Exploring the relations between video games, emotional responses and eye-tracking

Thesis · January 2013

DOI: 10.13140/RG.2.1.5021.1369

1 author:

Guusje Hallema
Amsterdam University of Applied Sciences/Centre for Applied Research on Education
3 PUBLICATIONS **1** CITATION

SEE PROFILE

UNIVERSITY OF AMSTERDAM

Exploring the relations between video games, emotional responses and eye-tracking

Drs. Guusje Hallema
0519235
Master's thesis
Graduate School of Communication
Research Master Communication Science
Dr. J.S. Lemmens
January 31, 2013

Abstract

Very few studies have been done concerning video games and eye-tracking. The aim of this explorative study was to examine whether a relation exists between eye-movements, pupil diameter, blink rate and emotional responses while playing a video game. For this purpose, 77 male adults played either a violent or a non-violent game while wearing eye-tracker glasses. During gameplay, eye-movements, blink rate and pupil diameter were measured. Additionally, state hostility, enjoyment and immersion were measured in a questionnaire. As expected from previous research, heat maps show a smaller focus from players of a violent video game compared to players of a non-violent game. Furthermore, after playing a violent first-person shooter, higher levels of hostile feelings were measured than after playing a non-violent first-person action-adventure game. Players of violent video games also show a lower blink rate and fewer fixations than players of non-violent video games, possibly due to the fast pacing and moving targets in the game. Higher levels of hostility were also related to more and rapid eye-movements.

Introduction

Eye-tracking devices are used within communication and media research to determine attention patterns by examining, among other things, eye-movement, pupil diameter, blink and fixation patterns. Eye-trackers have been used to analyze where viewers look at when watching television (Brasel & Gips, 2008) and how users look at banners on websites (Albert, 2002; Almeida et al., 2010). Recently, some studies have been done with eye-trackers and video games. For instance, eye gaze patterns in video games have been analyzed to estimate attention allocation and present information at locations where attention benefit will be high (Kenny, Koesling, Delenay, McLoone & Ward, 2005; Jie & Clark, 2008). Differences exist between action-adventure games and first-person shooters (FPS) concerning gaze patterns (El-Nasr & Yan, 2006). A much larger range of eye-movements was found within an action-adventure game, because such games are slow paced. It also seems that eye-movements of players can be related to moments of prediction and urgency of action in a videogame (Shalom, Dagnino & Sigman, 2011). They observed anticipatory behavior, indicating that there were more eye-movements at moments when the game was predictable.

Unfortunately, to date, not much else is known about the ways in which eyes respond to playing different types of games and corresponding emotional conditions. It seems relevant to know to what extent eye-tracking data, such as blink and pupil diameter, can be linked to certain emotional responses when playing video games, because these measures could provide a more valid assessment of emotional responses (such as immersion or hostility) than subjective post-hoc measures. Therefore, the purpose of this study is to acquire knowledge about several emotional responses players experience while playing games, such as hostility, enjoyment, immersion and performance, and their relations with blinks, eye-movements and pupil diameter.

The current study aims to address the knowledge gap in existing research regarding the

relation between video games, emotional responses and eye-tracking data. It may offer new information about the effects of video games on players' eye behavior and emotions. In contrast to previous studies, which mainly focused on differences in eye-movements between games (Bernhard, Stavrakis & Wimmer, 2010; El-Nasr & Yan, 2005; Jie & Clark, 2008; Kearney & Pivec, 2007; Koesling, Delenay, McLoone & Ward, 2005; Shalom, Dagnino & Sigman, 2011), the current study also investigates blink rate and pupil diameter. By including these two eye behaviors, it may provide a better insight into the relations between eye-tracking, emotional responses and video games.

Theoretical framework

Hostility

Most research concerning video games is focused on the correlation between video games and aggression. Exposure to media violence, including playing violent video games, is positively correlated with the level of aggressive behavior (e.g. Anderson & Bushman, 2001; Dill & Dill, 1998). Hostility can be considered as an element of aggression, because the feelings and attitudes of hostility motivate aggressive behavior (Spielberger, 1988). The state hostility causes impulsive and angry behavior intended to hurt another individual (Bushman and Anderson, 2001), whereas aggression is calculated behavior that is intended to harm another individual and is motivated by some other goal, such as to restore justice (Anderson & Bushman, 2002; Bushman & Anderson, 2001; Coie & Dodge, 1998). In addition, experimental research has shown that playing violent video games produces higher levels of aggressive behavior (in the short-term), aggressive cognition, aggressive affect, and physiological arousal, when compared to playing non-violent video games (Adachi & Willoughby, 2011; Anderson, Gentile, & Buckley, 2007; Bushman & Huesmann, 2006). Playing violent video games increase self-reported feelings of state hostility

(Arriaga, Esteves, Carneiro & Monteiro, 2006), therefore it is expected that hostility level will be higher after playing a violent video game than after playing a non-violent video game.

Enjoyment, Performance and Immersion

Next to hostility, enjoyment, performance and immersion are main measures in this study. The main source of enjoyment when playing video games comes from competitive elements (Vorderer, Hartmann & Klimmt, 2003). Generally, the better a player performs, the more one enjoys the game. Players' performance when confronted with challenges, dangers, and threats is one of the main dependent factors of game-enjoyment (Vorderer, Hartmann & Klimmt, 2003). It is expected that the more one is experienced and the better one performs, the more one enjoys the game. Thus a positive correlation between these two emotional responses during gameplay is expected.

Another emotional response that can be experienced during a gameplay is immersion, which can be described as being in a state when all attention is focused on the game. Video games can provide a distraction from daily life and allow people to lose themselves in the game world. If a player does not notice things happening around him anymore or does not know how much time is passed since the gameplay started, then the player is fully immersed in the game. This immersive state feels like as being 'in the game' (Jennett et al, 2008). Three main features of immersion can be distinguished, namely 'the lack of awareness of time', 'loss of awareness of the real world' and 'involvement and a sense of being in the task environment'. The extreme end of immersion is named 'flow', a process of optimal experiences, when someone is so involved in an activity that nothing else seems to matter (Csikszentmihalyi, 1990). Flow takes away the attention from the task at hand and clearly overlaps immersion in the sense of distorting time. Immersion could be seen as a precondition of flow, since immersion involves a loss of sense of context,

while someone who experiences flow is completely involved in the game (Nacke et al., 2008) and nothing else matters. If a balance between skills and challenges is attained during flow, players experience intense feelings of enjoyment (Csikszentmihalyi & Csikszentmihalyi, 1988; Moneta & Csikszentmihalyi, 1999). Immersive experiences are also reported as enjoyable experiences (Brown & Cairns, 2004; Jennett et al., 2008) therefore it is expected that higher levels of immersion will be related to higher levels of enjoyment. In sum, it is expected that immersion, enjoyment and performance will be interrelated with each other.

