If Looks Could Kill:

Gaze Aversion and Gaze Aiming in a 3D FPS Game

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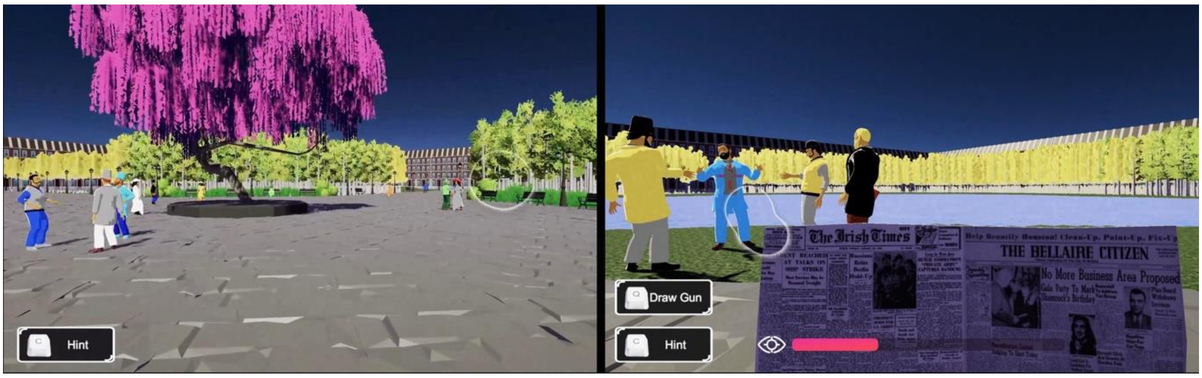

***Figure 1** The game 'If Looks Could Kill'. First phase on the left, when the player needs to find and follow a described person. The second phase on the right, when the player needs to identify the kill target without gazing too long at the group (indicator of being spotted in the bottom).*

ABSTRACT

Gaze tracking has been increasingly used in video games in recent years. However, most video games use gaze tracking more as an analytic tool and accessory than for main gameplay mechanics. In this research-through-design project, we developed a 3D first-person shooter video game 'If Looks Could Kill' that utilizes gaze tracking as the main mechanics to observe the role of gaze aversion and gaze aiming. To measure the game experience, we conducted a user study with six participants using the Game Experience Questionnaire, observations, and semi-structured interview as our measurement. The result from the questionnaire shows that the game concept delivered an entertaining experience for the participants. Issues that were identified from the observation and interview includes difficulties turning the in-game camera using gaze and looking at targets unintentionally due to trying to read the on-screen instructions.

Keywords

Research Through Design, Gaze Interaction, Video Games, Multimodal Interaction

INTRODUCTION

The use of eye tracking in gaming and research around it is seemingly increasing. However, current AAA video games mainly use eye tracking as an 'accessory' with little value to the main gameplay mechanics (Velloso & Carter, 2016). It has been argued that this is a current paradigm of gaze interaction, that AAA video games mainly use gaze interaction based on pointing with gaze (Ramirez Gomez, 2019). While the same sources proclaims that gaze can offer much more support and playful experiences than it currently does. Gaze as a unimodal input modality has been shown to have the potential to perform as well as mouse and joystick unimodal input in game-like interactions (San Agustin et al., 2009). Suggesting that gaze interaction is a viable control modality. Huang and Westin (2020) also showed that gaze has the potential to make games more accessible, but that players' eyes easily become fatigued when gaze is used as the single control modality in games. Huang and Westin argue that one of the challenges in using gaze interaction in video games is to design game mechanics that works well with gaze, i.e., does not strain the eyes but still create a meaningful experience. If putting too much workload on the eyes is too straining, but is still efficient, a possible middle way could be to use a multimodal approach. E.g., still using the traditional input of keyboard for a computer game while letting gaze be used in more natural interactions in the game mechanics.

