfaces and HUDs.

First, the proximity-compatibility principle can be used to explain and optimize information integration. Wickens and Carswell (1995) demonstrated that two information sources requiring divided attention in service of integration during a common task or mental operation should be placed close to each other in the display. In contrast, pieces of information used in isolation can be placed farther apart. Maximizing the spatial or temporal proximity reduces the amplitude of attentional moves in divided attention situations.

Second, the framework of the salience, effort, expectancy, and value (SEEV) model (Wickens et al., 2003; Wickens and McCarley, 2008) can help predict users' eye movements on the areas of interest (AOIs) of dynamic visual displays. The model claims that the probability of attending to each particular AOI results from four factors. The visual salience of the area and the effort needed to access the information (i.e., the distance between the AOI and other information sources) depend on the physical characteristics of the display. The two additional factors are the user's expectancy to find relevant information in each AOI (which is linked to the frequency of information changes in this area) and the value of the information for the user.

These two frameworks are usually applied to the design of productivity systems, in which users' performance is essential. However, they can also be used for the design of entertainment systems, such as video games. For example, Caroux et al. (2011) showed that the proximity-compatibility principle could be adapted to design interactive environments, such as video games, that require visual anticipation. They showed that the main elements of contextual information should be located in the expected direction of anticipation but should not overlap with the main action and anticipation zones.

1.3. The present research

The aim of the present research was to understand how HUD design choices influence player experience. The present study was composed of two experiments. Experiment 1 was an exploratory experiment on HUDs in existing commercial games. More precisely, the goal was to understand how and to what extent players use and experience HUDs. The characteristics of HUDs that are essential and that potentially have the highest influence on player experience were extracted and manipulated in experiment 2. The goal of this experiment was to understand more precisely the influence of HUD characteristics on player experience. Findings can be used to propose some recommendations for design of video games and, more generally, virtual environments. The first general hypothesis for the present study was that choices of HUD design influence player experience. In each experiment, player expertise