Eye-tracking

Eye-tracking machines are widely used and have become an attractive method for measuring attention. It is considered as one of the most important human-machine interfaces to find a relation between eye-movements and information-processing demands of a task (Lin et al., 2004). Eye-tracking research exists for a long time, but to date, a well-known eye-tracking study is the experiment carried out by Yarbus (1967). He concluded that eye-movements reflect inner thoughts and therefore a variation exists between subjects' eye behaviors when performing different tasks (Yarbus, 1967). With the emergence of eye-tracking technologies, video-based eye tracking is now commonly used for marketing research (MacKenzie, 2010; Moore & Churchill, 2011). It is important to know and predict to which stimuli consumers are attracted. Within game research, it enables designers to improve the game world and optimize the placement or visibility of objects within the game (e.g. El-Nasr & Yan, 2005; Jie & Clarck, 2008; Kenny et al., 2005). With eye-tracking machines pupil diameter, blink rate and eye-movements, such as saccades and fixations can be measured. These measures, and accompanying expectations, will be explained below.

Blink rate. People blink automatically in order to oil, lube and filter the eyes. A blink

causes temporary loss of visual information, since the eyelid creates a barrier between the eye and the stimulus (Fogarty & Stern, 1988). Research indicates that arousal or the sight of violence can influence the blink rate. For instance, eye blink rates increase with anxiety (Argyle & Cook, 1976; Jankovic, 1987) stress (Harris, Thackray, & Shoenberger, 1966) and arousal (Stern, Walrath, & Goldstein, 1984). Because increased levels of arousal, stress and anxiety usually play a role in the manifestation of aggression (Marsee et al., 2008) it is expected that blink rate is also positively correlated with subjective feelings of hostility while playing a game, and thus also more likely to occur among players of violent videogames.

Blinks can also be related to the degree in which players are absorbed by the game. When people concentrate, the blink rate decreases with the degree of the subjects' situation (Takahashi et al., 2000). Thus, it is expected that players who have a lower blink rate will be more immersed in the game due to the concentration. Similarly, the more experienced gamers are the less they blink (Green & Bavelier, 2003), and experienced gamers fail to show a blink at all. This shows that performance and experience can also affect blink rate. It is expected that within conditions, blink rate is lower for players who knew the game before than for players who are familiar with the game. Summarizing, it is expected that blink rate is positively correlated with level of hostility and thus also more likely to occur among players of the violent video game. Negative correlations regarding blink rate are expected with immersion, performance and familiarity of the game.

Pupil diameter. Our pupils dilate and constrict primary because of light reflexes; constriction occurs with bright light and dilation occurs with dim light. However, non-visual stimuli, (e.g. emotions) can also influence the pupil diameter (Goldwater, 1972; Loewenfield, 1993, Laeng et al., 2012). The study of pupil diameter *(pupillometry)* is a method that investigates the correlation between pupil diameter and psychological reactions to visual stimuli

(Goldwater, 1972). Pupil dilation can be brought about by almost any emotion, both pleasant and unpleasant, but it is characteristic for anxiety or fear (Bernick et al., 1971; Gang, 1945). Similar to eye-movements and blinks, the diameter of pupils may change when players are presented with violent stimuli. It is expected that pupils dilate if a participant experiences hostile and aggressive feelings, and thus also more likely to occur among players of violent video games (Cohen, 1954; Tinio & Robertson, 1969).

Moreover, the pupil diameter also changes during information processing and other forms of processing (Andreassi, 2000). Pupils constrict if one is in a low alertness state. Conversely, pupils dilate with interesting stimuli and as cognitive workload increases (Takahashi et al., 2000; Marshall, 2005). Expected is that players who are more immersed and are in a high alertness state, have a bigger pupil diameter. In conclusion, this study assumes that pupil diameter is positively correlated with immersion and the level of hostile, which will be more likely to occur among players of violent video games.

Saccades and fixations. Within eye-tracking research, two main types of eye-movements can be distinguished: saccades and fixations. Saccades are fast eye-movements (jumps) that last for 10-100 milliseconds. A saccade redirects the eye to a new part of the surroundings. Fixations on the other hand, are rests of the eye that occur between saccades in which gaze is held for 200 – 300 milliseconds (Snowden et al., 2012; Sundstedt, 2010). During fixations, information can be obtained, whereas during saccades, no information is obtained, because the eyes are moving too quickly. Between all fixation points on a screen a trajectory, or scan path, arises that shows where the gaze of the viewer was directed. According to El-Nasr and Yan (2006), scan paths differ between FPS and action-adventure games. They concluded that players of FPS tend to fixate their view on the middle of the screen, where the crosshairs are located. In action-adventure games, the player's scan path covers the whole screen, thus the range of eye-movements is larger in such

games than in FPS. El-Nasr and Yan (2006) argue that the wide range of a scan path in action-adventure games comes from the fact that these games are slow paced. Action-adventure games also have a crosshair, however, it is less important than in a FPS. Players of action-adventure games have to pay attention to objects that are important to reach their goal, rather than shooting and killing opponents. Players need to look around and discover the virtual world, in order to find the important objects. It is expected that a similar conclusion may be drawn from the data provided for this research. Thus, more fixations around the crosshair are expected in a FPS than in an action-adventure game.

At moments when a game can be predicted, gamers move their eyes, while they postpone these saccades at non-predictable or crucial and thrilling moments in the gameplay (Shalom et al., 2011). FPS are hectic and violent games, and a small mistake will result in the virtual death of a player. In contrast, action-adventure games are focused more on solving puzzles instead of thrilling moments of action. More crucial and non-predictable moments are expected in a FPS, it is therefore expected that fewer saccades will be made in FPS.

Fixations can also be related to the degree in which players are absorbed by the game. The number of fixations per second will increase if one is more immersed in a game (Jennett et al., 2008; Styles, 1997). The attention becomes more focused on visual components in the game, which causes less eye-movements. If one is more immersed in a task, the number of fixations increases over time and the number of saccades decreases (Jennett et al., 2008). One can suggest that eye-movements decrease as one's attention becomes more focused on visual components relevant to a game. Expected is that if one is more immersed, the more one gazes. Thus, fewer saccades and more fixations are expected when a player is more immersed in the game. Concluding, the current study assumes that players of the violent game make less eye-movements and have a smaller view on the screen. It is expected among all participants that the level of

immersion will be positively correlated with the number of fixations and negatively with the number of saccades.

Method

Sample

In September, October and November 2012 an experiment was conducted among Dutch young adult males ($N = 78$), between 17 and 49 years ($M = 22.24$, $SD = 4.74$). Participants were invited through flyers, posters and via the research website of the Psychology department of the University of Amsterdam. Flyers and posters were spread at the University of (Applied Sciences) Amsterdam. In order to test the hypotheses, a between-subjects experiment was designed in combination with a survey. All respondents were randomly allocated to one of the two (violent game versus non-violent game) conditions. One participant was eliminated from subsequent analyses as a result of errors that occurred during the data collection session. The violent game condition contained 39 participants, the non-violent game condition 38. A significant difference between the conditions was found regarding age, due to some outliers (t (53.55) = -2.33, $p < .05$). The age in the non-violent game condition was higher ($M = 23.46$, $SD = 5.92$) than the age in the violent game condition ($M = 21.03$, $SD = 2.74$). The sample consisted mostly of students, as the education level was approximately 90% university level in both groups.

