

Interaction Behavior of Hardcore and Inexperienced Players: “Call of Duty: Modern Warfare” Context

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Abstract

This paper presents the application of an existing innovative method used to identify areas of greater or less intensity in terms of interaction behavior. With this method, a comparative study aimed to understand and detect differences between hardcore players (those with experience playing games) and inexperienced players (those with little or no experience with games) was carried out. Based on the comparison of two distinct types of heat maps – one which characterizes global peripheral vision and another which indicates exact areas of visualization – an analysis of differences in interaction behavior was possible. Acquired results suggest that hardcore players’ interaction behavior is more objective than their counterpart. Additionally, the acquired results helped corroborate data previously obtained in an earlier study [Almeida et al. 2010b].

Keywords: interaction, visualization, heat maps, videogame

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1. Introduction

The grouping of video games and visual attention studies has resulted in a significant quantity of research, many related to the effects of playing games and their effects on cognitive processes, visual coordination or other perceptual processes [Green and Bavelier 2006]. Studies have shown that playing video games can help in apprehension levels, namely through changes in visual short-term memory skills [Green and Bavelier 2006] and that playing video games can improve visual and attention skills [Green and Bavelier 2003]. Recent work has studied the effects of playing games and their influence on cognitive abilities such as attention and memory [Boot et al. 2008].

This study aims, however, to understand how and if inherent differences between hardcore players and inexperienced players (namely in terms of attention) influence these groups’ interaction behavior in a specific context: a First-person shooter video game. Through the use of an eye tracker – a technology capable of indicating with great precision the exact point where an individual was looking – complemented with the use of video analysis, differences in terms of

hardcore and inexperienced players’ interaction behavior are analyzed.

2. Related Work

As this study aims to verify the validity of a previously developed method of analysis and evaluation in a gaming context, the topics of game evaluation and game usability are necessarily an area of related work worthy of being discussed.

2.1 Game Usability

The concept of usability, according to the International Organization for Standardization (ISO), can be defined as the “extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use” [ISO 2009, p. 6]. However, video games are a specific type of product and unique in nature. Video games are about enjoyment [Schaffer 2007] and are designed to entertain [Pinelle et al. 2008]. With that in mind, components associated to usability in a video game context are necessarily different from those we find in a general usability context.

While the concept of game usability is still debated today, one of the earliest signs of work in the area dates back 30 years. Thomas Malone [Malone 1980] was possibly one of the first researchers to approach the game usability concept, with special incidence in educational games. Recently, Chuck Clanton [Clanton 1998] approached game usability in a similar way as ISO did with usability, dividing the concept into 3 components: game interface, game mechanics, and game play. Clanton defined game interface – or user interface – as the visual and motor part of the game (i.e. how the game controller works or what elements are displayed on the screen); the game mechanics are related to the world’s physics and are developed through animation and programming; game play refers to the processes through which the players accomplish their goals. Melissa Federoff [2002] also elaborated on the game usability concept, exploring to a greater extent Clanton’s view on the matter. Federoff identified game interface as the components that are used to control a video game (e.g. keyboard, joystick, gamepad) as well as the visual representation of the actions the player executes while playing (e.g. moving through the game environment). The game mechanics

are related to the way the player is able to move in the video game (e.g. walking, running). Furthermore, Federoff indicates that the game mechanics are the result of the combination of animation (the movements), programming (the game code) and level design (the places in which the game takes place). Finally, Federoff refers that game play is related to the challenges and problems players must overcome to win the game or complete the game objectives.

Heather Desurvire, Martin Caplan and Jozsef Toth [Desurvire et al. 2004] also focused on game usability. These authors also presented a division of game usability, dividing the concept into 4 components: game play, which are the problems and challenges a user must face to win a game; game story, which includes all plot and character development; the game mechanics which involve the programming that provides the structure by which units interact with the environment; finally, game usability, which addresses the interface and encompasses the elements the user utilizes to interact with the game (e.g. mouse, keyboard, controller, game shell, heads-up display). David Pinelle, Nelson Wong and Tadeusz Stach [Pinelle et al. 2008] also researched game usability, but did not propose a specific division of the concept. However, these authors defined the concept as “the degree to which a player is able to learn, control, and understand a game”; having rejected the idea that game usability addresses issues related to entertainment, engagement and storyline [Pinelle et al. 2008, p. 1453]. Finally, Noah Schaffer [Schaffer 2009] also explored the concept, defending that “game usability is about eliminating obstructions in the game’s interface that can get in the way of the player experience (...); most game interfaces require some learning before they can get out of the way, so usability is often about making the game easier to learn” [Schaffer 2009, p. 2].

