Multi-sensory Game Interface Improves Player Satisfaction but not Performance

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Abstract

Players of computer games tend to be discerning about game quality. So, to be successful, game designers need to ensure that players receive the best possible experience. A growing trend in the design of game interfaces is the use of multi-sensory (visual, auditory and haptic) interfaces to broaden the experience for players. The assumption is that, by displaying different information to different senses, it is possible to increase the amount of information available to players and so assist their performance. To test this assumption, the first-person shooter game, "Quake 3: Arena", was evaluated in four modes: with only visual cues; with both visual and auditory cues; with both visual and haptic cues; and with visual, auditory and haptic cues. Players reported improved 'immersion', 'confidence' and 'satisfaction' when additional sensory cues were included, the multi-sensory game interface seemed to improve the player's experience, but there was no statistically significant improvement in their performance. We suspect that a better design of the information being displayed for each sense may be required if multi-sensory displays are to significantly improve the player's performance on specific game tasks.

Keywords: Multi-sensory; multimodal; user-interface design; computer games.

1 Introduction

Some predictions suggest that electronic games will continue to be the fastest growing segment of the computer industry over the next five years and reach an estimated $55 billion in annual revenue by the end of 2008 (PricewaterhouseCoopers, 2004). Although the market is large, the industry remains extremely competitive, and the key to providing market advantage is to provide players with an experience that is superior to that offered by the competitor's games.

One approach to improving the player's experience is to develop multi-sensory game interfaces. Indeed, auditory cues and haptic cues, such as force feedback, have been designed to augment the visual display of many modern games. However, the question remains, "Can such multi-sensory interfaces improve the player's experience and general performance?"

There are two basic approaches designers can take when adding sensory cues to a game interface. Firstly, designers can aim to improve the player's feeling of satisfaction or enjoyment of the experience. For example, background music and sound effects have long been used in motion pictures to augment the experience for the audience. A similar strategy has carried over into game design, where sound and haptic displays can assist players to become absorbed or immersed in the 'reality' of the game. If market forces are any guide, the wide-spread availability of force-feedback controllers and sound displays suggests that many players do prefer multi-sensory game environments.

The second way that designers can employ additional sensory cues is to design the feedback so that it assists the player to perform essential tasks. The emphasis is on providing the player with useful additional information. For example, an auditory alarm may be used to warn players in a first-person shooter game that they are running low on some vital resource, such as health or ammunition. The general assumption is that, by increasing the number of senses used in the interface, we can somehow increase the amount of information the player receives. This approach can be also be described as increasing the human to computer bandwidth.

Increasing the bandwidth is one thing, but the information must also be relevant to the player's task if it is to assist with their performance. Issues of perception and cognition also become relevant as players must perceive, interpret and react to the information being provided.

In practice, using a multi-sensory display to improve the quantity and quality of information available in user interfaces has proved challenging. One particular issue is that of sensory interaction where the combined sensory information will alter the perception of a single sense. For example, using sound in conjunction with haptics can alter the perceived stiffness of a surface (DiFranco et al., 1997). So when a hard sound is played on contact, the surface is reported as being harder than when a soft sound is played. This is despite the fact that, in each case, the same haptic model is used to represent the surface contact. Likewise, changing the visual representation of the object can alter the perceived haptic stiffness of a spring. Thick visual representations of a spring feel stiffer than thinner ones, despite the same force being required to compress the spring (Srinivasan and Basdogan, 1997).

Sensory interaction is related to sensory discrepancy (Welch and Warren, 1980). There is a strong tendency for our perceptions to produce an experience that is consistent across our senses. When conflicting information about an event is received, there is a tendency to perceive the situation as a single consistent event rather than two separate events. If a conflict occurs between two or more sensory modalities one or both modalities tend to bias each other. For example, when a stationary hand is viewed through a 14 degree displacing prism, it immediately feels as if it is located very near its seen position. Here the visually displaced view overrides haptic information about the actual location of the hand (Welch and Warren, 1980).

It should also be remembered that all displays rely on human perception and therefore general principles apply. For example, a user's perception is influenced by the individual's knowledge (Goldstein, 1989, p205). Furthermore, the sensory feedback that a particular observer pays attention to is determined by factors such as previous learning (Welch and Warren, 1980). We tend to take an active role in perception by seeking out stimuli that are of interest, therefore our attention is important as it directs our senses to the stimuli that we want to perceive and subsequently influences the way the information is processed (Goldstein, 1989, p118). Attention can enhance perception of stimuli on which we are concentrating and decrease awareness of stimuli that we are ignoring. For example, in a multi-sensory display, some users may attend closely to the auditory signal where others may simply ignore it.

