Perception and Visibility in Video Games Across Generations

Emily Johnson
Computing and Applied Sciences
Clemson University
Clemson, SC, USA
eaj4@clemson.edu

Kenny Nguyen
Computing and Applied Sciences
Clemson University
Clemson, SC, USA
kennyn@clemson.edu

Zoie Rast
Computing and Applied Sciences
Clemson University
Clemson, SC, USA
zrast@clemson.edu

ABSTRACT

In this present study we present an eye tracking experiment involving visibility and perception in video games in regards to two different generations of the game Modern Warfare, the 2007 version and the 2019 remastered version of the 2007 game. We evaluated the length of time it takes a participant to locate a target, an enemy video game character as seen in the Modern Warfare games. We used eye tracking software to monitor the time and accuracy taken to locate the target. We hypothesized that an older version of the game would result in an easier experience for participants, where they could locate the targets faster and more accurately because of clearer and more distinct outlines with less visual noise. The results aligned with our hypothesis and indicated that the newer version of the Modern Warfare Game, the 2019 version, resulted in a harder experience for participants and also resulted in a longer time for participants to locate the enemy target. We then concluded that the newer generation of the Modern Warfare video game, that included enhanced visual effects and enhanced visual noise in the newer scene was more difficult to quickly and accurately find a target than the older generation of Modern Warfare.

KEYWORDS

Visibility, Visual fidelity, video games, 3D graphics, eye tracking

1.1 Goals

The main goal of this experiment was to explore the effects of graphical changes on a person's general ability to find and select a target. We, as a team, found that the accuracy and speed of finding and selecting a target could be affected by the graphics of the images, either increasing the speed and accuracy, or decreasing it. In general, visual perception can be affected by a multitude of factors, but one that is not often explored would be the specific resolution of an image and how it can affect our perception of an image. Humans now look at computers, phones, and TV screens every day for work, school, or entertainment, and how different resolutions of screens or the application that is being used is hardly ever explored. As a team who grew up looking at screens every day for almost everything, we wanted to see how the different resolutions or levels of graphic fidelity affect our visual perception of finding targets, and more specifically our accuracy and speed of locating and choosing these targets.

1.2 Motivations

Our motivation for conducting this experiment was to explore the topic of visual perception and how our daily routines of staring at screens affect our perception skill. Many university students play video games in addition to a growing number of other people nowadays. We wanted to explore how, over time, the shift to enhanced graphics and larger resolutions have noticeably, or if they even have, affected people's abilities to locate targets in video games.

1.3 Hypothesis

Before conducting our research, we hypothesized that the general increase in visual fidelity would lower the speed and accuracy of finding targets. The higher the visual fidelity typically means more pixels, polygons, visual effects, and visual noise within the 3D scene. The human eye has evolved to perceive and identify objects that may help us with our survival, such as spotting an enemy or target that could possibly hurt us. With higher visual fidelity, and therefore higher resolutions, subjects will theoretically be able to spot the target faster with more accuracy due to a higher level of photorealism. However, we believe the limitation of compressing these denser 3D scenes into a 2D screen will make it so that these advantages will be nullified, and as a result older generation video game targets will be much easier to spot due to clearer and distinct outlines with less visual noise. Unfortunately, we believe the target acquisition speeds measured in this experiment will be longer in general than in actual gameplay, due to the experiment using still images instead of videos, and stationary targets are harder to spot than moving ones to the human eye.

2 Background

Traditionally video games have used visual aids to help the player, emphasizing certain points, such as an objective,

teammate, enemy, etc (as shown in figure 1). There have been very few eye tracking studies that evaluate players' interactions with video game environments that improve understanding of how players interact with their gaming environments. This is important information for understanding how players are interacting with gameplay elements that are important for successful gameplay from both a game designer standpoint, and a consumer standpoint. Gameplay can be improved by altering elements, such as texture, color choices, level design, and object locations[1]. According to Almeida, et al. "many non-gamers get lost in 3D game environments, or they don't pick up an important item because they don't notice it". According to Vanacken, Grossman, and Coninx's study on Exploring the Effects of Environment Density and Target Visibility on Object Selection in 3D Virtual Environments, the experiment found that subjects took longer to complete seeking tasks if objects were denser and involved occlusion of objects behind one another.