2.2 Game Evaluation

While having worked on defining the concept of game usability, many of the referred authors [Federoff 2002; Desurvire et al. 2004; Pinelle et al. 2008; Schaffer 2009] also proposed methods of evaluating games. All these authors focused on one method in particular – heuristic evaluation – a method of evaluation introduced by Jacob Nielsen and Rolf Molich [Nielsen and Molich 1990]. Both Federoff [2002] and Desurvire et al. [2004] developed a group of heuristics based on an extensive literature review and adaptation according to their game usability components. Furthermore, Federoff extracted information for developing her heuristics after questioning and observing members of a game development company. Pinelle et al. [2008] developed their set of heuristics with a different approach, having consulted an extensive number of video game reviews. Based on the reviews of more than 100 games, a group of 12 categories of problems was extracted and a final list of 10 heuristics was developed. Finally, Hannu Korhonen and Elina Koivisto [2006] also proposed a set of heuristics for

game evaluation. However, their focus was on the mobile gaming platform.

Eye tracking has also been explored as a method of video game evaluation and analysis, although the quantity of research is scarce. El-Nasr & Yan [2006] developed a study based on the assumption that game and level design could be improved if players’ visual search patterns were analyzed and understood. Additionally, they believe that game designers could improve game play by altering game elements such as textures, colors and object locations if players’ visual attention patterns were understood. Specifically, El-Nasr & Yan’s study aimed to determine if players’ visual attention followed the bottom-up or top-down visual theories. Having used two games of distinct genres, they concluded that because action-adventure games are goal-oriented, top-down visual patterns are more frequent. Additionally, through eye tracking, they demonstrated that the type of search pattern demonstrated for one type of game genre was different than that verified with the other game genre: in an adventure game there is a more heterogeneous search pattern while in a shooter game, the player concentrates mostly on the center of the screen.

Almeida [Almeida 2009] developed a study using eye tracking technology to evaluate how players visually interacted with game scenarios. Although one of his study contributions resulted in a preliminary suggestion of guidelines for the development of greater quality video games; another contribution was the method developed and applied to understand what areas of video game scenario players visualize and consequently, what areas are not visualized – also explored in [Almeida et al. 2010a]. Almeida’s study consisted in participants playing a First-person shooter video game while their eye movements were registered with an eye tracker. After all sessions were complete, information related to areas that were and were not visualized by the players were identified through the use of a heat map paradigm.

2.3 Games & Visual Attention

Video games and visual attention studies are two areas that have been analyzed as a whole in recent years. Much of the existing research focuses on apprehending how playing video games can alter “visual attention, visual-motor coordination or other perceptual and cognitive processes” [Green and Bavelier 2006].

Green and Bavelier [2006], using two groups – video game players (VGP) and non-video game players (NVGP) – demonstrated that action video games can assist in increasing the number of objects that an individual can apprehend; additionally, this increase is possible through changes in short-term memory skills. In an earlier study, Green and Bavelier [2003] also demonstrate that playing action video games can change a number of visual skills. Using once again VGP and NVGP, these authors show that VGP are

capable of outperforming NVPG in terms of their efficiency of distributing attention over space and time. Yuji [1996] showed that playing video games decreased the reaction time (RT) of younger aged subjects when these were asked to respond to visual stimuli. Gopher and colleagues [Gopher et al. 1994], in a study with the Israeli military, demonstrated that cadets trained with video games performed better on measures of flight performance than cadets without game training. Finally, studies have shown that VGP demonstrate shorter response times [Castel et al. 2005], better spatial resolution of visual processing [Green and Bavelier 2007] as well as higher attention capacity and abilities [Green and Bavelier 2006; Castel et al. 2005; Green and Bavelier 2003].

3. Objectives & Analysis Method

The main objective of this study was to apply an innovative method and execute a comparative study to understand what differences can be detected between hardcore players – players with a great degree of experience playing video games – and inexperienced players – players with little or no experience at all with video games. The comparison of these two groups was based on the analysis of each group's respective Peripheral view heat map and Point of Regard heat map. The differences and similarities between these maps were analyzed according to player movements (with the help of video analysis) as well as the locations where players *spawned* after being killed. Additionally, areas of interest on the map were analyzed to see if there was any correlation between the players' interaction behavior and the data acquired in the questionnaires. The method applied in this study was previously demonstrated in [Almeida et al. 2010a]. Additionally, the data on which this study was based was previously acquired during the development of Almeida's [Almeida 2009] Master's dissertation.

