MALMÖ UNIVERSITY

Influential observation

How observers can influence activities with gaze, and how this impacts social presence perception.

Max Derlow

max.derlow@gmail.com

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Supervisor: David Cuartielles

Abstract

There is a distinction between participants and observers; the former performs an activity, whereas the latter spectates. The idea of observers who can influence activities is largely unexplored and could contain potential use-cases for eye-trackers and improve social presence in digital settings. This thesis adds to existing research by investigating whether higher degrees of observer influence correspond to increased social presence perception in digital co-located settings. It also provides designers with a tool that helps design and evaluate interactions accounting for observers' influences. The thesis presents five gaze implementations across two games that allow observers to influence them to investigate the hypothesised link between social presence perception and an observer's degree of influence. The results indicate that the link exists, although more tests are necessary to determine whether there is a noticeable difference between observers who impact activities directly and indirectly.

Acknowledgements

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Another thanks goes to Michael Lankes for an incredibly insightful interview that helped shape the scope and direction of this project.

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1 Introduction

There is a clear separation between the participants and the audience in virtually any activity. In the case of sports or video games, one party is playing the game for the other to spectate. However, what happens when the line separating the two is blurred, and spectators become able to influence the games they are watching? Are they still spectators when they throw paper aeroplanes onto the field or do they become something more? How do the paper planes, negligible as they may be, affect the game's outcome or the players' experience? How is the spectator's experience any different, for that matter, now that they are in some way tangibly involved with the game and its players? This thesis will explore how the notion of influential observation can affect the game experience for participants and observers alike through the creation of video games that observers can influence using their gaze. By the end of the thesis, it will be clear whether influential observation has a noticeable impact on each party's perceived levels of social presence in co-located settings.

1.1 Context

The eye reflects our cognitive processes, and subtle cues in gaze behaviour can often reveal what a person is thinking or how they feel (Kleinke, 1986). As a result, the eye carries the largely subconscious quality of expression that has come to be expected in social interactions. However, when viewed through a digital filter, the lack of physical eye contact becomes apparent as the means of expression decreases, contributing to a diminished human connection in digital environments.

Eye-trackers are widely explored as a way to interact with computers, and their qualities have proven the technology able to optimise the human-computer dialogue by broadening the communication’s bandwidth (R. J. K. Jacob, 1995, p. 1). While some research has explored how eye-trackers can relate to social interactions and connectedness (Lankes, 2020; Maurer et al., 2015, 2018), the body of work is comparatively sparse. The notion that observers can influence activities using their gaze is even less explored, presenting a largely unfamiliar area as well as an opportunity for further investigation.

Generally, activities involve one or more participants, and observers may watch them for entertainment. In social science research, a distinction has emerged between *“passive”* and *“active”* observers, with the difference being whether the observer is simply looking at the activity or if they are interacting with other observers while doing so (Miller & Norman, 1975). While the categories can help clarify an observer's level of engagement, neither description expects the observer to be able to influence the activity. Such a classification could help clarify how the observers relate to the activities they are watching in the domain of interaction design and human-computer interaction (HCI).

Contemporary eye-trackers see use among consumers, researchers, and industry professionals alike. Consumers primarily use eye-trackers as accessibility tools in conjunction with software like *"Windows Eye Control"*[1] or as complementary peripherals that enhance game experiences by providing players with an additional layer of input that can lead to an increased sense of immersion (Smith & Graham, 2006, p. 8). In professional fields, eye-trackers are frequently used to collect users' gaze data, providing developers and researchers insight into their users' minds through analysis of their viewing behaviour. The research fields of computer-supported collaborative work (CSCW) and computer-supported collaborative learning (CSCL) have also utilised the technology by investigating how it can optimise the human-to-human dialogue while operating computers (Brennan et al., 2008; Cheng et al., 2022; Chetwood et al., 2012). However, despite the mentioned use-cases and the technology's improving accessibility and maturity, eye-trackers remain niche and expensive for researchers and consumers alike (Funke et al., 2016; R. Jacob & Karn, 2003).