Several studies showing how novel gaze interactions can be used in game mechanics (Nacke et al., 2010; Navarro & Sundstedt, 2017; Ramirez Gomez & Gellersen, 2019a, 2019b). However, most of example games are quite simple and 2D, combining some of these gaze interactions in a more complex 3D game might give some new insights. This study conducted research through design to iteratively develop a video game that implements gaze interaction in its game mechanics. The objective of the project was to design and prototype a game that combines the input modality of eye tracking and standard tangible keyboard to create a unique game experience to be evaluated. A starting approach to the game design was to use Gaze Aversion, playing with peripheral vision, and Gaze Aiming in a 3D First-Person game. Insights as to how well this works will help other researchers and game designers in the industry to decide how to implement gaze interaction in their games.

1 BACKGROUND

1.1 Eye tracking

Eye tracking technology has a wide range of applications and the area of interest for this study is in interactions with computer interfaces and games. An early study (San Agustin et al., 2009) user evaluated gaze input with other input devices in experiments with game-like interactions called target acquisition and target tracking. The study indicated that gaze input in these interactions could perform as well as a mouse and better than a joystick, given a sufficiently accurate and responsive eye tracker.

Velloso and Carter (2016) identified three common problems for gaze interaction; the Midas Touch (i.e., false positive activation), inaccuracies of the tracking and the double role of eyes being used for both observation and control. Huang and Westin (2020) demonstrate that gaze, as a control modality, can make games more accessible, but that the eye fatigue is limiting any extensive or complex use of gaze. A gaze-enabled game mechanic must, therefore, be designed with these limitations in mind. This study aims to solve it by a multimodal approach of using gaze for natural interactions (i.e., in game mechanics that does not require extra movements of the eyes) while using the traditional keyboard for navigation and ability activations.

1.2 Gaze Interaction in Games

In an extended abstract, Ramirez Gomez (2019) argues that implementations of gaze interaction have so far been mostly based on gaze pointing, calling this gaze interaction paradigm "What you look at is what you get" (p.56), originating from an early study (Jacob, 1990). Ramirez Gomez present two novel design approaches in two separate studies *Playing with Peripheral*

Vision (Ramirez Gomez & Gellersen, 2019a) and *Playing with Tension and Attention* (Ramirez Gomez & Gellersen, 2019b). The latter investigated gaze selection, navigation, and aiming (similar to the categories of Velloso and Carter (2016)) in simple 2D games indicating that their design could be challenging and create a playful experience. The former investigating gaze aversion by relying on peripheral vision in simple 2D games. I.e., the player must consciously focus on things in their peripheral vision. This design of playing with peripheral vision also indicated to be an engaging and playful experience.

Velloso and Carter (2016) reviewed 70 works regarding gaze interaction in games and categorized them based on 112 game mechanics that were identified within them. The study provides a clear list of vocabulary on the topic and examples of gaze-enabled game mechanics. These mechanics were categorized into navigation, aiming & shooting, selection & commands, implicit interaction, and visual effects. Velloso and Carter argues that games have overemphasized the use of specific eye-movements and mechanics, that does not provide novel game experiences.

Navarro and Sundstedt (2017) conducted research through designing a 2D space shooter that compared a multimodal to a unimodal approach. The multimodal version used the natural gaze pattern of players to control the activation of a key player ability, while a gamepad controlled the navigation and shooting. The unimodal approach solely used a gamepad input for all actions. The game was user evaluated and the two approaches compared. The results suggested that there was no discrepancy in performance, but that the multimodal design provided a positive experience and that users preferred this interaction.

In an extended abstract, Ramirez Gomez (2019) argues that implementations of gaze interaction have so far been mostly based on gaze pointing, calling this gaze interaction paradigm “What you look at is what you get” (p.56), originating from an early study (Jacob, 1990). Ramirez Gomez and Gellersen (2019a, 2019b) developed a series of 2D minigames that explored the design of novel gaze interaction in certain game mechanics. Three games used Gaze Aversion that force players to use their peripheral vision to play and the other three used Gaze Selection, Gaze Navigation, and Gaze Aiming. The user evaluation results suggested that all the games provided a playful experience.

The use of gaze for aiming has been tried in many games before (Velloso & Carter, 2016), most likely because it is a natural interaction to look where you aim/shoot in a game. In another study (Nacke et al., 2010) they used gaze input for controlling a first-person viewport, i.e., aiming, while walking was controlled with a keyboard, in a 3D First-Person game, with the results suggesting a positive game experience. With Gaze Aiming having been shown to be viable, this study was interested in trying to combine it with Gaze Aversion. The combination of using gaze to control the viewport in game while forbidding the player to not gaze at certain objects could create an interesting game experience.