The source data used for this study consisted in the data acquired from the participation of 41 individuals of three distinct gaming experience groups – inexperienced, casual and hardcore – in an empirical study. These participants completed two tasks with a duration of 5 minutes. Simultaneously, their eye movements were recorded with an eye tracker. The tasks consisted in playing different levels and different game modes of a First-person shooter video game – “Call of Duty: Modern Warfare”. Participants' eye movements were registered using the Tobii T120 Eye Tracker. In addition to the qualitative data acquired with the eye tracker, complementary information was obtained through a questionnaire that assessed the players' opinions on what elements conditioned and influenced the places in the game environment to where players looked and moved; as well as the efficiency of the interface and game level elements. The results acquired from the questionnaire are discussed in [Almeida et al. 2010b].

Briefly describing the analysis method presented in [Almeida et al. 2010a], “the method is based on a heat map paradigm, translated into two visual representation techniques to understand in what way 3D video game scenarios are observed and explored, and consequently, to identify areas and artifacts that are not visualized by players”.

The method behind the development of the respective heat maps consists of several steps. The game map used in the study – a two-dimensional representation of the level played – served as a georeference basis for the developed heat maps. To understand what areas were visualized with greater or less intensity, it was necessary to map out the players' in-game movements throughout the level. With the help of the Tobii Studio analysis software, each players' movements was mapped out, including their position, orientation in the map as well as the element or object they were looking at. Due to the large quantity of information the eye tracker collects, and because analyzing and mapping out player movements every second would be difficult as well as redundant on occasion, a sampling strategy was chosen. Therefore, for each player and experience group, samples were taken on average every 5 seconds. Afterwards, the game map was divided into a grid, resulting in a map with a large quantity of square areas. As a result of this process, a total of 390 codified squares were defined. Based on the information acquired with the samples and the players' interaction behavior, the map was then generated and codified.

Using this method, two distinct heat maps could be developed. First, a Peripheral vision map; which represents for each sample not only what was in the players' focal point but also, everything in his line of sight. Second, a Point of Regard (PoR) heat map, which represents the exact spot and location on the map to where the player was looking for each sample taken. Therefore, while in the Peripheral vision heat map multiple squares could be codified; in the PoR heat map, only a single square was codified. Finally, the codification process was carried out using a color look-up table in which black and darker colors represented a smaller number of visualizations while red represented a higher number of visualizations.

While the original source data used included results for three distinct groups; for this study, only inexperienced and hardcore players' data was used to understand what differences exist between those with little or no gaming experience in contrast with players that are avid gamers. The global study sample consisted of 24 participants, 12 in each experience group. Of these, 17 were male and 7 female. All the hardcore players were male while the inexperienced players group was composed of 5 males and 7 females. All the participants belonged to the University of Aveiro community.

4. Results & Discussion

As a result of the method described earlier, two distinct heat maps were generated for each of the experience groups. Figure 1 and Figure 2 represent the heat maps that characterize hardcore and inexperienced players' peripheral visual activity as a result of their movements in the game.