For designers, such complex perceptual issues complicate the design of multi-sensory displays. One encouraging note for game designers is that many other fields of study have grappled with the same issues. Thus, game designers can draw on existing work in fields such as Human Computer Interaction and Information Visualisation.

Human Computer Interaction provides many useful foundations for the study of computer game design. Indeed, one thing that computer games share in common with traditional software is that the user interface is a crucial component of the application. However, what is an effective interface? Often with traditional interface design, the key design goals are issues such as learnability, memorability, utlity and efficiency (Preece et al., 2002, p14). It is possible to define quantitative measures for these goals and thus to objectively measure the usability. For example, the number of errors a user makes when carrying out a task, or the time for task completion can be used as performance measures. In some interfaces, such as games, there is also a requirement to consider criteria such as satisfaction, fun, motivation and entertainment value (Preece et al., 2002, p18). While it is more difficult to measure such criteria objectively, appropriate questionnaires or interviews can be used to gain some subjective feedback (Dix, et al., 2004, p349).

'Information Visualisation' is the term commonly used to describe interactive computer systems that provide the user with visual models of abstract data (Card et al., 1999). Recently, the field has expanded to include both the auditory and haptic display of abstract data. The design of auditory displays of abstract data is an emerging field in its own right and is often described as 'Sonification' (Kramer et al., 1997). Where multiple senses are used to control an interface, the term 'multi-modal' is frequently used. However, this term has a strong implication that both the input and output of information between the computer and user is involved (Wickens and Baker, 1995) and so the term 'multi-sensory' is often used to emphasise that the primary focus is on the output of information to the user (Stuart, 1996).

Within these existing fields of study there is much literature to assist game designers. For example, the aviation industry has studied the design of auditory alarm systems for pilots in some depth to produce useful guidelines (Patterson, 1982). Such guidelines can simply be adapted to the design of simulator games. By comparison, the use of haptic displays is still in its infancy, but there are notable examples such as the use of force feedback displays to interpret intramolecular forces (Brooks et al., 1990), to allow blind users to interpret graphs (Ramloll et al., 2000), to augment a doctor's surgical skills (Mor et al., 1996) and to train dentists (Ranta and Aviles, 1999).

It is also useful to characterise multi-sensory displays as either complementary, conflicting or redundant (McGee et al., 2000, Pao and Lawrence, 1998). Complementary displays attempt to provide useful, but different, information on each sensory channel. Compared to a single-sensory display a complementary display should allow the user to perform better. If the user actually performs worse with the multi-sensory display then the display is described as conflicting. This is presumably due to some conflicting information that the user receives on the different sensory channels. With redundant displays the same information is displayed to each sense. This may serve the purpose of increasing the user's confidence or reducing the perceived workload. Although users may report a reduction in workload or an increase in confidence with redundant displays, the performance of the user with the multi-sensory display is the same as with single-sensory display.

All three types of display may be relevant to the design of computer games. For example, complementary displays may improve user performance and they could also act as a reward for players who reach higher levels. In most domains, it would be abnormal for the designer to provide the user with a conflicting display, but a conflicting display could be useful if game designers wished to increase the level of difficulty for the player, or to punish the game player, or make a task more taxing by increasing the player's stress level. On the other hand, redundant displays may give players greater confidence in some situations and this may act as a reward or assist the player to learn skills required in higher levels of the game.

In summary, this study is motivated by the trend towards increased use of multi-sensory displays in game interfaces. The main question to be considered is: "Can providing additional sensory cues for players improve the game experience and their ability to perform tasks in the game?" We will show that players do subjectively rank the more multi-sensory displays to be more effective but also that objective measures show no improvement in their performance when the additional sensory cues are provided. Therefore, the multi-sensory display being studied can best be categorised as redundant as it increased the player's confidence without improving their performance. One implication of this outcome is that a more careful design process may be required to produce a complementary display.