Procedure

Participants were seated behind a monitor and asked to fill out a short survey about their game habits and experience. Then the participants were randomly allocated to one of the two conditions; either they played a violent video game or a non-violent game for twenty minutes. During experiments, subjects wore SMI eye-tracking glasses, a non-invasive video based eye-

tracker with a HD camera (1280x960 pixels). This eye-tracking device is able to measure gaze position, pupil diameter and position, tracking status and eye image via scene video. A three-point calibration was carried out before the experiment started in order to maintain the relationship between the fixation point on the screen and the position of the eye in the camera.

Participants were randomly assigned to play either a violent game or a non-violent game. The FPS Call of Duty: Modern Warfare 2 (Infinity Ward, 2009) was played in the violent video game condition. Participants played the Special Ops level 'O Cristo Redentor', which takes place in the slums of Rio de Janeiro, Brazil. The main goal is to kill all enemies (both humans and dogs) and not harm the civilians. Participants started in the easiest (normal) mode, if they completed this, they could play the hardened mode, and after that the hardest (veteran) mode. Portal 2 (Valve, 2011) was played in the non-violent video game condition and is a first-person puzzle-platform video game, where the task is to move through walls using a portal gun in order to find the exit. Participants who were allocated to this condition started at the beginning of the game. During the game players need to complete tests; if a test is accomplished one finds an elevator, which brings the player to a new test chamber. After twenty minutes of playing, participants were asked to fill in a large survey measuring subjective feelings of hostility, immersion and enjoyment. Every participant received €10 and snacks after completion of the experiment.

Measures

Blink rate, pupil diameter, saccades and fixations. Raw data of the eye-tracker consists of a 20-minute video of each participant's play session. The analysis program (BeGaze) shows pupil size and the frequency of fixations, blinks and saccades. Participants showed a blink rate between 119 and 1546 (M = 761, SD = 303.29). Pupil diameter, in millimeters, was registered

every time a pupil dilated or constricted. For each participant the mean pupil diameter of both eyes was calculated. The minimum diameter was 3.12 millimeter and the maximum was 5.69 millimeter (M = 4.55, SD = .55). A red dot in the video shows where the subjects looked at while they played the game. A saccade was measured as any movement of the eye before and after a fixation, with a minimum duration of 22 milliseconds. Participants made between 205 and 4392 saccades with their eyes (M = 2423, SD = 744.01). The duration of fixations was set to a minimum of 80 milliseconds. Participants fixated their eyes between 344 and 4831 times (M = 2869, SD = 687.17). In order to compare the recordings, each file was cut from the beginning of the game until exactly twenty minutes.

Hostility. A repeated measure of hostile feelings on the short-term has been conducted in this research. Respondents' agree of hostility was measured using seven selected items from the State Hostility Scale, adapted from Anderson, Deuser and DeNeve (1995). The items measured what the participants' current hostile mood was. Example items are: "I feel mean"; "I feel furious" and "I feel aggressive" (see also Appendix 1). The answer options ranged from 1 (*totally disagree*) to 5 (*totally agree*). Cronbach's alpha for this scale was *.91* (M = 1.20*,* SD = .39) before playing and *.81* (M = 1.58 SD = .53) after playing.

Enjoyment. Enjoyment was measured through eight items on a 5-point scale from Hartmann and Vorderer (2010). Items measured the degree to what extent participants enjoyed the game. Example items are: "The game was interesting"; "The game was entertaining" and "The game was exciting" (see also Appendix 2). Response options ranged from 1 (*not at all*) to 5 (*extremely*). This scale had Cronbach's alpha of *.85* (M = 3.87, SD = .62).

Immersion. Immersion was measured through five selected items from the iGroup presence questionnaire (IPQ) (Schubert, Friedman and Regenbrecht, 1999). Example items are: "It felt like I was present in the virtual world"; "I forgot that I participated in an experiment" and

"I was involved in the story" (see also Appendix 3). Response options ranged from 1 (*totally disagree*) to 5 (*totally agree*) on a 5-point scale. Cronbach's alpha for this scale was .*70* (*M* = 3.29, *SD* = .73).

Performance. Performance was measured within conditions by analyzing the gameplay of each participant. In Call of Duty, eleven participants did not finish the first level, twenty-seven participants started the second level and only two participants played the third level. For each participant in the violent game condition, the total kills, total deaths, killed civilians, killed dogs and kill/death ratio were computed. The total kills in Call of Duty ranged from 29 to 164 (*M* = 98, *SD* = 22.54). Kill/death ratio is an indication of how good the player is in the game. The ratio averages the amounts of deaths a player need per kill. The total kills of each participant was divided by the total deaths and resulted in the kill/death ratio. Among the 39 participants who played Call of Duty, the ratio varied between 2.9 and 49.0 (*M* = 15, *SD* = 10.08). The lower the ratio, the more virtually deaths a player needs per kill and the worse he performed. In Portal, performance was measured by the progress in the gameplay. In order to make a good distinction between the performances among Portal players, every test chamber in Portal was divided into two parts. In the first levels of the game, every test chamber consists of two test stages. The progress was measured by counting the total of completed stages for each participant. Portal players completed between 3 and 18 stages (*M* = 8.42, *SD* = 3.60) and they reached on average test chamber 4. There were four people who got stuck in the first chamber after the introduction and eleven players did not finish the first level and thus did not shoot with the Portal gun. Apparently they did not understood how it worked. The other 23 players reached chamber 4 or further; one participant, who was familiar with the game, reached test chamber 9.

Results

Pupil diameter and blink rate

Pupil diameter was only analyzed within conditions, because both games differed in brightness. In Portal, the mean pupil diameter ranged between 3.12 and 5.67 millimeters (M = 4.58, SD = .56), while in Call of Duty the minimum measured mean pupil diameter was 3.80 millimeters and the maximum 5.67 millimeters (M = 4.53, SD = .54). There was no significant difference between the conditions concerning pupil diameter (t (75) = -.34, *n.s.*).

It was expected that pupil dilation would have a positive correlation with hostile feelings. However, no significant correlation exists between pupil dilation and hostility in both Portal (r = .11, *n.s.*) and Call of Duty (r = -.10, *n.s.*).

A significant difference exists between conditions and blink rate (t (75) = -2.13, $p < .05$). Participants who played the violent video game blinked less (M = 689.69, SD = 253.98) than participants who played the non-violent video game (M = 833.58, SD = 334.55).