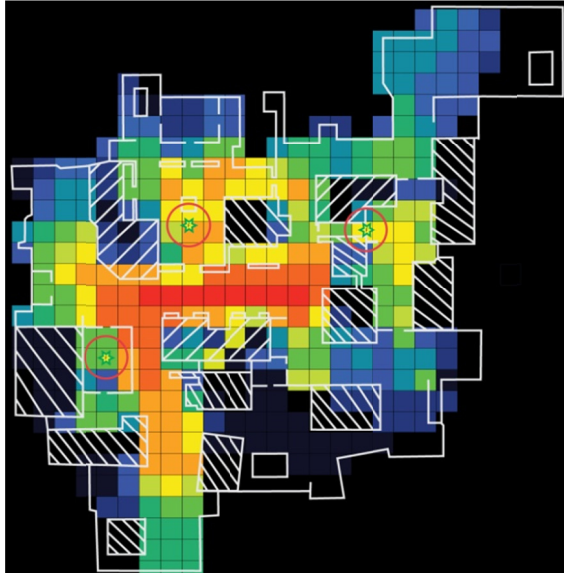


Figure 1: Hardcore players' peripheral vision heat map

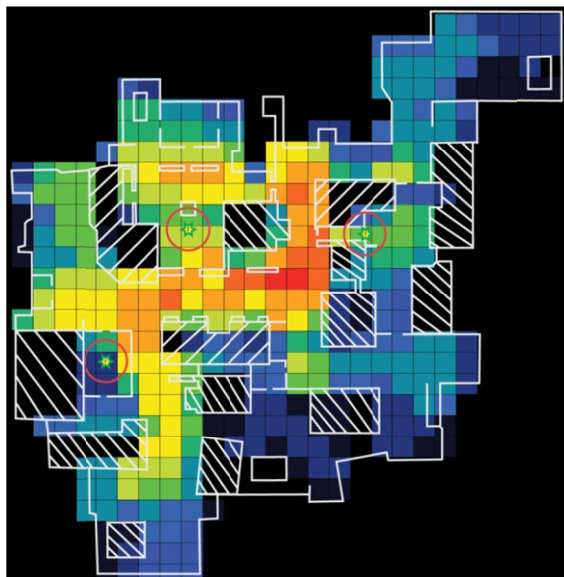


Figure 2: Inexperienced player's peripheral vision heat map

A general overview of the two heat maps suggests that hardcore players' interaction behavior and visual activity specifically, was more objective than that of inexperienced players. Bearing in mind the goal of the game mode played on this map – conquering and defending the flags (represented by stars on the maps) – the number of distinct players that visualized the squares in the circumference in which these flags are located is greater for the hardcore players. For the flag on the left side of the map (F1 in Figure 3), a

maximum number of 7 hardcore players visualized the square in which the flag is located; while only 2 inexperienced players visualized the same square. For the central flag (F2 in Figure 3), 10 hardcore players visualized the square in which the flag was located, dropping to 8 for inexperienced players. For the flag on the right of the map (F3 in Figure 3), the number of player visualizations is 9 for hardcore players and 7 for inexperienced. Table 1 indicates the distribution of the number of unique player visualizations made on the square where each of the three flags are located as well as the 4 closest squares (on Top, the Bottom, Left and Right).

Hardcore Players						
Flag	C	T	B	L	R	Total
F1 (L)	7	7	3	7	10	34
F2 (C)	10	9	10	8	10	47
F3 (R)	9	5	4	7	9	34
Inexperienced Players						
Flag	C	T	B	L	R	Total
F1 (L)	2	6	2	2	9	21
F2 (C)	8	7	9	8	8	40
F3 (R)	7	4	5	8	7	31

Table 1: Distribution of number of unique player visualizations in Flag areas

As Table 1 presents, the number of visualizations in the squares where the flags are located is always higher for the hardcore players. These results suggest that hardcore players had a greater understanding of the objective of the game and task, paying closer attention to the flags, whether their objective was to conquer or defend them.

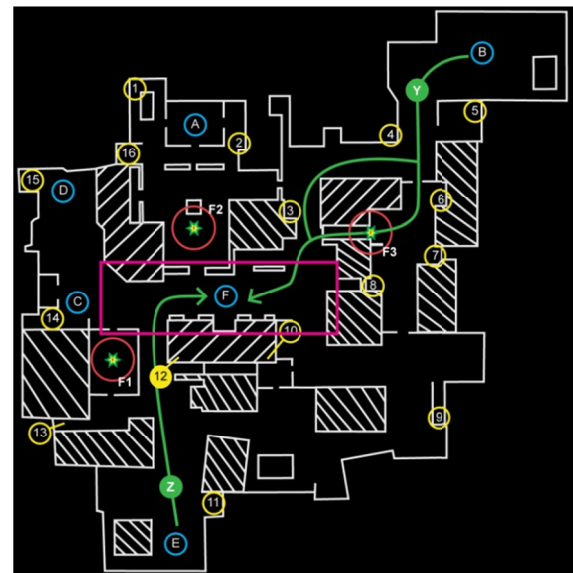


Figure 3: Representation of the various spawn points (SP; 1-16), Flags (F1, F2, F3), Areas of Interest (A, B, C, D & E), and player routes (Y and Z)

A second general look at the differences between hardcore and inexperienced players visual behavior suggests that inexperienced players took greater advantage of the spaces of the map and explored it to a greater extent. While this is true – as there are more squares with higher values of visualization in Figure 2 – one element in particular appeared to contribute towards this greater dispersion of visual activity: number of deaths. Each time a player died, he would *spawn* (i.e. restart his presence in the game) in one of 16 different locations – spawning points (SP) – indicated in Figure 3. Table 2 represents the total number of unique spawns that were registered for each of the experience groups at the indicated spawning points. Although the number of player spawns registered for hardcore players did not differ significantly from the inexperienced players (47 to 51); based on video analysis, it was visible that for inexperienced players, five areas in particular benefited from the number of spawns that occurred for this player category: area A, B, C, and D (in Figure 3).