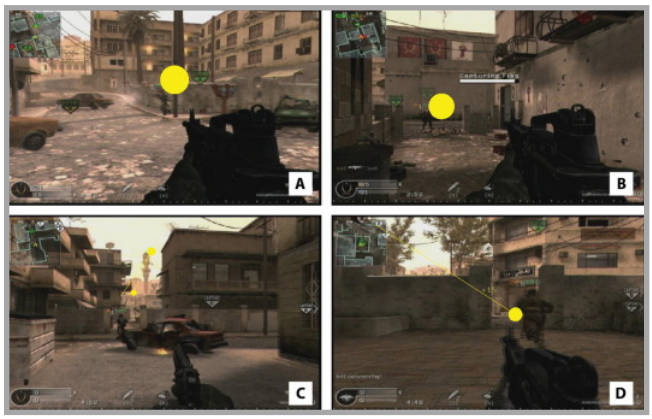

Figure 1: An eye tracking experiment shows that players are focused on their teammates, objectives, and a mini-map thanks to Heads Up Display elements added by the UI designer (Almeida, Mealha & Veloso, 2016)

3.1 Apparatus

For our experiment we used a Gazepoint (GP3) eye tracker that was mounted underneath the computer monitor display in the Clemson University Eye Tracking Lab. The GP3 is a research grade eye tracker utilizing a 60Hz machine-vision camera. The Gazepoint uses an infrared lamp to measure the center of the pupil to the reflection of the infrared light on the cornea. The GP3 has a 0.5 – 1 degree of visual angle accuracy and the computer monitors that we are using during the experiment have a resolution of 1680 x 1050.

3.2 Stimulus

Our Stimuli consisted of different images, screenshots taken from two different versions of the popular video game franchise Call of Duty. To keep consistency, both video games were set to the maximum graphic settings and be set to an 80 degree field of vision in order to maximize consistency between the images. There were seven stimuli scenes for each test, not including the calibration crosshair and sample subject in between the test stimuli.

3.3 Subjects

The subjects of our experiment consisted of students at Clemson University. We had 10 Clemson University students participate in the study. Ideally, we would have an even number of men and women in the study, however 6 participants were male and 4 were female. The median age of the study was 21, with the youngest subject being 19 and the oldest subject being 28. None of the subjects had any pre-existing eye conditions that would impact screen viewing, 50% were casual gamers, 25% considered themselves hardcore gamers, and the other 25% have rarely ever touched a video game.

3.4 Experimental Design

The experiment was built with the help of Gazepoint Analysis. The participants were randomly divided into two groups (A and B), one group (A) received the lower quality graphical images from Call of Duty 4: Modern Warfare (2007) and the second group (B) received higher quality graphical images from the newer Call of Duty: Modern Warfare (2019). The images between the groups consisted of images from the same level, but with differing quality of graphics between group A and B. As a result, this was a within-subjects experiment rather than a between-subjects experiment. We believe this was the best way to directly compare the visibility and user perception of targets because the two images were of the same scene but have different levels of graphical fidelity. Therefore, it would make the learning effect too effective if we gave one person the same level with the same target location, just with a different game (See Figure 2 and 3 for example Stimuli). The independent variable of the experiment was the game generation. The control variable was be the target location/scene type. The dependent variable would be the time the subject takes to locate the target.

Figure 2: One group will receive the below image of Call of Duty 4: Modern Warfare (2007) and be asked to find the enemy in the scene as quick as possible (enemy AOI highlighted in red for demonstration purposes)

Figure 3: The other group will receive the above image of Call of Duty: Modern Warfare (2019) and be asked to find the enemy in the scene as quick as possible (enemy AOI highlighted in red for demonstration purposes)

3.5 Procedures

Participants were given a short survey before they began their experiment. Next, they were given a short set of instructions from the experimenter. The experimenter let them know that they are participating in an experiment pertaining to eye tracking and video game graphics. Afterwards, the experimenter gave the subject instructions as to where to hold their head, and to avoid major head movement.

First, there was a 5 point calibration of the eye tracker before the subject began the experiments. This calibration was repeated as many times as needed if the subject's eyes do not line up accurately with the target point in the sample calibration. Then, they began the experiment program, which took the subject through a set of instructions, spoken by the instructor telling them that they are going to be given a set of images where the subjects are asked to find the enemy on the screen as fast as they could. Next, we presented them a sample image of what the enemy looks like so they know what they are looking for before the start of the experiment (see figure 4 and 5).