2 METHOD

2.1 Designing the Game

In designing ‘If Looks Could Kill’, we wanted to explore how well Gaze Aversion and Gaze Aiming could be combined with the traditional controller of keyboard. Both Gaze Aversion and Gaze Aiming have been shown viable in simpler games but to our knowledge not combined in a 3D FPS. As an initial approach we therefore started the development and design of the game with these game mechanics in the hopes of gaining new knowledge.

We first imported the Tobii SDK to Unity and built a demo scene with a basic first-person character controller and implemented the eye tracking to control the viewport. The arrow keys or “WASD” buttons were used to navigate. Looking at the edges of the screen can rotate the viewport towards the corresponding direction.

The team worked on coding, environment modelling and shaders separately. Then we combined all the work to finish the game. The game theme is set to be in the 1950s and the game uses toon shader and several post-processing effects to better illustrate the game background. The game objective is to play as a spy who needs to kill an evil mayor. The player is provided with a description of a man’s clothing, this man will be meeting the evil mayor shortly. The player should first locate this man in the center of the park and follow him to find the mayor’s group. When the player is close to this group, a description of the evil mayor is given. Killing the right target completes the level and killing the wrong one, or gazing too long at the group, fails the mission.

In detail, the game has two phases. In phase 1 the player is spawned at the center of a park and needs to follow a man with given description to locate the target group. The player needs to use both the keyboard and gaze aiming to navigate successfully. When the player spots the target group, the player needs to intentionally avoid looking directly at the group while approaching them using the keyboard. By sitting down on a nearby bench, the game enters phase 2, where player needs to identify a target using their peripheral vision, that matches a given description. The game will enter slow motion when the player takes out the gun, which gives them a couple of seconds to shoot at the right target before getting shot by the enemy themselves. The player controls the gun with their gaze and the crosshair for the gun will be locked to certain targets if the gaze gets near the target. The game has three different rounds with varying description for the target’s outfits.

2.2 Participants

The game was tested by 6 international students at the university KTH in Stockholm, Sweden, around the ages of 18 - 36. Five identified as female and one as male. Two had never played video games before, another two rarely played and the last two casually played. None had used eye tracking technology in video games earlier.

2.3 Evaluation Design and Data Collection

The evaluation was to assess the designed game by looking at the experience users had while playing. A playtesting session based on Fullerton's (2018) description of playtesting was conducted to investigate the players’ experience. The playtest was split up in three parts: pre-session (3 minutes), playtest-session (10 minutes) and post-session (15 minutes). In the pre-session the eye-tracker was calibrated to the participant, and they got briefly introduced to the game and its controls. In the playtest-session data was collected by two researchers taking notes while observing the participant play the game. The observations followed a pre-constructed guide (see Appendix A). In the post-session the participant was briefly interviewed on their overall experience and then asked to fill out the core module of the Game Experience Questionnaire (GEQ) (IJsselsteijn et al., 2013). The GEQ measures the experiential dimension of the game as scores on seven components: *Sensory and Imaginative Immersion, Flow, Competence, Positive and Negative Affect, Tension/Annoyance,* and *Challenge.* There are six items per component, formed as statements, that measure agreement in a five-point Likert scale ranging from 0 (not agreeing with) to 4 (completely agreeing with). Component scores are computed as the average value of its items. Observation notes and interview answers will be used to enhance the validity of the GEQ by triangulation.

2.4 Data Processing and Analysis

After the user evaluation, one researcher grammatically corrected the observational notes, merged the notes of the two observers and compiled it in one digital table sorted by each GEQ dimension. The notes were summarized with Table 1 showing the results. The same researcher grammatically corrected and transferred the interview notes to a digital format and coded each noted answer according to the GEQ dimension and identified what was prominently discussed. The interview results are presented in Section 3.2.

The GEQ was answered digitally in a Google Forms. The result was then exported into a CSV format, and then proceed to be cleaned manually, and finally was fed into the statistical analysis tool for further analysis. The statistical analysis tool used was R Studio 2021.09.0 Build 351.