1.2 Aim and contribution

Following Maurer et al.'s finding of the "in-between"(2015), which bridges the gap between the traditional roles of participant and observer, it seems sensible to explore the concept further due to its remaining novelty and untapped potential that could lead to the creation of new use-cases for eye-trackers. This project seeks to verify the original assessment that higher degrees of observer influence corresponds to increased social presence perception. It will also seek to map out the in-between more thoroughly by creating a continuum depicting varying levels of observer influence. Subsequently, the continuum will be tested and evaluated using methods similar to those presented by Maurer et al., namely, by creating a game that allows for individual testing of games with varying degrees of observer influence. Along with the existing distinction between active and passive observation, a proposal will be made to add Maurer et al.'s in-between as another kind of observer called *"influential observer."* The project also seeks to briefly examine the state of eye-trackers in the consumer market to explain the seeming disinterest in the technology. Finally, the project will conclude by relating findings to interaction design by discussing the implications influential observers can have in designing artefacts in the future.

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[1] Feature overview: (*Eye Control Basics in Windows*, n.d.) *https://support.microsoft.com/en-us/windows/eye-control-basics-in-windows-97d68837-b993-8462-1f9d-3c957117b1cf#WindowsVersion=Windows_10*

1.3 Research questions

This project sets out to answer questions on the experiential consequences of allowing influential observers to affect activities. It also seeks to investigate why the adoption rate of eye trackers remains low despite their decade-long presence in the consumer market. The following research questions were devised through the lens of interaction design to showcase the relatively new and promising area of influential observation and provide insight into the challenges of designing eye-tracking applications with today's tools.

- *How is social presence perception affected by different degrees of observer influence?*
- *How can influential observation facilitate novel forms of collaboration?*
- *Can digital eye-tracking prototypes be created using out-of-the-box technologies?*

1.4 Delimitations

Due to the breadth of the chosen area of research, it is essential to narrow the project's scope by introducing several delimitations that affect the number of variables that need consideration.

1.4.1 Only natural eye movements

In eye-tracking research, a distinction has been made between *"natural"* and *"unnatural"* eye movements (R. Jacob & Karn, 2003, p. 591). Natural eye movements represent normal eye behaviour, most often in the form of gazing, meaning that users can interact with eye-tracking applications simply by looking at the screen. Unnatural eye movements, on the other hand, do not reflect normal eye behaviour; rather, they represent conscious actions performed to interact with the eye-tracker, often imitating conventional peripherals, such as mice, by blinking to click or rolling the eyes to pan the screen (R. J. K. Jacob, 1995, p. 16). The prototypes for this project will exclusively consider natural eye movements while developing interactions for the influential observer to emphasise the influential observer's spectating qualities.

1.4.2 Non-accurate tasks to accommodate for eye-tracking's limitations

While accuracy refers to how well the computer's interpretation of a user's gaze point matches reality, precision indicates how frequently similar inputs yield similar results (see Figure 1). Contemporary near-infrared eye-trackers, often deemed the most accurate category of eye-trackers, have an accuracy limit corresponding to 0.5° degrees of the eye's field of view (Majaranta & Bulling, 2014, p. 42). The size of the fovea and the eye's movements are primary components of video-based eye trackers that are inextricably associated with the estimated viewing angle and its radius. Although a person's fixation regularly attains focus at greater levels of accuracy, any movements that do not lead to a saccadic jump[2] are imperceivable using today's eye trackers (R. J. K. Jacob, 1995, p. 11). Because the project's primary concern is the interaction between participants and influential observers, it is best to avoid the unnecessary complexities that can arise from demanding greater than possible levels of accuracy.