As Table 1 shows, a weak positive correlation exists between blink rate and pupil diameter (r = .24, $p < .05$). Among Portal players a positive significant correlation was found between pupil diameter and blink rate (r = .32, p = .05). The more a pupil dilates the more one blinks, but this is only significant for Portal players and not for Call of Duty players (r = .12, *n.s.*).

Table 1. Correlations between conditions

	1	2	3	4	5	6	7
1. Fixation	1						
2. Saccade	.94***	1					
3. Blink	.22	-.05	1				
4. Pupil diameter	.13	.08	.24*	1			
5. Hostility	-.21	-.19	-.01	-.01	1		
6. Immersion	-.01	.02	-.12	.01	.03	1	
7. Enjoyment	-.03	.01	-.09	-.09	-.02	.50***	1

*Note: * $p < .05$; ** $p < .01$; *** $p < .001$*

Fixations and saccades

A very strong positive correlation exists between saccades and fixations ($r = .94$, $p < .001$). The more a player fixates the more he moves his eyes to search for a new fixation point. As Table 2 and 3 show, the correlation between saccades and fixations among Call of Duty players is even stronger ($r = .96$, $p < .001$) than among Portal players ($r = .91$, $p < .001$).

Table 2. Correlations within Portal (non-violent game condition)

	1	2	3	4	5	6	7	8	9
1. Fixation	1								
2. Saccade	.91***	1							
3. Blink	.18	-.20	1						
4. Pupil diameter	.12	.02	.32a	1					
5. Hostility	.32a	.23	.07	.11	1				
6. Immersion	-.01	.02	-.15	.13	-.01	1			
7. Enjoyment	.20	.17	-.02	.03	-.16	.48***	1		
8. Progress	-.03	-.00	-.08	.14	-.40**	.32*	.39*	1	
9. Familiarity	-.17	-.17	-.01	-.16	-.18	-.24	.18	-.01	1

*Note: a $p = .05$, * $p < .05$; ** $p < .01$; *** $p < .001$*

A significant difference in amount of fixations was found between the two conditions (t (64.25) = -2.67, $p < .05$). Participants who played the violent video game fixated their eyes less ($M = 2671$, $SD = 789.34$) than participants who played the non-violent video game ($M = 3072$, $SD = 496.52$).

Table 3. Correlations within Call of Duty (violent video game condition)

	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Fixation	1												
2. Saccade	.96***	1											
3. Blink	.18	-.03	1										
4. Pupil diameter	.13	.11	.12	1									
5. Hostility	-.43**	-.41*	.04	-.10	1								
6. Immersion	-.09	-.20	-.20	-.10	.15	1							
7. Enjoyment	-.12	-.06	-.11	-.25	.05	.66***	1						
8. Total kills	-.02	.09	-.26	.16	.01	.18	-.08	1					
9. Total deaths	.03	.01	.09	.07	.12	-.12	-.19	-.07	1				
10. Kill/death ratio	.01	.04	-.12	-.02	-.35*	.12	.15	.30	-.74**	1			
11. Civilians	.13	.15	.13	.46**	.01	.03	.06	.48**	.20	-.11	1		
12. Dogs	-.13	-.08	-.21	-.25	.22	.17	.38	.60**	-.06	.26	.33	1	
13. Familiarity	.01	.04	-.12	-.01	-.24	.25	.27	.18	-11	.23	-.12	.39	1

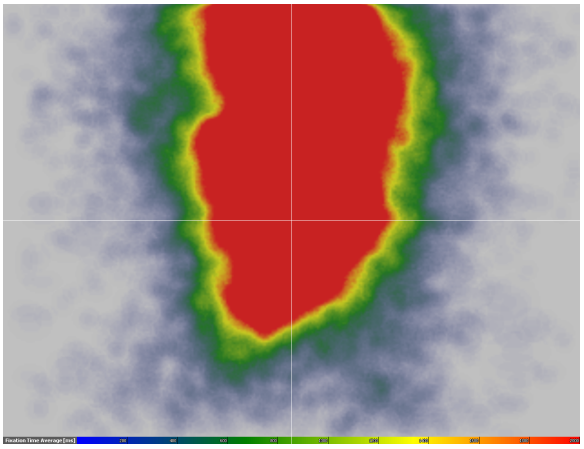
Note: * $p < .05$; ** $p < .01$; *** $p < .001$

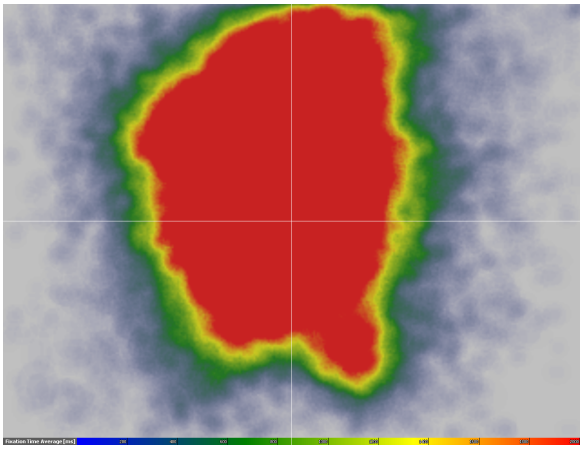
No significant difference was found between condition and number of saccades (t (75) = -1.84, *n.s.*).

In general, no correlation was found between hostility and fixations (r = .21, *n.s.*). However, within Call of Duty, a strong negative correlation exists between hostility and fixations (r = -.43, p < .01). The more hostile a player feels, the fewer fixations he makes. In Portal, a significant positive correlation exists between hostility and number of fixations (r = .32, p = .05). The same holds for hostile feelings and saccades, whereby no correlation was found among all participants (r = -.19, *n.s.*), whereas among Call of Duty players a strong negative correlation was found (r = -.41, p < .05). The more hostile players feel, the less they move around with their eyes in search for a new fixation point. Among Portal players no significant correlation exists (r = .23, *n.s.*).

Eye movements and fixations are visualized in the heat maps below (see Figure 1). A heat map uses colors to show the most attractive elements in the form of hot (red) and cold spots (grey). The heat maps below show the fixations and movements of all participants in the two games. The more the participants fixated at a certain point on the screen, the warmer that point is and the more they moved their eyes around the screen, the broader the heat map. As can be seen in the heat maps below, axes are included in the mid of the scope of the eye-tracker (1280 x 960) in order to show the differences in movement between the two games. The left heat map shows a closer heat around the axes, while the right heat map shows a longer and broader heat. The right heat map shows that participants who played Portal have a wider focus than Call of Duty players. The crosshair in Call of Duty is situated in the middle of the screen, which causes a smaller focus in the middle of the screen. All in all, the focus from Call of Duty players is narrower than Portal players.