3 RESULTS

3.1 Observations

The observations are presented in a summarized form in Table 1 below.

__Table 1__ Summary of the most prominent observational notes by GEQ dimensions.

Observed Dimensions		Summary
Immersion	Positive	• Some players seemed emotionally engaged while playing. • The gaze interactions became more natural with practice.
	Negative	• Struggle and confusion may have broken many players' immersion.
Flow	Positive	• Some players were still joyful when losing.
	Negative	• The players struggled with turning the camera fast enough with their gaze. • Overall, the instructions and mechanics in-game were unclear to all the players. • The players struggled with averting their gaze from the target group while approaching. • All players had some kind of difficulty with the second phase.
Competence	Positive	• The gaze aiming interaction went smoother with each round.
	Negative	• The players could not swiftly rotate the camera. • Even with verbal instruction, the players had difficulty performing tasks.
Tension	Positive	• One player finished all their rounds without apparent frustrations.
	Negative	• Most players struggled with the gaze aiming. • Most players struggled with approaching the target group and the second phase
Challenge	Positive	-
	Negative	• Most players struggled to win a round.
Affect	Positive	• Some players were excited to play and pleased with the gaze interaction.
	Negative	-

3.2 Interview

The questions guiding the semi-structured interview was; (1) What is your impression of this gaze interactable game?; (2) Was the gaze interaction working satisfactory? (What was good/bad?); and (3) Would you want to play more games that use these gaze interactions?

Each answer was coded according to the GEQ dimension (see Appendix B). For question (1) the dimension Affect – Positive was the most prominent with participants expressing excitement about the experience of using gaze as a control. Two participants also brought up the issue of looking at the UI, that showed instructions on what keyboard keys to press etc., as the camera would begin to rotate when they tried to look at the UI. The participants hence felt they could not look at the UI. Question (2) had answers most prominent in Flow – Negative and

Tension – Negative. Further explaining issues participants had with the interactions; an issue of not wanting to look at the UI; that instructions were unclear; that the eye tracking was not precise; and that approaching the target group without gazing at them, in the second phase, was hard. Question (3) was split between Affect – Positive and Affect – Negative. One half expressed interest in trying out similar games while the other half was not so interested.