SP	1	2	3	4	5	6	7	8
H	4	4	4	4	2	1	0	4
I	2	3	3	4	5	0	3	1
SP	9	10	11	12	13	14	15	16
H	3	6	1	7	1	0	2	4
I	4	1	4	6	3	4	4	4
Total			Hardcore		47	Inexper.		51

Table 2: Distribution of the number of unique player spawns for each of the 16 spawning points (SP)

The greater number of player visualizations visible in area A is the result of a large number of spawns by inexperienced players; namely in the SP marked by number 1, 2 and 16. While the total number of spawns made by hardcore players is superior than inexperienced players for these three SP, the interaction behavior registered for inexperienced players – namely in terms of action and decisions after spawning – was different. Video analysis showed that while hardcore players would spawn and move quickly to the closest flag (flag F2) – which contributed towards a greater number of visualizations for this flag, inexperienced players preferred to visually explore the area near these spawn points, namely area A.

In terms of area B, a similar attitude was verified. Area B represents one of the two possible starting points, depending on the team selected at the beginning of the game. When beginning in area B, while hardcore players began to move in direction of the closest flag, inexperienced players visually explored the area and the surroundings, looking to the side and behind. Additionally, a greater number of spawns in SP 4 and 5 also contributed towards a more extensive visual activity. A total number of 9 unique spawns in both these areas were counted for inexperienced players while hardcore players only registered 6 spawns.

Area C is a third area where spawning influenced the overall number of player visualizations. At SP 14, the number of inexperienced players that spawned into the game was 4 while at the same SP, the number of spawns for hardcore players is 0. Therefore, the slightly larger number of player visualizations in this area for the inexperienced players' map is due to the number of unique spawns. This analysis can also be applied to area D, where 4 unique players' spawns at SP 15 for inexperienced players, in comparison to 2 spawns from hardcore players, contributed towards a larger number of player visualizations in this area.

While player deaths and consequent spawns had some contribution towards the variation of player visualizations and general interaction behavior for some areas of the game, video analysis also contributed towards understanding some of the differences in the two respective heat maps.

As previously mentioned, hardcore players demonstrated a greater understanding of the game objectives – conquer and defend the flags – mainly supported by previous knowledge with other FPS games. Therefore, what was verified was that when hardcore players began the game, they would naturally move in the direction of the flags to conquer or defend them. This implied that the time spent visualizing areas near the starting points (marked by “B” and “E”) was reduced. However, for inexperienced players, this was not always the case, as some would begin their game and visualize their surroundings. This was, nevertheless, more significant in area B than area E.

Another visible difference between the hardcore players' and inexperienced players' heat maps is relative to the central corridor of the map, marked by “F” and enclosed in the pink box in Figure 3. As the differences in the maps of Figure 1 and Figure 2 demonstrate, the number of hardcore players that visualized the squares in this area is superior when compared to the inexperienced players. Table 3 indicates the number of squares (of a total of 33) inside the box in Figure 3, which received 8 or less player visualizations; or were visualized by at least $\frac{3}{4}$ of the players: by 9, 10, 11 or all 12 players.

	<= 8	9	10	11	12
H	1	4	6	14	8
I	7	8	12	4	2

Table 3: Number of squares (in the central corridor) that received player visualizations

For the hardcore players, what was verified was that 32 of the 33 squares in the central corridor (area “F”) were visualized by $\frac{3}{4}$ of the players. Specifically, there were 8 squares that received 12 player visualizations (PV), 14 squares with 11 PV, 6 squares with 10 PV and 4 squares with 9 PV. In what concerns the inexperienced players, a total of 26 of the 33 squares were visualized by 9 or more inexperienced

players: 2 squares were visualized by all 12 inexperienced players; 4 squares received 11 PV, 12 squares had 10 PV and 8 squares had 9 PV. These values suggest, and based on video analysis, that hardcore players had a greater understanding of where the main area of action was occurring.

Video analysis additionally allowed the researchers to understand that on more than one occasion, when beginning the game, hardcore players would move directly towards the center of the map (area “F”). In fact, the researchers verified that the greater part of hardcore players beginning in area “E” would move directly towards the central corridor of the map (area “E”), disregarding the flag closest to their starting point (flag F1), as the arrow marked by “Z” indicates. A similar phenomenon was verified for hardcore players that began in area “B”. Here, hardcore players would move towards the central corridor using one of two paths marked by “Y”, “ignoring” the flag closest to their starting points (flag F3).