Figure 1. Heat maps of Call of Duty (n = 39) and Portal (n = 38)

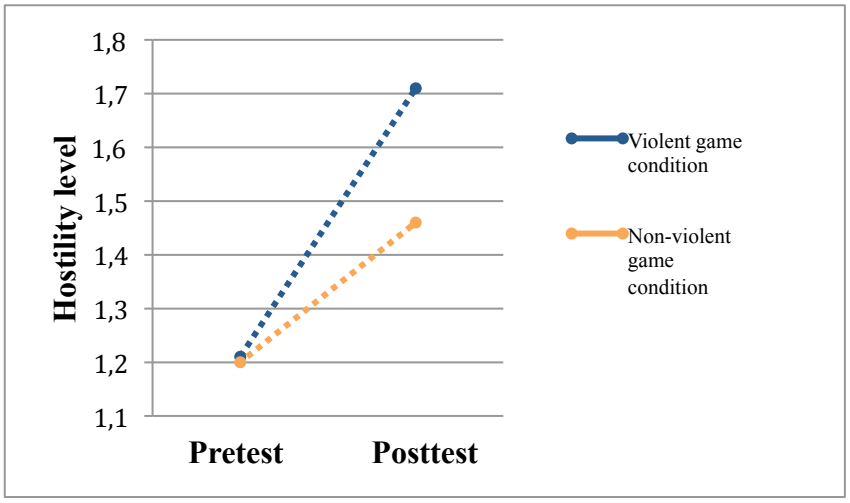




Hostility

Hostility was measured before and after the gameplay. Before the gameplay, no significant difference was found between condition and hostility level (t (75) = .15, *n.s.*). The hostility level in the violent condition was equal (M = 1.21, SD = .39) to the hostility level in the non-violent condition (M = 1.20, SD = .39) before participants played the game. As Figure 2 shows, Call of Duty players felt more hostile (M = 1.70, SD = .46) than Portal players (M = 1.46, SD = .58) after twenty minutes of playing. The difference between conditions was significant (t (75) = 2.01, $p < .05$). A repeated measure shows a significant difference between the two game conditions and hostility level (F (1,75) = 5.24, $p < .05$). An increase in hostility is measured in both groups, however, in the violent game condition the increase in hostility level is significantly higher (M = .49, SD = .44) than in the non-violent game condition (M = .27, SD = .43).

Figure 2. Repeated measure of hostility level in both conditions



Enjoyment and immersion

No significant difference exists between conditions regarding immersion (t (75) = -1.47, *n.s.*) and enjoyment (t (75) = 1.56, *n.s.*). This means that the two games are rated equally regarding enjoyment and immersion. Thus, differences between groups are not caused by differences in enjoyment or immersion between the games. As shown in Table 1, a strong positive correlation exists between immersion and enjoyment (r = .50, p < .001). The more a player enjoys the game, the more he feels immersed and vice-versa. The correlation between these two emotional responses is stronger among Call of Duty players (r = .66, p < .001) than among Portal players (r = .48, p < .01).

Performance

As shown in Table 2 and 3, neither performance nor the other measures were affected by the familiarity of the game. Moreover, results show that regarding the performance in Call of Duty, the total kills is strongly correlated to total killed civilians (r = *.48, p < .01*) and total killed dogs (r = .60, p < .01). A negative correlation exists between hostility and kill/death ratio (r = -

.35, $p < .05$). The better the performance, and thus the higher the kill/death ratio, the less hostile feelings a player experiences.

A negative strong correlation was found between progress in Portal and hostility ($r = -.40$, $p < .05$). The more test chambers or stages players completed, and thus the less they struggled in the game, the less hostile feelings they got. Furthermore, the more chambers they completed the more they enjoyed ($r = .39$, $p < .05$) and felt immersed in the game ($r = .32$, $p < .05$).

Covariates

Also a multivariate analysis of covariance (MANCOVA) was performed with condition as independent variable and immersion, enjoyment, aggression as well as blink rate, pupil diameter, saccades and fixations as dependent variables. The MANCOVA controlled for age, education level and familiarity with the game. Familiarity measured whether the participant was familiar with the game before the experiment. The three covariates age, education level and familiarity, did not affect emotional responses, because still no significantly differences between conditions were found. However, the differences between conditions concerning blink rate (F (1,70) = 1.04, *n.s.*) and fixations (F (1,70) = 3.82, *n.s.*) are not significant anymore. The difference in hostility level between the games is still significant (F (1,70) = 4.19, $p < .05$).

A MANCOVA with age as covariate yielded significant differences between condition and saccades (F (1,74) = 4.21, $p < .05$), fixations (F (1,74) = 6.99, $p < .05$) and hostility level (F (1,74) = 4.24, $p < .05$). The difference between conditions and blink rate is not significant anymore (F (1,74) = 2.74, *n.s.*). Education level as covariate shows a significant difference between conditions and blink rate (F (1,74) = 4.11, $p < .05$), fixations (F (1,74) = 7.89, $p < .01$) and hostility level (F (1,74) = 5.16, $p < .05$). When controlling for familiarity, only the hostility level significantly differs between conditions (F (1,72) = 6.50, $p < .05$). Blink rate (F (1,72) =

3.02, *n.s.*) and fixations (F (1,72) = 3.91, *n.s.*) are not significantly different between conditions.

The above-mentioned results show that none of the covariates affected the difference between conditions regarding hostility level. Age affected the blink rate, while education level did not affect any of the variables, because the same differences were significant between conditions. By contrast, when performing a MANCOVA with familiarity as covariate, none of the eye-movements is significantly different between conditions. T-tests show that a significant difference between conditions and familiarity exists (t (73) = 4.32, $p < .001$). More Call of Duty players (M = 1.84, SD = .37) agreed that they were familiar with the game than Portal players (M = 1.41, SD = .50). This unexpected finding and the other interesting results will be further elaborated upon in the discussion.

Discussion

The aim of this experiment was to investigate how video games, eye-movements and emotional responses are related to each other. Although a few previous studies have investigated the difference between video games and eye-movements in the broadest sense, no correlational studies have tested if blink rate, pupil diameter, saccades and fixations differ between video games and how this is related to hostility, enjoyment and immersion.

Regarding differences in eye-movements between games, players of FPS tend to fixate their view on the middle of the screen, where the crosshairs are located. As expected, the scan path in the action-adventure game covered more screen, thus participants had a larger range of eye-movements than in the FPS. Both games have a crosshair, however, it is less important in Portal for reaching the goal. Players need to pay attention to objects that are important for their goal, and thus need to discover the virtual game world. This resulted in broader eye-movements

in the action-adventure game than in the FPS. These findings dovetail with previous findings by El-Nasr and Yan (2005).

The two different video game genres also resulted in different blink rates. Players of the FPS blinked around 150 times less than players of the action-adventure game. In FPS like Call of Duty, enemies continuously target players. In order to survive, players must pay constant attention and therefore cannot blink continuously. In Portal, players were able to play at slow pace and there were no enemies that targeted them, nor were they required to shoot or kill opponents. Therefore, Portal players could take their time and blink more. It was expected that players of FPS fixated their eyes more. However, the results showed that players of the FPS fixated their eyes less than the players of the action-adventure game. Although they moved their eyes more around the center of the screen, as seen in the heat map, they showed not as many fixations as players of the non-violent video game. In general, there are more moving targets on the screen in Call of Duty than in Portal. Thus, the focus shifted continuously when playing Call of Duty, because it is imperative not to ignore these movements in order to survive. No significant difference was found between the two games concerning saccades, however, results showed a very strong correlation between saccades and fixations. This can be explained that more fixations, and thus shorter fixations, also cause more saccades between the fixation points.