3.3 Questionnaire

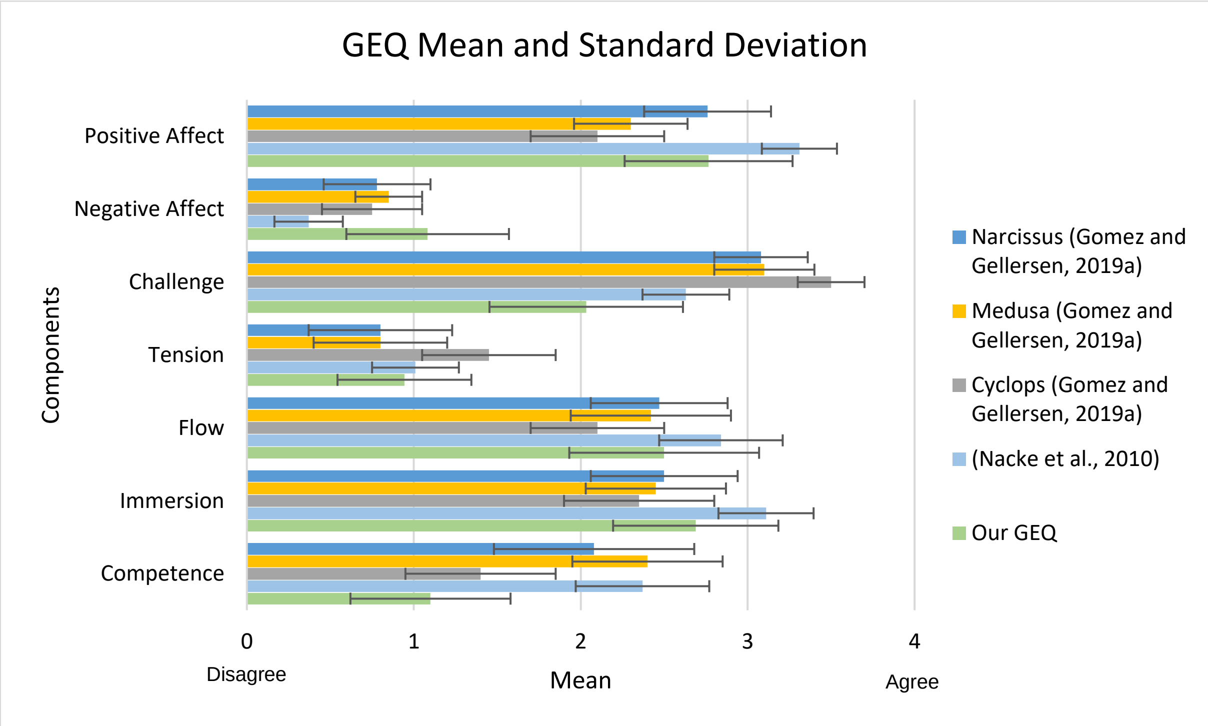

Figure 2 *Game Experience Questionnaire (GEQ) result of our game alongside results from previous similar research. Note that the results for Narcissus, Medusa, and Cyclops are estimated from the original paper.*

The figure above presents the descriptive statistics of our GEQ alongside results from previous similar research (Nacke et al., 2010; Ramirez Gomez & Gellersen, 2019a) to compare the performance of our game. The middle of the spectrum, the mid value, is valued 2. The result suggests moderately positive game experience, shown from the positive affect, flow, immersion, and challenge values that have reached the mid value, with each mean ± SD value of 2.76 ± 1, 2.5 ± 1.137, 2.69 ± 1, and 2.03 ± 1.159 respectively. The result also indicates that the game has low negative affect, tension, and competence value, with mean ± SD scores of 1.08 ± 0.97, 0.944 ± 0.8, and 1.1 ± 0.95 respectively, indicating that the game delivers a relatively pleasant experience for the players with little feeling of frustration (low tension and negative effect) although the participants did not feel competent when playing the game. However, none of the positive components reached a value above 3.0, suggesting there are still room for improvements in the game. When compared to previous results, our game recorded a considerably higher negative affect score and low competent score, and the challenge component is also seen to be the lowest compared to the other four.

4 ANALYSIS & DISCUSSION

Here the paper analyzes and discuss the results, and the project is assessed.

4.1 Results Analysis

Regarding the observations, the most common GEQ dimension shown in the results were 'Negative Flow'. Because this is a naturally easy dimension to observe, the higher number of occurrences may not be suggesting anything. However, there are some common and notable observations throughout the results. The players struggled with turning the camera in a smooth and fast manner, trying to turn faster by turning their own heads. The in-game instructions and mechanics were unclear, even after getting verbal clarifications, and all the players struggled with successfully completing the second phase of the game. Lastly, it seemed hard for many players to approach the target group without gazing at their direction.

The 'Negative Flow' observations explained above seemed inconsistent with the flow component from the GEQ, as the component delivered positive responses in the questionnaire. One possible explanation for this is that the participants may be aware of the difficulties that were present during the playtesting session, but they did not consider them to be a hindrance to be fully occupied in the game. However, it is also possible that the participants were not fully aware of the difficulties, hence answering high values in the questionnaire. Still, the fact remains that most participants experienced various technical difficulties and bad design decisions that affected the performance of the game.

Compared to previous research, our game scored the highest negative affection component and the lowest competence component in the GEQ. Upon detailed observation of the point that made up the negative affection component, it is revealed that most participants found the game to be tiresome. The points that made up the competence component also shows similar results, indicating the participants did not feel good or successful about the game. This may be explained by our observation findings that most participants experience difficulties with turning the viewport camera, hence causing issues that hinders completing the game successfully.

The interview results enhance some of these observations. These results show that participants felt that they could not look at the in-game UI as the camera would unwantedly begin to turn as well. Those that did read the in-game instructions expressed that they were unclear. This could explain why the participants struggled with the second phase of the game, the instructions were unclear and maybe not even read. This could also explain the difficulty in approaching the target group without gazing at them. When the participants were to start approaching the group, a prompt with instruction was placed in the center of the screen, overlaying the target group. Hence a conflict arose where if the participant looked at the prompt, they would start getting spotted by the target group and fail the game.