Another variation visible on the two heat maps is related to the number of unique player visualizations that was registered in the corridor that begins in area “E” and leads to the central corridor in area “F”. The hardcore players’ heat map shows that these players had a greater visual activity in this area when compared to inexperienced players. While the squares in these areas were visualized to some extent by inexperienced players due to the fact that 4 players spawned at SP 11; for hardcore players, video analysis demonstrated that what occurred with these was different. In this lateral corridor, the quantity of squares visualized by 6 or more players is significant, mainly because of what was referred earlier, related to the hardcore players movements towards the center of the map; but also because of their interest in moving towards flag F1, consequently visualizing the nearby areas that lead up to area “E”.

Figure 4 and Figure 5 represent the number of squares, in percentage (out of the 390 that could be visualized and therefore, codified), that were visualized by no players up to all twelve of the players. Specifically, what these two graphs indicate is that 13% (52) of the squares that make up the map were not seen by hardcore players while 11% (43) of the squares were not seen by inexperienced players, confirming a slightly larger usage of the map. Additionally, for hardcore players, the data acquired indicates that $\frac{1}{4}$ (100 squares) of the map was seen by only one or no players at all. Once again, this value drops for the inexperienced players as 19% (73 squares) of the map was seen by one or no players. Analyzing the total number of squares visualized by $\frac{3}{4}$ or more of the hardcore players, the values indicate that 21% (83 squares) of the map was seen by 9, 10, 11 or all twelve hardcore players. However, for the inexperienced players, this value drops, as only 18% (68 squares) of the map was seen by 9, 10, 11 or all of the inexperienced players. The remaining distribution of

player visualizations for the hardcore players was relatively balanced. Table 4 summarizes the distribution of the number of squares (N.º S) and respective percentage (%) that were registered according to the total number of player visualizations (PV) (i.e. the number of squares with 0 PV was 52, with 1 PV was 48, and so forth).

Hardcore Players							
PV	0	1	2	3	4	5	6
N.º S	52	48	32	31	22	32	30
%	13%	12%	8%	8%	6%	8%	8%
PV	7	8	9	10	11	12	
N.º S	42	18	28	29	18	8	
%	11%	5%	7%	7%	5%	2%	
Inexperienced Players							
PV	0	1	2	3	4	5	6
N.º S	43	30	47	24	36	58	24
%	11%	8%	12%	6%	9%	15%	6%
PV	7	8	9	10	11	12	
N.º S	32	28	31	27	8	2	
%	8%	7%	8%	7%	2%	1%	

Table 4: Distribution of the number of squares and respective percentage according to number of player visualizations for hardcore and inexperienced players’ Peripheral view heat map

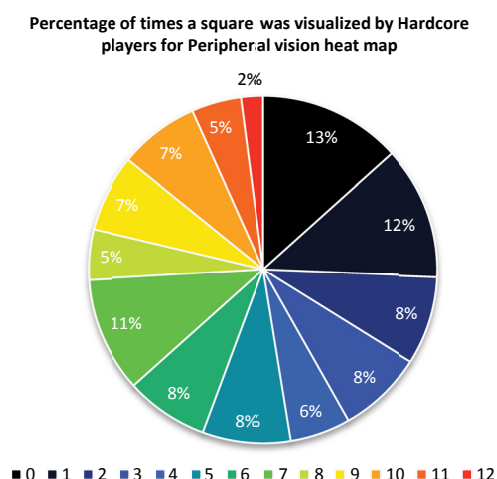


Figure 4: Representation of the number of squares (in percentage) that were visualized by hardcore players for the Peripheral view heat map

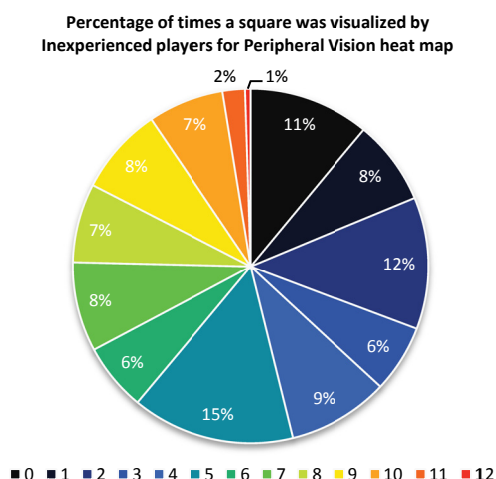


Figure 5: Representation of the number of squares (in percentage) that were visualized by inexperienced players for the Peripheral view heat map

As mentioned previously, some of the comparative analysis was possible through video analysis with the help of the Tobii Eye Tracker. However, one of the main qualities of the eye tracker is its capability of indicating with precision the exact location on the screen – in the case of a game, the level or game world – where the player was looking at. Therefore, while the heat maps presented above related to player Peripheral vision were constructed with the help of video analysis, two other heat maps were developed that indicate precisely for each of the samples taken, what location in the map the players were looking at. Figure 6 and Figure 7 represent these two heat maps that indicate the location on the map where the players were looking at.