2 Methods

The evaluation used version 1.3.2 of the popular first-person shooter game Quake 3: Arena. This game, which has been designed to provide visual, auditory and haptic feedback, was run under the windows XP operating system. The relevant game options were set to be the same for each player (level=Q3DM7, No. Bots=4, Bot Skill="Bring It On", Effects=Maximum, Music=Minimum/Off).

The hardware consisted of a Dell Dimension 8100 PC with: 1.4GHz Pentium 4 CPU; 256 Mb Ram; 32Mb Nvidia Geforce3 Video Card; Onboard sound; standard 104-Key Keyboard; and a 2-button mouse. The graphics were displayed on a Sony 21" flatscreen monitor at 1024 x 768 pixel resolution which is capable of an 85Hz refresh rate. The sound was displayed using Sony MDR-P180 circumaural headphones. The haptic feedback was provided by an Aura-Interactor Force-Feedback Cushion. This device is designed to sit comfortably behind the user's back and provide the player with haptic sensations, such as vibration.

The 12 subjects had various degrees of gaming experience with 7 subjects playing daily, 2 weekly, and 3 only occasionally. Only 2 of the 12 subjects had not previously played the game. The group was composed of 2 females and 10 males and all were aged between 19 and 25 years. All subjects were second-year undergraduate students in an Information Technology course and had proficient computing skills and a general knowledge of user-interface principles.

The experiment used a within-subject design, with each of the participants' being tested in four different modes: visual cues alone; both visual and auditory cues; both visual and haptic cues; and visual, auditory and haptic cues. To minimise the possible learning effect, blocking was used and the mode order was randomly allocated to each subject. Mode order and subject differences were assumed to be the two major sources of variation. Our hypothesis was that more sensory channels would improve the user's performance.

The test for each of the four modes consisted of 3 minutes of familiarisation followed by 10 minutes of game play. After ten minutes, the participant's game score was recorded as the objective measure of their performance. It needs to be noted that the game score of each participant is influenced by certain uncontrolled factors within the game environment. For example, the way adversaries in the game move is determined by the game software. Therefore, the number of adversaries the player may encounter can fluctuate. It is assumed that these fluctuations average out over the ten minutes of the game. The player's risk strategy can also influence scores.

Qualitative feedback was collected after each mode. On a five-point Likert scale (1=low, 5=high), subjects ranked their experience on three key criteria: immersion, confidence, and satisfaction. Immersion captured how engrossed in the game the player felt, how realistic the experience seemed and how much they felt they were a part of what was happening around them. Confidence was used to rate the degree of difficulty the player experienced. That is, did they feel it was easy or hard to play the game? Satisfaction was designed to measure how well the information provided by the interface supported or distracted the player from their task. After each mode, the subjects were also asked to provide general feedback about their experience.

Mode				
Visual	Visual/ Haptic	Visual/ Auditory	Visual/ Auditory / Haptic	Mean score for subject
12	14	9	21	14
25	35	38	36	34
34	32	46	30	36
44	50	70	48	53
55	37	50	73	54
70	57	58	62	62
60	57	77	58	63
66	58	61	83	67
86	72	45	69	68
57	79	68	71	69
58	86	70	64	70
61	73	76	72	71
52.33	54.17	55.67	57.25	Mean score for mode

Table 1: There was a slight, but statistically non-significant, improvement in scores as sensory cues were added. Note also the wide differences in individual performance, which provided the major source of variation in the experiment

3 Results

There was a wide variation in scores between subjects (table 1) and the differences between the four modes were not significant. Despite this, the player's ratings of experience (table 2) showed a strong preference for the interfaces with more sensory channels. For all three criteria (immersion, confidence and satisfaction), visual plus haptic was rated superior to visual alone, visual plus auditory was rated higher again and visual plus auditory plus haptic received the highest rating of all (table 2).

Individual comments about the four modes were consistent with these ratings (table 3). The importance of sound was noted by most subjects, but the response to the haptic display was more varied. Furthermore, subjects noted that the haptic cues were heightened when they were combined with the sound cues. When using the visual only mode, most players commented on how the absence of sound detracted from the game experience. By contrast, one player preferred the game without sound as it lessened the sense of threat from adversaries.