After the subject read these instructions, we gave them a moment to ask any questions, and then continued with the experiment. Afterwards, we gave them the first stimulus image in which they immediately started their task. Once they located the enemy as fast as possible, they were asked to verbally tell the experimenter that they found the target and where they found the target. They were then asked to maintain their gaze on the target until the next slide was shown. In between stimuli images the subject was presented with a blank image with a grid and were asked to gaze at the center of the image for five seconds. This was done to make sure all participants start scanning the image from the same location, to prevent the possibility of the participants starting the next test and coincidentally be staring at the target already. The sequence was repeated until all the stimulus images were looked at. After the experiment was finished, the participant was given another short survey, to properly convey their feelings about the difficulty of the task.

Finally, we extracted the data received from both groups from Gazepoint Analysis. We mainly compared the time to find the target between the two video game images, in addition to hit rate because some targets were never ever found by the subjects.

Figure 4: One group was given the target from the image above in different settings and was then tasked to find this image. This target is from Modern Warfare 2007.

Figure 5: One group was given the target from the image above in different settings and was then tasked to find this image. This target is from Modern Warfare 2019.

4 Results

Stimulus	Modern Warfare 2007	Modern Warfare 2019
1	0.8958	2.8272
2	1.3756	7.6058
3	1.874	5.8488
4	4.4135	5.466
5	4.145	7.612
6	3.2748	4.4296
7	1.2538	5.8306
Average	2.461785714	5.66

Figure 6 Mean target acquisition times for both games (in seconds) and the 5 participants times were averaged

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Modern Warfare 2007	7	17.2325	2.461786	2.123371
Modern Warfare 2019	7	39.62	5.66	2.872911

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	35.80001	1	35.80001	14.33066	0.002597	4.747225
Within Groups	29.97769	12	2.498141			
Total	65.7777	13				

Figure 7 ANOVA table

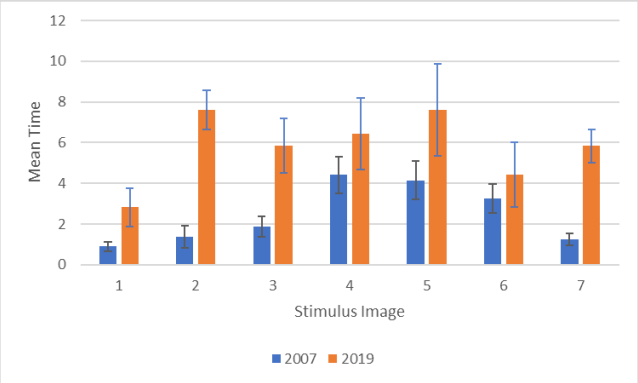

Figure 8 Comparison of enemy acquisition times between the two games for each stimulus image