Figure 6: Representation of Hardcore players' Point of Regard heat map

Nevertheless, because the game used for this study is three-dimensional, and includes a “depth” dimension, the position of the players’ PoR for some samples was also influenced by the researchers’

assumption. Contrary to the Peripheral view heat maps, these heat maps have fewer colored squares because only the square that contained the object or scenery element the player was looking at was codified.



Figure 7: Representation of Inexperienced players' Point of Regard heat map

These two heat maps show that for both hardcore and inexperienced players, visualization patterns were disperse. For both experience groups, only a few squares received a significant number of player visualizations. Table 5 represents the distribution of squares and the respective percentage according to the number of player visualizations for the hardcore and inexperienced players’ Peripheral view heat maps.

Hardcore Players							
PV	0	1	2	3	4	5	6
N.º S	228	75	42	24	9	4	6
%	58%	19%	11%	6%	2%	1%	2%
PV	7	8	9	10	11	12	
N.º S	1	0	1	0	0	0	
%	0%	0%	0%	0%	0%	0%	
Inexperienced Players							
PV	0	1	2	3	4	5	6
N.º S	222	91	40	20	7	6	2
%	57%	23%	10%	5%	2%	2%	1%
PV	7	8	9	10	11	12	
N.º S	1	1	0	0	0	0	
%	0%	0%	0%	0%	0%	0%	

Table 5: Distribution of the number of squares and respective percentage according to number of player visualizations for hardcore and inexperienced players’ Peripheral view heat map

In terms of numbers, for the hardcore players, 59% (228 squares) of the Point of Regard (PoR) heat map was not visualized by a single hardcore player. Another 19% of the map was visualized by at most one hardcore player. Together, more than $\frac{3}{4}$ of the map – 78% (303 squares) – was visualized by one or no

players at all. For the inexperienced players, similar results were verified. Inexperienced players did not visualize 57% (222 squares) of the PoR heat map and an additional 23% (91 squares) of the map was visualized by at most one player. Together, 80% (313 squares) of the map was visualized by one or no inexperienced players. These distributions are additionally represented in Figure 8 for the hardcore players and Figure 9 for the inexperienced players.

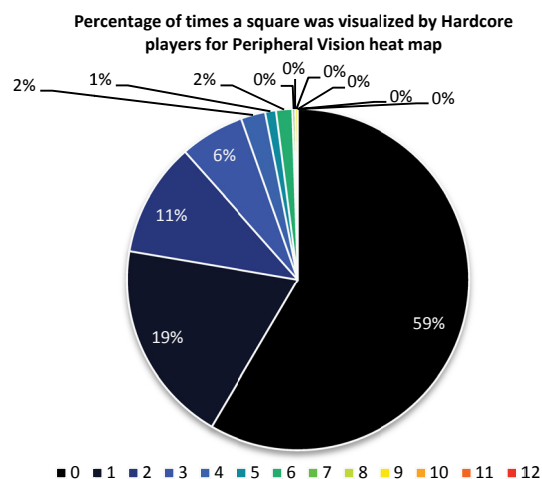


Figure 8: Representation of the number of squares (in percentage) that were visualized by hardcore players for the Point of Regard heat map

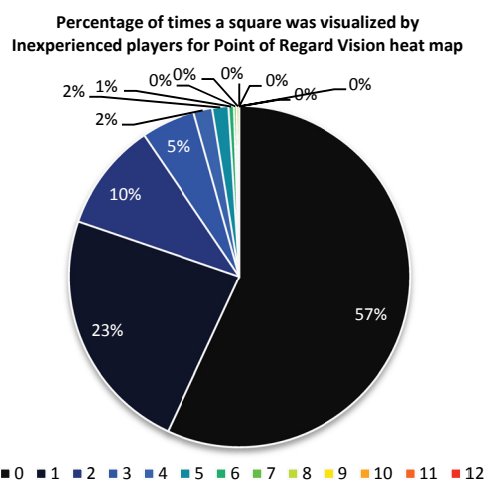


Figure 9: Representation of the number of squares (in percentage) that were visualized by inexperienced players for the Point of Regard heat map

Despite the lack of visual attention by players, some squares received a relatively positive amount of player visualizations and interaction behavior. For hardcore players, 9 single squares were visualized by 4 players; 4 squares by 5 players and 6 squares were visualized by 6 players. Additionally, one square in particular – square where the central flag is located – was visualized by 9 of the 12 hardcore players, verifying the idea that reaching the central flag was always a priority for hardcore players. As for the

inexperienced players, these also demonstrated some positive values: 7 squares were visualized by 4 players, 6 squares by 5 players and 2 squares by 6 players. For this experience group, the square that received the greatest number of views had at most 8 player visualizations. The square in question is not located at the base of any of the three flags; it is however, near the entrance to the central flag in the map's main corridor.