An unexpected finding is the strong negative correlation between hostile feelings, fixations and saccades among Call of Duty players. The more hostile they feel, the less saccades and fixations they make with their eyes. The minimum duration of a saccade is 22 milliseconds, which means that eyes are moving at fast pace around the screen if a player feels hostile. Eyes respond to hostile feelings with more movement and less fixations. However, among Portal players a weak positive correlation was found between hostility and fixations. Portal players were overall less hostile than Call of Duty players, but if they experienced hostile feelings during the

gameplay then they fixated their eyes more than players that did not experienced hostile feelings. No appropriate explanation can be found for the difference between the games regarding hostility and amount of fixations. However, it is interesting that the correlation is reversed in both conditions and further research could elaborate on this finding.

The two video games differ a lot in brightness. The non-violent action-adventure game Portal is much darker than the violent FPS Call of Duty. Call of Duty takes place in daylight and several light flashes and explosions light up the screen during play, whereas Portal takes place underground with no explosions or bright flashes. Pupils dilate with dim light and constrict with intense light, so it was expected that pupil diameter in Portal would be higher than in Call of Duty. However, there was no difference found between the games concerning mean pupil diameter. Another possible explanation for the equal mean pupil diameter in both games could be the level of hostility, because pupils dilate if one feels aggressive or hostile. Because participants in the violent game condition felt more hostile than the participants in the non-violent game condition, it could be that their pupils dilated due to hostile feelings, even though the game is quite bright, thereby negating any difference. Furthermore, it was expected that pupil diameter would have a positive relation with hostility and immersion. However, there was no relation at all between these variables, neither between games nor within games. Just the overall mean of pupil diameter was measured and luminance was not controlled during the experiment. Therefore no further conclusions could be drawn regarding pupil diameter.

Moreover, it was expected that blink rate, pupil diameter, saccades and fixations would be affected by emotional responses. However, except that hostile feelings affect fixations and saccades, no other relations are found between the eye-movements and emotional responses. On the other hand, several interesting results were found between and within conditions regarding emotional responses. Consistent with previous studies, the violent video game caused higher

levels of hostility than the non-violent game. Although participants in both conditions felt equally hostile before playing, after playing the video game, participants who played the FPS felt more hostile than players of the non-violent condition. This finding is in accordance with previous research and implies that shooting and killing virtual opponents rather than shooting a portal on the wall without hurting anyone, increase feelings of hostility.

Another finding regarding the level of hostility is the relation with performance. The results showed that performance (either the progress in Portal or the kill/death ratio in Call of Duty) is negatively correlated with hostility. The more levels or test chambers a player completes, the less hostile one feels. If a player gets stuck in the game, frustration or even aggression can be experienced. Then the players' skills are not sufficient for the challenges of the game, which will cause frustration and aggressive feelings (Adachi & Willoughby, 2011; Breuer, Scharkow, & Quandt, 2012; Eastin, 2006; Eastin, 2007; Eastin & Griffiths, 2006; Schmierbach, 2010; Williams & Clippinger, 2002). A poor performance increases the level of hostility irrespective of the game genre. Thus, violent content in video games does not fully explain the hostility in playing video games, because a poor performance can cause frustration and increase the level of hostility as well.

Finally, it was expected that immersive experiences would be enjoyable as well. In accordance with previous studies (Brown & Cairns, 2004; Jennett et al., 2008), results showed a strong relation between immersion and enjoyment. Players who were more immersed in the game enjoyed the game more as well. The relation between immersion and enjoyment was found in both conditions and thus not dependent on game genre.

Limitations and future research

There are a few limitations to the current study. A first limitation to this study is the use of

eye-tracking glasses instead of an eye-tracking monitor. By using a mobile device, it is difficult to draw a proper conclusion concerning eye-movements and fixations as seen in the heat maps. Participants could have moved their head during the recordings, which causes a different scope for each participant. If an eye-tracking monitor was used, only the eye-movements within the screen were measured. This means that a better comparison could have been made between all subjects.

A drawback regarding pupil diameter is that this study did no thorough investigation concerning pupil diameter. A thorough investigation could measure at which moments pupils dilate or constrict, which could gain more knowledge about the effect of video games. Another limitation is that this study drew conclusions within conditions regarding pupil diameter and emotional responses. More information could be obtained if pupil diameter was compared between games. Luminance should have been controlled between the games, because they differ in brightness and pupillary light reflexes should therefore be ruled out. Luminance was not controlled at all, so pupil diameter could not been compared between games. It would be interesting for future research to investigate if there is also a difference between the games in pupil diameter.

Another limitation is the familiarity of the two games. Portal was unknown by 22 participants in the non-violent condition, while in the violent condition there were only 6 participants who did not know Call of Duty beforehand. Results indicated that familiarity is a confounding factor, because all existing differences between the two conditions disappeared. A relation between familiarity and conditions was found, however, no significant relations between familiarity and the other variables exist. This could indicate that familiarity is not the main factor for the differences between the conditions. It would be more logical that game genre causes differences in eye behavior and emotional responses, because people just act differently in

another type of game. Nevertheless, further research should test if the familiarity of the game is an important factor for the differences between games concerning eye-movements and emotional responses.

Furthermore, this study only used two game genres, in order to make a beginning on analyses in this quite new field of research. Further research should also include more games and game genres, which should expand this study and test if there are differences between several game genres.

Conclusion

The present study is the first to examine the relation between video games, eye-movements and emotional responses. Previous studies have shown that regarding eye-movements differences exist between game genres. This research extends previous research on both the relation between the variables as well as the use of relatively large groups in eye-tracker research. To examine the relations between video games, emotional responses and eye behaviors, an experiment among 79 Dutch young adult males was conducted. Results indicated that eye-movements and blink rate are strongly related to game genre. Players of non-violent games make more fixations and blinks than players of violent video games. Moreover, results indicated that the hostility level is both affected by violent content in video games as well as by frustration of a poor performance. Furthermore, a strong relation between hostility level and eye-movements was found. This provides evidence that emotional responses, such as hostility and aggression, could be traced by changes in eye-movements. This implies that without the need of subjective measures, emotional responses can be traced by analyzing eye-tracking data.

The analyses presented in the current study should offer more insights into the

understanding of eye behavior. Future research could now include other variables to expand the knowledge of underlying effects of eye-movements. In the meantime, this research may offer information for scientists who are doing research with eye-trackers.

References

Adachi, P., & Willoughby, T. (2011). The effect of violent video games on aggression: is it more than just the violence? *Aggression and Violent Behavior*, *16*, 55-62.