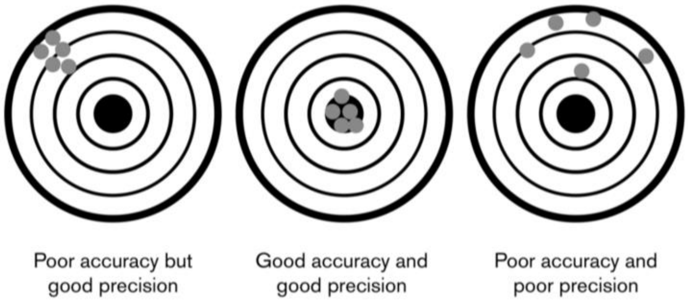

Figure 1 Illustration of precision and accuracy (Lech et al., 2019). CC BY 4.0

1.4.3 Screen-based near-infrared eye-trackers

There are several eye-tracking techniques, and there are various housings for each method that respond to the design challenges presented by different settings and use cases. Among the video-based eye-tracking techniques, near-infrared eye-trackers are some of the most accurate (Majaranta & Bulling, 2014, p. 42) and accessible. Because of the project's emphasis on play and digital prototyping, screen-based eye trackers are especially suitable since they can be attached to stationary and portable screens, enabling development and interactivity with digital prototypes in the same environments. Furthermore, the limited variety of eye trackers available to consumers, as evident by Tobii's dominance in the market (Ramirez Gomez & Lankes, 2021, p. 6), drastically narrows the number of options from which to choose. Although affordable options virtually exclude all alternatives besides near-infrared screen-based eye-trackers and webcams from being used in the project, it is coincidentally fortunate that they are the most desirable ones due to the mentioned benefits.

1.4.4 The setting of digital play

The context of the play is practical for this project because of its ability to emphasise moment-to-moment interactivity between humans and computers - and the two collaborators - in digital environments. Unlike the comparatively rigid nature of CSCW contexts, it is also malleable since the activities do not have to be rooted or related to real-life applications. Such characteristics grant developers the freedom to design the interactions first without relating them to problems that need solving (Maeng et al., 2012), thus emphasising the explorative aspect of the project.

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[2] Eye movement that describes the move from one point of fixation to another.

1.4.5 *Co-located setting*

In keeping with Maurer et al.'s methodology (2015), this project will focus on testing games in co-located settings where it is possible to monitor environmental factors. Consequently, efforts to verify the link between influential observers' degrees of influence and the perceptions of co-presence may differ in remote settings. It also means that the results become more immediately comparable to real-life activities, such as watching someone play a video game or working on a computer. Finally, a co-located setting allows for the use of games that do not require online functionality, which substantially impacts the time and complexity involved with developing prototypes.

1.5 Ethical consideration

This project requires several testers to evaluate the prototypes, and their personal information must be kept confidential or redacted from any published results. However, there are few ethical concerns because there are no external interests involved in the project. Neither does the project intrude on peoples' privacy as it does not try to solve real-world problems that require personal introspection. Although, as with most forms of computer vision, privacy concerns are inherently coupled with the technology. Seeing as this work aims to create new use-cases for eye-trackers, it is necessary to consider the ethical implications of perpetually having a camera observe its users when discussing the results.

1.6 Structure of thesis

The structure of this thesis comprises five sections besides this one.

Section 2: Theory
Provides an overview of the eye-tracking domain, including relevant physiology, technologies, eye-tracking concepts, and interaction techniques.

Section 3: Methods
Presents the methods used for the design work and outlines the design process.

Section 4: Design work
Chronicles the development, testing, and evaluation of the project's prototypes. Divided into five parts - early explorations, insights from an expert interview, mapping degrees of an observer's influence, prototype 1, and prototype 2 - each of which will demonstrate insights that helped shape the direction and outcome of this project.

Section 5: Discussion
Reflects on the design work's findings and relates them to interaction design. Emphasis is placed on the final prototype since it is particularly closely linked to research questions concerning social presence.

Section 6: Conclusion
Summary of the project at large with the research questions being answered directly using the results yielded from the design work.

2 Theory

When looking at the eye as an input modality, it becomes necessary to consider its natural characteristics and behaviours when designing eye-tracking applications or devices. In this section, theories about the eye's physiology and the technology allowing eye-tracking will demonstrate fundamental knowledge designers need to be aware of when creating interaction techniques utilising a user's gaze. The section will help motivate the project's delimitations and provide critical insight into the design challenges involved with eye-tracking interactivity. It will also give a brief overview of the state of consumer eye-tracking and previous work that helped inspire this project.