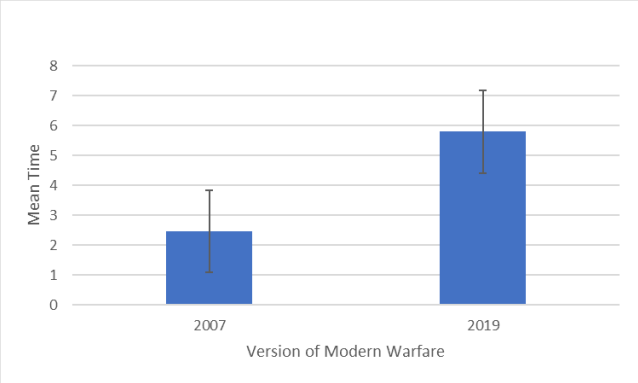

Figure 9 Comparison of average enemy acquisition times for each game

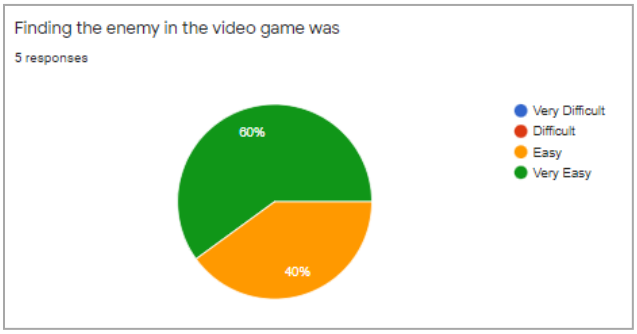

Figure 10 Modern Warfare 2007 participants response to ease of finding the enemy

The scan paths from stimulus one of the 2007 version can be found in figure 12 and the scan paths from stimulus one of the 2019 version can be found in figure 13. There was only one instance of a participant not being able to find the target in the stimuli for Modern Warfare 2007 for a 97.14% task completion rate, while there were two instances for participants taking the Modern Warfare 2019 test for a 94.29% task completion rate. We did find that there was a highly significant effect on target acquisition time: $F_{1,12} = 14.3306$, $p < 0.05$ (as seen in figure 7),

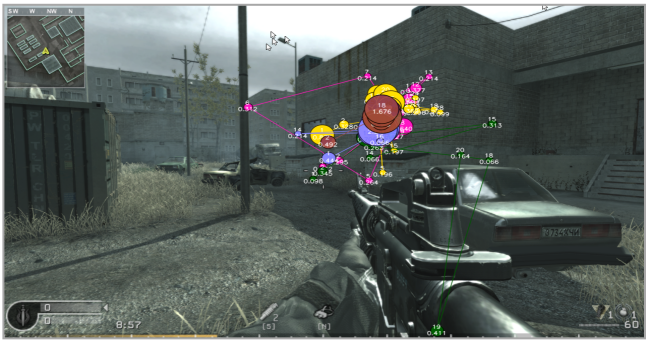

Figure 11 The scan path from stimulus one of all participants from the 2007 Modern Warfare Group.

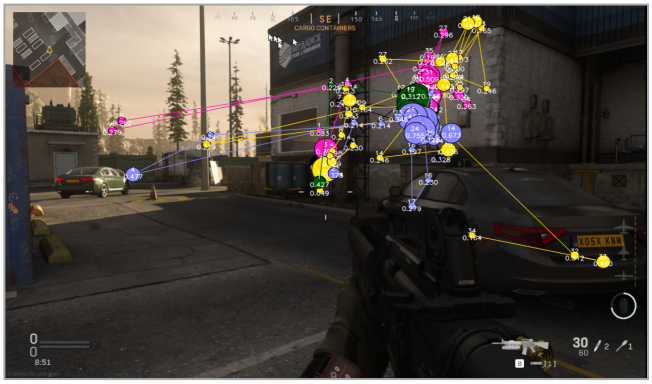

Figure 12 The scan path from stimulus one of all participants from the 2019 Modern Warfare Group