Albert, W. (2002). Do web users actually look at ads? A case study of banner ads and eye-tracking technology. *Proceedings of the Eleventh Annual Conference of the Usability Professionals' Association.* Orlando, Florida, July 2002.

Almeida, S., Mealha, Ó., Veloso, A. & Luís, A. (2010). *Empirical study of user behavior on home page layouts.* Paper presented at Congresso Nacional de Interacção Humano-Computador, Brazil.

Anderson, C. A., & Bushman, B. J. (2001). Effects of violent video games on aggressive behavior, aggressive cognition, aggressive affect, physiological arousal, and prosocial behavior: A metal-analytic review of the scientific literature. *Psychological Science, 12*, 353−359.

Anderson, C. A., & Bushman, B. J. (2002). Human aggression. *Annual Review of Psychology, 53,* 27−51.

Anderson, C.A., Deuser, W.E., & DeNeve, K. (1995). Hot temperatures, hostile affect, hostile cognition, and arousal: Tests of a general model of affective aggression. *Personality and Social Psychology Bulletin, 21,* 434-448.

Anderson, C. A., Gentile, D. A., & Buckley, K. E. (2007). Violent video game effects. New York: Oxford University Press.

Andreassi, J. L. (2000). Psychophysiology: Human behavior and physiological response. Hillsdale, New Jersey: Lawrence Erlbaum Publishers.

Argyle. M. & Cook, M. (1976). Gaze and mutual gaze. Cambridge, England: Cambridge

University Press.

Arriaga, P., Esteves, F., Carneiro, P., & Monteiro, M.B. (2006). Violent computer games and their effects on state hostility and physiological arousal. *Aggressive Behavior, 32*, 358-372.

Bernhard, M., Stavraki, E., & Wimmer, M. (2010). An empirical pipeline to derive gaze prediction heuristics for 3D action games. *ACM Transactions on Applied Perception, 8*, 1-30.

Bernick, N., King, A., Borowitz, G. (1971). Physiologic differentiation of sexual arousal and anxiety. *Psychosomatic Medicine, 33*, 341-352.

Brasel, A. & Gips, J. (2008). Points of view: Where do we look when we watch TV? *Perception, 37*, 1890-1894.

Breuer, J., Scharkow, M., & Quandt, T. (2012). Winning matters – A re-examination of the frustration-aggression hypothesis for digital games. Paper presented at the ICA 2012 Conference, Phoenix.

Brown, E., & Cairns, P. (2004). A grounded investigation of game immersion. *CHI'04 Extended Abstracts on Human Factors and Computing Systems*, 1297-1300. New York: ACM Press.

Bushman, B.J., & Anderson, C.A. (2001). Is it time to pull the plug on the hostile versus instrumental aggression dichotomy? *Psychological Review, 108,* 273-279.

Bushmann, B.J., & Huesmann, R. (2006). Short-term and Long-term Effects of Violent Media on Aggression in Children and Adults. *Archives of Pediatrics and Adolescent Medicine, 160*, 348-352.

Cohen, M.D. (1954). Hostility and psychotic symptoms. *The Psychiatric Quarterly, 28*, 264-278.

Coie, J. D., & Dodge, K. A. (1998). Aggression and antisocial behavior. In W. Damon, & N.

Eisenberg (Eds.), Handbook of child psychology (5th ed.). Social, Emotional, and Personality Development, vol. 3. (pp. 779−862) New York: John Wiley & Sons.

Csikszentmihalyi, M. (1990). Flow: psychologie van de optimale ervaring. New York: Harper & Row.

Csikszentmihalyi, M. & Csikszentmihalyi, I.S. (1988). Optimal Experience: Psychological studies of flow in consciousness. Cambridge: Cambridge University Press.

Dill, K. E., & Dill, J. C. (1998). Video game violence: A review of the empirical literature. *Aggression and Violent Behavior, 3*, 407−428.

Eastin, M. S. (2006). Video game violence and the female game player: Self and opponent gender effects on presence and aggressive thoughts. *Human Communication Research*, *32*, 351–372.

Eastin, M. S. (2007). The influence of competitive and cooperative group game play on state hostility. *Human Communication Research*, *33*, 450-466.

Eastin, M. S., & Griffiths, R. P. (2006). Beyond the shooter game: Examining presence and hostile outcomes among male game players. *Communication Research*, *33*, 448-466.

El-Nasr, M., & Yan, S. (2006). Visual attention in 3d video games. *Proceedings of the 2006 ACM SIGCHI International Conference on Advances in Computer Entertainment Technology*. New York: ACM Press.

Fogarty, C. & Stern, J. (1988). Eye movements and blinks: their relationship to higher cognitive processes. *International Journal of Psychophysiology, 8*, 35-42.

Gang, K. (1945). Psychosomatic factors in the control of pupillary movements. *Journal of Clinical Psychopath and Psychotherapy, 6,* 461-472.

Goldwater, B. C. (1972). Psychological significance of pupillary movements. *Psychological Bulletin, 77*, 340–355.

Green, C., & Bavelier, D. (2003). Action video game modifies visual selective attention. *Nature, 423*, 534-537.

Harris, C. S., Thackray, R. I. & Shoenberger, R. W. (1966). Blink rate as a function of induced muscular tension and manifest anxiety. *Perceptual and Motor Skills, 22*, 155-160.

Hartmann, T. & Vorderer, P. (2010). It's okay to shoot a character. Moral disengagement in violent video games. *Journal of Communication, 60,* 94-119.

Infinity Ward (2009). *Call of Duty: Modern Warfare 2*.

Jankovic, J. (1987). Blinking and blepharospasm. In G. Adelman (Ed.), *Encyclopedia of Neuroscience,* (pp. 138-139). Boston: Birkhauser.

Jennett, C., Cox, A. L., Cairns, P., Dhoparee, S., Epps, A., Tijs, T., & Walton, A.(2008). Measuring and defining the experience of immersion in games. *International Journal of Human-Computer Studies*, *66*, 641-661.

Jie, L., and Clark, J. J. (2008). Video game design using an eye-movement-dependent model of visual attention. *ACM Transactions on Multimedia Computing, Communications, and Applications (TOMCCAP), 4*, 22: 1-16.

Kearney, P. R. & Pivec, M. (2007) *Immersed and how? That is the question. Game in' action.* Paper presented at the Games in Action Conference, Gothenburg, Sweden.

Kenny, A., Koesling H., Delaney D., McLoone S., & Ward T. (2005). A preliminary investigation into eye gaze data in a first person shooter game. *Proceedings of the 19th European Conference on Modelling and Simulation (ECMS 2005).*

Laeng, B., Sirois, S., & Gredebäck, G. (2012). Pupillometry: A window to the preconscious? *Perspectives on Psychological Science, 7,* 18–27.