2.1 Physiology of the eye

Unsurprisingly, the eye is a complex body part. Nevertheless, some familiarity with the intricacies of its anatomy and movements is necessary to set reasonable expectations of the affordances and limitations of eye-tracking technology. In this section, the qualities of the technology will be related to the physiological properties of the eye to understand how eye-trackers can provide precise gaze estimations. It will also discuss movements of the eyes will also to provide insight into what actions users experience as *"natural"* and *"unnatural"* (R. Jacob & Karn, 2003, p. 591), as well as the possible interaction techniques they enable.

2.1.1 Anatomy: features that make eye input possible

There are receptors in our eyes, called rods and cones, that help us visually perceive the world around us. Their sensitive response to light signals everything from colours to intensities, allowing us to see the world as a series of moving pictures that we can then interpret. However, these receptors are distributed unevenly across the retina's surface (see Figure 2) (Kolb, 1995, p. 2), with its centre, the *"fovea,"* being an area where they are particularly densely packed (Kolb, 1995, p. 3).

The fovea's size corresponds to approximately 0.5° of the eye's field of view(Majaranta & Bulling, 2014, p. 42), often referred to as our *"point of gaze"* (POG) (Majaranta & Bulling, 2014, p. 40) and it is here that visual focus is the strongest. However, the eye can make imperceivably small movements that further hone the person's focus within the fovea's 0.5° field, giving contemporary eye-trackers an inherently inaccurate characteristic as they cannot truly determine where the user is looking (Yarbus, 1967, p. 202). The visual clarity fades gradually the further away from the fovea that the light lands (Yarbus, 1967, p. 9), which introduces the retina's neighbouring fields, namely, the *"parafovea"* and *"perifovea"*, which describe areas of peripheral vision. However, for eye-trackers whose purpose is to estimate the user's POG, it is enough to understand the concept of the fovea and how to determine its field of view and viewing angle.

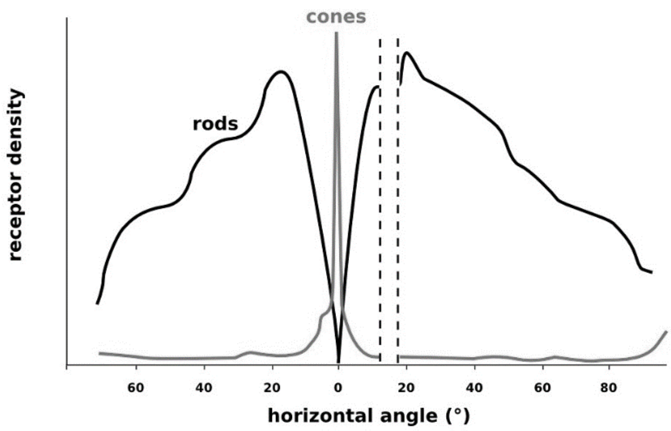

Figure 2 Rod, cone density in the human retina (Ahlmann, 2011). CC BY 2.0

A transparent, cone-shaped layer covers a large portion of the eye's surface in the front-most part, protecting vital components such as the iris and pupil, namely the *"cornea"* (Yarbus, 1967, p. 5). Furthermore, the cornea acts as a lens due to its convex curvature (Yarbus, 1967, p. 20), which helps refract light toward the retina. Because of the shape and fixed nature of the cornea, any light will leave a noticeable *"glint"* (see Figure 3) (Majaranta & Bulling, 2014, p. 44), whose location is a function of the eye's current viewing angle. For eye-tracking purposes, the glint can be used with traditional video-oculography methods to accurately estimate the user's gaze point (Majaranta & Bulling, 2014, p. 44).