Mode	Mean Immersion Rating	Mean Confidence Rating	Mean Satisfaction Rating	Mean Experience Rating
Visual	1.8	2.9	2.1	2.3
Visual/ Haptic	2.9	3.6	3.0	3.2
Visual/ Auditory	4.3	4.3	4.3	4.3
Visual/ Auditory/ Haptic	4.9	4.6	4.4	4.6

[1=very weak, 5=very strong]

Table 2: Players subjectively rated their experience as improving as additional sensory cues were provided. This same trend was evident for all three criteria used.

4 Discussion

Overall, players rate their experience to be improved when additional sensory cues are provided. The highest rankings were received for the visual plus auditory plus haptic display. These trends were consistent for the three experience criteria of immersion, confidence, and satisfaction.

When comparing the other interfaces, players preferred the displays with one additional sensory cue (visual/haptic, visual/auditory) over the solely visual interface. Of these two interfaces, the players preferred the display with auditory cues over visual plus haptic feedback. The player's comments supported these overall rankings. Six players noted the superiority of the display which used all three senses. Two players suggested that adding the haptic feedback to the visual display provided some novelty value but was not useful for playing the game. By contrast, most players made some comment about the importance of sound to the game experience. Reasons for this included: "Sound helps to block out external distractions", "Sound allows me to anticipate and understand apparent movement and combat areas."

Mode	Representative comment	Number of subjects with similar comments
Visual	"Sound was important when enemies approached from behind, or I was being shot at, for powerups etc."	4
	"Without sound, it was harder to focus on the game and ignore the surrounding environment"	4
	"I liked it this way because it was less threatening! I felt I had more control."	1
Visual/ Haptic	"Force feedback really needs the sound for immersion."	2
	"Force feedback didn't really work and can get annoying."	4
Visual/ Auditory	"Sound allows me to anticipate and understand apparent movement and combat areas."	3
	"Sound helps to block out external distractions"	3
	"Harder to focus in a sense because the sound was distracting as well as helpful."	1
Visual/ Auditory/ Haptic	"Covers all bases - improves the game immensely."	6
	"Force feedback doesn't seem to add as much to the experience. More just a novelty."	2
	"Force feedback is much better when sound is included."	2

Table 3: Many players suggest that the visual, auditory and haptic display improves the game experience. Of the additional sensory cues, sound is felt to be most important to the overall experience. Players also reported that sound improved the effect of the haptic display.

The study was not designed to distinguish between the various possible explanations for the observed preference for auditory over haptic cues. Therefore explanations for the preference for sound cues over haptic cues are speculative and require further investigation. However this outcome might be explained by a number of factors including player experience, hardware maturity, and the way information is mapped to each sense.

Although haptic cues received a mixed response from players, many commented that haptic cues were better when sound was included. For example, four players made comments along the lines of ""Force feedback is more better when sound is included." Indeed, the ability of sound to alter haptic perceptions has previously been measured in multi-sensory interfaces (DiFranco et al., 1997).

Individual preferences for sensory feedback were highlighted by one novice player who found the sound annoying. In this unfamiliar task, the user possibly felt overloaded with information and found it difficult to attend to even the visual information available. Again, individual attention (Goldstein, 1989, p118) and experience (Goldstein, 1989, p205) are well-known to influence perception of information. It is also common when designing sound displays to consider that some users will find sound annoying (Kramer, 1994). The level of annoyance will vary greatly with the characteristics of the sound and the preferences of the listener. However, even interesting sounds can become annoying when presented repeatedly (Smith et al., 1994).

In summary, the players report a better experience with the more multi-sensory displays. Players also feel more confident of their performance when using the multi-sensory displays even though the actual measure of their performance did not support this perception. This type of multi-sensory display is characterised as redundant (McGee et al., 2000). This is not a criticism of the display, but it does highlight the difficulty of designing displays with complementary information available to the different senses. "Increasing the human to computer bandwidth" is also a problem that is common to designers of multi-sensory interfaces for industrial and business applications. This difficulty is not particularly surprising when the complexity of human perception is considered. Preliminary work into the targeted design of such displays is taking place in the field on information visualisation but it is only embryonic. One approach that has been adopted to support the design of multi-sensory abstract data displays is to follow a structured design process, supported by guidelines and a range of formative and summative evaluations (Nesbitt and Barrass, 2004; Nesbitt 2004). The authors suggest that such a methodology could also be useful for game designers who wish to use multi-sensory displays to provide a greater spectrum of information levels to the player. Better design of the way information is displayed to the different senses could be used to improve player performance or alternatively to make some game tasks more challenging.

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