4.2 Multimodality

The game combined keyboard and gaze for input. The keyboard is responsible for character movement and the gaze for the game's viewport. Most people today have experience in using keyboards and are quick to pick up these controls. The gaze can be a natural way of rotating the viewport as it is how we do in real life, improving the immersion of the game. However, the limitation is that gaze detection is not always accurate. It can have some offset and jittering issues, making the view rotation not so convenient sometimes. Also, when the gaze control replaces the function of the mouse in the game, the utilization of both hands should be considered as the hand that was controlling the mouse is now free.

There were some problems identified during the playtesting sessions with rotating the viewport with gaze. The most prominent was the *Midas Touch* problem, i.e., unintentional target activation (Velloso & Carter, 2016), that was present in each playtesting session when the participants tried to focus on the UI elements but triggered the target group's attention instead, causing the participant to lose the game. Another issue that occurred was when the participants wanted to look at the UI in the corner of the screen which caused the viewport to inadvertently rotate. One possible solution to the former problem would be to deactivate gaze activation when a UI element appears on the screen. As for the latter, it is possible to map the camera rotation input to the mouse pan instead of gaze, however, further research needs to be conducted to validate said design.

4.3 Methodology Critique and Future Research

In real life, gaze works in tandem with head and body rotation where head and body movement allow for a relocation of view. In this experiment, participants used a computer screen and were only able to turn the view by looking at the edges of the screen. This effect provides a less familiar use of gaze than people are used to in real life and can affect the experience as users try to place the screen in the correct position. Future research could improve this by combining eye-tracking technology and virtual reality headsets where body movement is included in gaze direction, providing participants a more familiar experience in their gaze experience.

The buttons for interactions of the game were not so clear and player might not have time to process the buttons in a short time. It is partly because the instruction of the buttons was given in the left bottom corner, and it leads to turning the view if the player looks at the instruction. For one hand, it seems better to have less controls for this game to make it not so complex. On the other hand, the player movement can be handled with one hand and the eyes can handle the rest, which makes the other hand uncomfortable for users who have been used to holding the mouse. In future research and game development, it is essential to find a balance between these two issues and make the interactions more natural.

Although the theme and the main concept of the game was discussed and decided collectively as a group, the intricate design decisions, such as the button mappings and UI placements, were overlooked throughout the development process. The lack of discussion when deciding such elements was very likely to have contributed to the negative aspect of the flow component, captured throughout the observation. To mitigate such problem from occurring in future research, a dedicated design phase should be allocated prior to the development phase.

Most of our participants had little experience with video games and had to contend with the novelty of playing a video game alongside the novelty of using an eye tracker. This effect could have affected the results by blurring the border that decides if the difficulty, enjoyment, etc., was the result of using gaze or lack of experience with video games. Perhaps the results of the study would have been different if all participants had previous experience with video games, specifically games experienced in "first-person." In that case, the effect of the eye tracker could have been better insulated from other game experience effects.

The familiarity of the participants with the researchers could also have affected the results. The participants may, thus, have been affected by a positive feedback bias. Wanting to avoid damaging their social relation with the researchers by giving positive feedback on their experience in the evaluation. To remedy this in future studies, a third party could execute the evaluation with participants with no relations with the researchers. This would hopefully reduce the possible effect of familiarity on results and provide further unbiased results.

5 CONCLUSION

In this report, we conducted research through design project by developing a 3D FPS video game 'If Looks Could Kill' that utilizes Gaze Aiming and Gaze Aversion as its main mechanics, aiming to understand how said mechanics perform in video games with similar design. The game was assessed using the Game Experience Questionnaire (GEQ) paired with observations and semi-structured interviews for each participant after they finished the playtesting session. The result showed that the game scored a relatively high GEQ score comparable to result from previous research, but the observations introduce problems that were overlooked by the questionnaire.

The participants were exposed to several difficulties during the playtesting sessions. The most apparent problem observed was turning the in-game camera using gaze, which was difficult for most participants. Other problems that occurred revolves around the *Midas Touch* problem, i.e., unintentional activation, e.g., unintentionally looking at the target group while trying to read the on-screen instructions or unintentionally turn the camera rotation while trying to focus on the UI elements present in the corner of the screen.