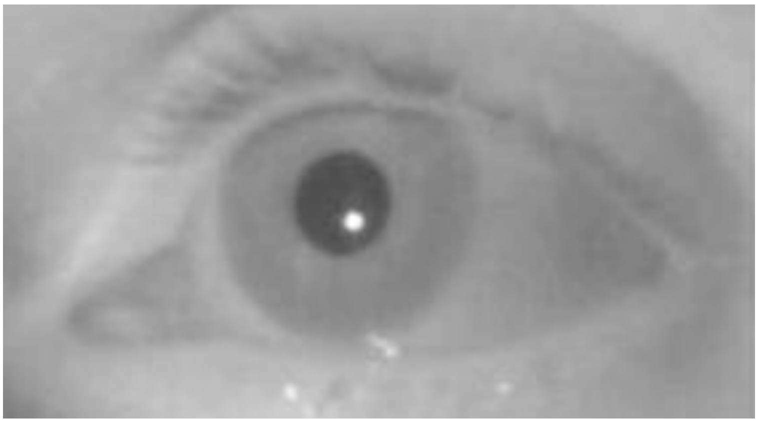

Figure 3 image of the glint (D'Alessio, 2012). CC BY 2.0

Later, there will be an overview covering the eyes' movements and how tracking them can enable various means of user input. However, for now, the thesis will explain how the main eye-tracking methods take advantage of the eye's inherent characteristics to estimate their POG.

2.2 Eye-tracking methods

Over the decades, researchers have developed several ways of tracking the user's gaze. Various eye-tracking methods will be presented in this section to provide a general overview of potential options. Although other factors such as availability, cost, and ease of use will be considered, the emphasis will be on how each method uses the eyes' characteristics to estimate a user's POG.

2.2.1 Video-oculography (VOG)

Video-based eye-tracking involves streaming footage of the user's eyes into the computer and estimating their gaze point by processing the data (Hansen & Pece, 2005, p. 157). After asking a user to create a small number of reference points in the guise of calibrating their eye-tracking devices, algorithms can determine the user's point of gaze by estimating the orientation of their eyes through analysis of the provided footage (Hansen & Pece, 2005, p. 156). Such a surface-level description is essentially all that is necessary to understand how eye-trackers operate on an elementary level. However, some parameters tie directly into the quality of the devices' gaze estimations that should be familiar even to non-engineers.

An eye-tracker's camera is the cornerstone that determines whether the algorithms have the necessary information to accurately estimate the user's gaze. It is the camera's primary objective to send detail-rich information to the computer as frequently as possible in the form of zoomed-in images of the user's eyes, meaning that the camera's refresh rate and resolution are particularly influential in yielding desirable results (Majaranta & Bulling, 2014, p. 42). Although the resolution of the images and the frequency of their capturing are important, external factors can affect how they may appear as well. Elements such as the distance between the user and the screen can reduce the number of pixels depicting the user's eyes. Light of the environment can emphasise glare on the user's glasses or make their eyes troublesome to find due to its absence. Even the camera's lens serves an important role, as it can distort the image in ways that emphasise focus and screen-presence of the user's eyes, providing even richer input (Majaranta & Bulling, 2014, p. 48). Finally, from an experiential point of view, the most noticeable drawback of traditional video-based eye-trackers is how sensitive they are to head movement, thus necessitating that the user remains still while using the devices.

2.2.2 Infrared pupil-corneal reflection (IR PCR)

Video-based eye-tracking describes a foundational basis from which tangentially related methods can emerge. One such method that is particularly common entails augmenting video-based devices with infrared light, resulting in a *“corneal reflection”* or glint appearing on the user's eye visible to the camera (Majaranta & Bulling, 2014, p. 44). The glint serves as a reference point for gaze-estimating algorithms and provides a low-cost but high-impact addition to video-based eye trackers, as it improves both the accuracy and reliability of the devices. Its implementation also helps alleviate the restrictive quality of traditional video-based eye trackers, as the device is less affected by head movement (Majaranta & Bulling, 2014, p. 44). Despite the augmentation's overall benefits, it does not work well in environments with ambient light, such as outdoor settings (Holmqvist & Andersson, 2017, p. 175). Although anecdotal, some researchers report that proven eye-trackers do not work for some people, even in laboratory settings (Majaranta & Bulling, 2014, p. 43).