Analyzing once again the numbers – as presented in Table 4 –; squares seen by 4, 5 and 6 hardcore and inexperienced players only represent 5% (19 squares) and 4% (15 squares) of the respective PoR heat maps. While these percentages are low, they suggest, nevertheless, that the elements in these squares or the area itself were of greater interest to the players. Specifically, for the hardcore players – and visible on Figure 6 – 4 of the 6 squares visualized by 6 players are squares at the entrances of locations where flags are placed, while a 5th square is the location of the flag to the right of the map (flag F3). Other squares with a greater number of visualizations contained elements such as buildings (in general) and windows. Of the squares that received significant visualizations, 1 square in particular received 7 player visualizations; precisely one associated to a building. This square in particular, as well as others with 3, 4 or even 5 player visualizations that also had buildings, corroborates some of the data presented in Almeida et al.'s work [Almeida et al. 2010b]. In their previous work, the authors presented results that indicated that more than 75% of hardcore players believed that buildings influenced or influenced greatly their eye movements, while 85% stated that they influenced or influenced greatly their movement choices and consequent interaction behavior. Other data presented in their work was also confirmed, such as the fact that more than half of the hardcore players stated that windows also influenced their interaction behavior, whether it be movement or visualization. One square, where a window was located, in the hardcore players PoR heat map had 5 visualizations.

As mentioned above, the inexperienced players demonstrated in their PoR heat map a greater interest in the squares where the entrances to the flags are. These entrances are precisely bounded by walls. As occurred with the hardcore players, the greater interest in walls by inexperienced players confirms data acquired in Almeida et al.'s [Almeida et al. 2010b] previous work. Their questionnaire data indicates that more than 75% of inexperienced players reported that walls influenced greatly their eye movements, while 84% indicated that walls influence their game movements, and therefore, consequent interaction behavior.

Therefore, these examples suggest that there is a straight correlation between the qualitative data acquired in the heat maps with the data acquired via

questionnaires in [Almeida et al. 2010b], both for inexperienced and hardcore players.

3. Conclusion

This paper presents an extensive comparative analysis in terms of interaction behavior between hardcore and inexperienced players, in a “Call of Duty: Modern Warfare” game context. Having applied a method presented in [Almeida et al. 2010a], two heat maps of qualitative value were generated for each of the experience groups. First, a Peripheral vision heat map, representing the interaction behavior of the players based on their in-game movements and visual behavior as a whole. The second, a Point of Regard heat map, representing the exact location of the players’ sight. These two heat maps allowed for a comparative analysis of the human vision modality and its influence in terms of interaction behavior in a specific first person shooter game context.

Some of the most relevant conclusions made suggest that hardcore players have a much more objective approach to the game, supported by previous experiences with similar games. Their understandings of the game objectives, based on a greater concentration of visualizations in the areas where the flags are located corroborate this idea. Additionally, their greater objectivity in the game was also established with the help of video analysis. This analysis confirmed that when beginning the game, hardcore players moved rapidly in the direction of the flags to complete the game goals while inexperienced players preferred to visually explore their surroundings. This interaction behavior allowed for certain areas of the inexperienced players Peripheral view heat map to be more “complete” in terms of number of visualizations. For both experience groups, the central corridor of the map is the most concentrated and visualized area of the map. However, hardcore players were slightly more incisive in visualizing the area. The Point of Regard heat maps demonstrated that a great portion of the scenic artifacts were not directly or specifically visualized by the players, with percentages of 78% and 80% of scenic artifacts on the map seen by 1 player at most, for hardcore and inexperienced players respectively. Finally, both these heat maps helped corroborate and confirm some of the values presented in previous work, namely in terms of the influence certain game scenario elements had on player interaction behavior [Almeida et al. 2010b].

Generally, this comparative analysis study helped confirm the value and validity of a game analysis and evaluation method based on a heat map paradigm, presented in Almeida et al.’s work [Almeida et al. 2010a].

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