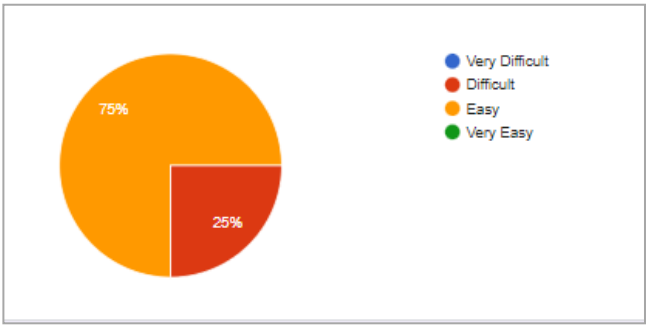

Figure 13 Modern Warfare 2019 participants response to ease of finding the enemy

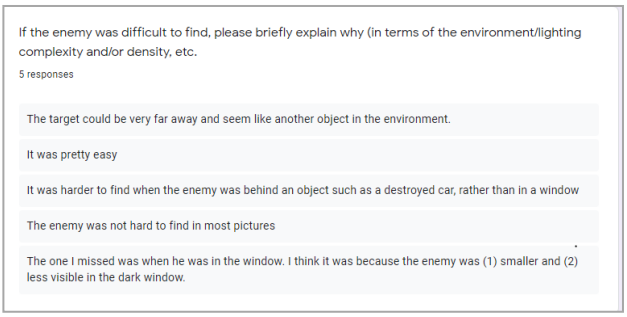

Figure 14 Modern Warfare 2007 Post-Survey short answer responses

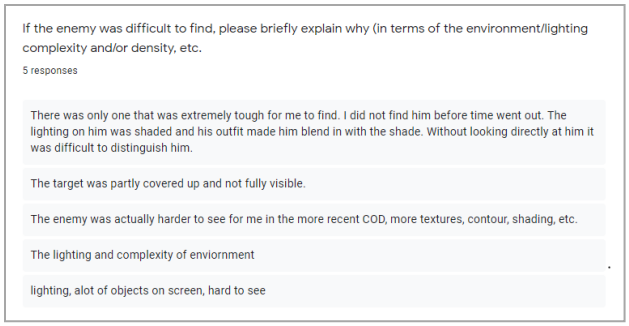

Figure 15 Modern Warfare 2019 Post-Survey short answer responses

and the mean target acquisition time for each stimulus is shown in Figure 6 for further detail. In the post survey, as shown in Figure 10, 60% of the subjects looking at the old game believed finding the enemy was very easy, while 40% only believed it was easy. On the other hand, 25% of the participants looking at the new game believed finding the enemy was difficult, with the other 75% believing that finding the enemy was easy, as shown in Figure 13. Figure 10 and Figure 13 shows the participants' opinions on how easy it was to complete the task for Modern Warfare 2007, and Modern Warfare 2019, respectively.

Finally, there was a short answer section which asked participants to explain why they found that the enemy was hard to find , the anonymized individual responses can be found in Figure 14 and 15. To summarize these results, Modern Warfare 2007 participants either did not find the enemy hard to find, found the enemy was hard only if the enemy was farther away and/or occluded by another object, or was placed in a darker section of the scene. The Modern Warfare 2019 participants found that the enemy was harder to find if the enemy was farther away and/or occluded by another object just like the other group. However, some added that the lighting helped the enemy blend in at first glance because they searched for humanoid outlines, and that there were too many objects to look at in the scene.

4.1 Limitations

While both sets of stimuli were set up in the same level with the enemy in the same location, we realized that the scenes weren't identical for reasons other than graphical improvements. Sometimes the new game would add additional objects to the level, change the positions of some existing objects and their scaling. The enemy character models were also completely different from each other. Some of the levels from the newer game had an entirely different time of day and weather from the old game. Finally, we had to settle for still images for stimuli for simplicity, and humanoid shapes are much easier to find if they are moving. In terms of the subjects, we were unable to evenly distribute the non-gamers and gamers to each group due to scheduling conflicts and time constraints. There were certain variables that we would not be able to control, such as the amount of sleep they received the night before, their levels of stress, their experience with eye tracking, and other uncontrollable variables.

5 Discussion

The newer version of Modern Warfare 2019 had a significantly longer mean time to find the target per stimulus. It took participants an average of 5.660 seconds to find the target if they were looking at Modern Warfare 2019, and an average of 2.462 seconds to find the target if they were looking at Modern Warfare 2007, as shown in Figure 9. In terms of individual stimuli, all of the targets were found faster in the 2007 game compared to the 2019 game. The average variance of results for Modern Warfare 2007 were lower at 2.123 seconds, while Modern Warfare 2019 had an average variance of 2.873 seconds, as shown in Figure 7. There were two stimuli, stimuli four and stimuli six, where the standard error of each mean time overlapped, which resulted in an insignificant result for those two stimuli. There were two participants that could not find the target in stimulus 5 of the 2019 group. While the 2007 group only had one participant that could not find the target for stimulus 4. There was more variance in how participants believed the difficulty of the task was based on our post surveys. Participants from the 2019 Modern Warfare group described the task of finding the target more difficult than the participants from the 2007 Modern Warfare version. There are many different variables and human factors that could have been affecting this outcome including, if a participant was lacking sleep, if the participants were experiencing stress, the amount of time a participant has played video games and the type of video games the participants have experienced playing. Although these potential variables could have affected the outcome of what we were testing, we found that our hypothesis was supported by results of our experiment. The participants of the 2019 Modern Warfare group had a harder time locating the targets than the Modern Warfare 2007 group.

6 Conclusion

Our findings and data for this study supported our hypothesis that stated that our participants would have a harder time finding the target within the newer generation of the Modern Warfare game, and have an easier time locating the target within the older generation of the Modern Warfare game.

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[2] Vanacken, L., Grossman, T., & Coninx, K. (2007). Exploring the Effects of Environment Density and Target Visibility on Object Selection in 3D Virtual Environments. In 2007 IEEE Symposium on 3D User Interfaces.