Lin, C.S., Huan, C.C., Chan, C.N., Yeh, M.S., Chiu, C. (2004). Design of a computer game using an eye-tracking device for eye's activity rehabilitation. *Optics and Lasers in Engineering*,

42, 91-108.

Loewenfeld, I. (1993). *The pupil: Anatomy, physiology, and clinical applications*. Detroit, MI: Wayne State University Press.

MacKenzie, I. (2010). An eye on input: Research challenges in using the eye for computer input control. *Proceedings of the 2010 symposium on eye-tracking research and applications*, 11-12.

Marsee, M., Weems, C., Taylor, L. (2008). Exploring the association between aggression and in youth: a look at aggressive subtypes, gender, and social cognition. *Journal of Child and Family Studies, 17,* 154-168.

Marshall, S.P., (2005). Assessing cognitive engagement and cognitive states from eye metrics. In D. Schmorrow (Ed.), *Foundations of Augmented Cognition* (pp. 312–320). Mahwah, New Jersey: Lawrence Erlbaum Publishers.

Moneta, G.B. & Csikszentmihalyi, M. (1999). Models of concentration in natural environments: A comparative approach based on streams of experiential data. *Social Behavior and Personality, 27*, 603-637.

Moore, R., & Churchill, E. (2011). Computer interaction analysis: Toward an empirical approach to understanding user practice and eye gaze in GUI-Based interaction. *Computer Supported Cooperative Work, 20*, 497-528.

Nacke, L., Stellmach, S., Sasse, D., & Lindley, C. A. (2009). Gameplay experience in a gaze interaction game. The 5th Conference on Communication by Gaze Interaction – COGAIN 2009: Gaze Interaction For Those Who Want It Most (pp. 49-54).

Schmierbach, M. (2010). "Killing spree": Exploring the connection between competitive game play and aggressive cognition. *Communication Research, 37,* 256–274.

Schubert, T., Friedmann, F., & Regenbrecht, H. (1999). Embodied presence in virtual

environments. In Ray Paton & Irene Neilson (Eds.), *Visual Representations and Interpretations* (pp. 269- 278). London: Springer-Verlag.

Snowden R., Thompson P., & Troscianko T. (2012). Basic vision: An introduction to visual perception. Oxford: Oxford University Press.

Spielberger, C.D. (1988). Manual for the state-trait anger expression inventory. Odessa, FL: Psychological Assessment Resources.

Stern, J. A., Walrath, L. C., & Goldstein, R. (1984). The endogenous eyeblink. *Psychophysiology, 21,* 22-33.

Styles, E.A. (1997). The psychology of attention. UK: Psychology Press.

Sundstedt, V. (2010). Gazing at games: Using eye tracking to control virtual characters. SIGGRAPH 2010, Conference Courses. Los Angeles.

Shalom, D.E., Dagnino, B., & Sigman, M. (2011). Looking at Breakout: Urgency and predictability direct eye events. *Vision Research, 51*, 1262-1272.

Takahashi, K., Nakayama, M., & Shimizy, Y., 2000. The response of eye movement and pupil size to audio instruction while viewing a moving target. *Proceedings of Eye Tracking Research and Applications Symposium* (pp. 131–138). New York: ACM Press.

Tinio, F. & Robertson, M. (1969). Examination of the indices of hostility: fantasy and change in pupil size. *Proceedings of the 77th annual convention of the American Psychological Association.* (pp. 173-174). Washington, D.C.: American Psychological Association.

Valve Corporation (2011). *Portal 2*.

Vorderer, P., Hartmann, T., & Klimmt, C. (2003). Explaining the enjoyment of playing video games: the role of competition. *Proceedings of the second international conference on Entertainment computing* (pp. 1-9). Pittsburgh: Carnegie Mellon University Press.

Williams, R. B., & Clippinger, C. A. (2002). Aggression, competition and computer games:

Computer and human opponents. *Computer in Human Behavior, 18,* 495–506.

Yarbus, A. (1967). Eye Movements and Vision. New York: Plenum Press.

Appendix 1 – State hostility scale

Please indicate the extent to which you agree or disagree with each of the following mood statements.

	Strongly Disagree	Disagree	Neither agree Nor disagree	Agree	Strongly Agree
1. I feel mean	1	2	3	4	5
	Strongly Disagree	Disagree	Neither agree Nor disagree	Agree	Strongly Agree
2. I feel vicious	1	2	3	4	5
	Strongly Disagree	Disagree	Neither agree Nor disagree	Agree	Strongly Agree
3. I feel frustrated	1	2	3	4	5
	Strongly Disagree	Disagree	Neither agree Nor disagree	Agree	Strongly Agree
4. I feel irritated	1	2	3	4	5
	Strongly Disagree	Disagree	Neither agree Nor disagree	Agree	Strongly Agree
5. I feel mad	1	2	3	4	5
	Strongly Disagree	Disagree	Neither agree Nor disagree	Agree	Strongly Agree
6. I feel furious	1	2	3	4	5
	Strongly Disagree	Disagree	Neither agree Nor disagree	Agree	Strongly Agree
7. I feel aggressive	1	2	3	4	5

Appendix 2 – Enjoyment scale

Please indicate the extent to which you agree or disagree with each of the following statements regarding the game you just played.

The game was:

1. Interesting	Not at all 1	Slightly 2	Moderately 3	Very 4	Extremely 5
2. Boring	Not at all 1	Slightly 2	Moderately 3	Very 4	Extremely 5
3. Entertaining	Not at all 1	Slightly 2	Moderately 3	Very 4	Extremely 5
4. A waste of time*	Not at all 1	Slightly 2	Moderately 3	Very 4	Extremely 5
5. Fun	Not at all 1	Slightly 2	Moderately 3	Very 4	Extremely 5
6. Challenging	Not at all 1	Slightly 2	Moderately 3	Very 4	Extremely 5
7. Exciting	Not at all 1	Slightly 2	Moderately 3	Very 4	Extremely 5
8. I'd like to play the game again	Not at all 1	Slightly 2	Moderately 3	Very 4	Extremely 5

*Note: * Item was rescored afterwards*

Appendix 3 – Immersion scale

Please indicate the extent to which you agree or disagree with each of the following statements about the game you just played.

1. It felt like I was present in the virtual world.

Strongly Disagree		Neither agree		Strongly
	Disagree	Nor disagree	Agree	Agree
1	2	3	4	5

2. I was fully captivated by the virtual world.

Strongly Disagree		Neither agree		Strongly
	Disagree	Nor disagree	Agree	Agree
1	2	3	4	5

3. I was involved in the story.

Strongly Disagree		Neither agree		Strongly
	Disagree	Nor disagree	Agree	Agree
1	2	3	4	5

4. I forgot that I participated in an experiment.

Strongly Disagree		Neither agree		Strongly
	Disagree	Nor disagree	Agree	Agree
1	2	3	4	5

5. I was disappointed when the game was over.

Strongly Disagree		Neither agree		Strongly
	Disagree	Nor disagree	Agree	Agree
1	2	3	4	5