Finally, the eye tracker we used was initially released in 2014. A newer eye tracker may have given more accurate tracking for our participants. Due to limitation in scope the study did not have time to implement changes in the game after the user evaluation to see if we could reduce pain points. But this demo game already shows a promising combination of keyboard and eye tracking.

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APPENDIX A – Observation Guide

Observed Dimensions		Example of Player's Behaviors to look for in a game round
Immersion	Positive	–The player was very concentrated on playing the game. –The player revealed emotions in-game.
	Negative	–The player could not devote himself/herself to the gameplay.
Flow	Positive	–The player completes (win/lose) a game round without any hindrance and seems joyful.
	Negative	–The player was interrupted by malfunctioning tech, unclear instructions etc.
Competence	Positive	–The player could efficiently interact with the game.
	Negative	–The player could not swiftly perform a game task.
Tension	Positive	–The player finishes a game round without any frustration.
	Negative	–The player expresses/experiences annoyance or frustration over the game.
Challenge	Positive	–The player believes he/she can do (gaze control) better next time. –The player tries to beat a score/time.
	Negative	–The player fails the game even if he/she tries hard. –The player finishes the game without any apparent difficulty.
Affect	Positive	–The player seems pleased with the game and interaction.
	Negative	–The player seems bored of the game and interactions.

Note: The guide followed for taking observational notes during the playtest, inspired by Table 1 in (Huang & Westin, 2020).

APPENDIX B – Interview coding

What is your impression of this gaze interactable game?

P1: "It would be better if there were no keys to press, I wanted to focus on the environment and not the UI." [Tension - Negative]
P2: "It was quite stable and precise, but hard in the beginning as it was not natural to turn around. It got easier once I got used to it." [Affect - Positive]
P3: "It was interesting to control with my eyes, compared to normal games." [Affect - Positive]
P4: "It was a new experience to me, interesting and immersive to not have to look at the target in this spy game as compared to normal spy games you are free to look at your targets." [Immersion - Positive] [Affect - Positive]
P5: "It was exciting, the first time I have tried eye tracking." [Affect - Positive]
P6: "I wanted to look around with my eyes to see what buttons I should press but couldn't, so I think I miss-pressed the keyboard keys." [Immersion - Negative]

Was the gaze interaction working satisfactory (what was good/bad)?

P1: "I was getting distracted. I wanted to look at the target group to walk towards them but couldn't." [Flow - Negative]
P2: "I don't play many games, so I don't know. It might be a bit harder than with a mouse." [N/A]
P3: "In the first round I thought I was supposed to go back to the beginning when the prompt instructed me to go to the bench." [Flow - Negative]
P3: "It was a bit awkward when walking around the corner to approach the target group, as I couldn't look where I needed to go without looking at the group." [Tension - Negative]
P4: "The eye tracking was not precise and accurate." [Tension - Negative]
P4: "It was hard for me to turn the screen, I tried to turn it with my head." [Tension - Negative]
P5: "Sometimes the tracking was bad." [Flow - Negative]
P5: "It was hard to figure out the keyboard controls as you don't want to look [at the UI] since the camera will be turning then." [Tension - Negative]
P6: "It was a bit overwhelming, I'm not a gamer and it was a lot to remember and keep in mind, especially the keyboard keys when trying to press them while controlling the aim with the eyes." [Immersion - Negative]

Would you want to play more games that use these gaze interactions?

P1: "Yes it was interesting, I would definitely want to play more similar games." [Affect - Positive]
P2: "Maybe." [Affect - Negative]
P3: "No." [Affect - Negative]
P3: "Sometimes the controls for the keyboard were confusing." [Tension - Negative]
P4: "Yeah I would like to." [Affect - Positive]

P5: “Yes it was fun.” [Affect - Positive]
P6: “Depends on the type of game, probably easier games than this if so.” [Affect - Negative]

Other remarks:

P3: “In the second round I didn’t understand why I was spotted and who the instructions told me to kill.” [Tension - Negative] [Flow - Negative]