2.2.3 Webcams

Unlike the previously mentioned methods, webcameras were not designed for eye-tracking. While the software is an essential aspect of all eye-trackers, it is especially important in webcamera-based solutions since they lack the benefits provided by better hardware (Papoutsaki et al., 2016, p. 3839). Despite the drawback, webcameras are a promising alternative since they lower the barrier to entry for eye-trackers due to their ubiquitous availability, offering users and developers alike a comparatively convenient entry-point.

In terms of performance, multiple tests comparing webcamera-based eye-trackers with their near-infrared counterparts show a noticeable gap between the two methods' accuracy, consistency, and sensitivity (Burton et al., 2014; Papoutsaki et al., 2016). Even Papoutsaki et al., the creators of *“WebGazer,”* one of the more renowned webcam trackers, remark that their AI-powered solution is best used *"where the approximate location of the gaze is sufficient"* (2016, p. 3844). Although today’s webcam-based eye-trackers are less suitable for interacting with computers than the other methods, the rapid pace of A.I. development in conjunction with the open-source development of many webcam-based solutions suggests that the quality of the eye-tracking can improve over time.

2.2.4 Electrooculography

Majaranta and Bulling eloquently describe the eye’s electric property: "*The human eye can be modelled as a dipole with a positive pole at the cornea and a negative pole at the retina”* (2014, p. 45). In essence, the eye harbours an electrical field whose potency is a function of its rotation. This field can be monitored by placing electrodes on the periorbital sections[3]. When combined with a reference point[4], one can determine a user's gaze point in virtually all conditions (Majaranta & Bulling, 2014, p. 44).

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[3] The periorbital region represents the §§§§area surrounding the eye’s orbit.
[4] An electrode placed on an area with comparatively little electrical activity, typically the forehead.

One of the most noticeable benefits of the electrooculographic method is that external factors, such as the environment's lighting conditions or the distance between the user and the subject of interest, can vary without affecting the quality of the eye-tracking. The size of the processed data is also comparatively small to that of video oculographic eye-tracking, making the method compatible with less powerful hardware typically found in smaller or embedded devices (Manabe & Fukumoto, 2006). However, the necessity of electrodes is an unavoidable drawback that makes the method more obtrusive than its alternatives. Furthermore, although the accuracy of the gaze tracking is sometimes more precise than that of IR-PCR trackers (Haslwanter & Clarke, 2010), it is comparatively obtrusive and rarely chosen as the method of choice for screen-based applications (Morimoto & Mimica, 2005). Although, its unique quality of being functional in most conditions makes it particularly apt for tracking the user's eyes when other methods would be unable to, such as in the dark or when they are asleep (Penzel et al., 2005).

2.3 Housings: the devices' physical forms

The eye-tracking method is not the only variable to consider when choosing an appropriate eye-tracking device. The physical structure of the eye tracker can have a significant effect on the user experience, with some solutions being more or less obtrusive and others being more appropriate for tracking the user's gaze in specific environments. This section will briefly overview three housings for eye-tracking devices and showcase their differentiating properties.

2.3.1 Screen-based

Screen-based eye-trackers are stationary devices commonly mounted on or in front of a monitor. One notable benefit of the screen-based solution is how users can interact using gaze while remaining hands-free and untethered, making it the least obtrusive solution mentioned in this thesis. However, the user's positioning becomes especially important since distance, angle, and posture are factors they must consider to ensure their eyes remain within the camera's field of vision. Consequently, setting such constraints prohibits the user's free movement and may make the user experience comparatively conscious; regardless, such limitations may also compromise the designer's ability to create concepts involving physical activities.

2.3.2 Glasses

Eye-trackers can also take the form of glasses, both for VOG and EOG methods. Their wearable aspect makes it possible to track a user's view in virtually any environment, which devices may record with a front-facing camera. However, for VOG eye-trackers, powering the devices may be an issue that necessitates either using batteries or tethering the user to a power supply. Although, EOG eye-trackers suffer less from this issue due to their comparatively slim power demands.

2.3.3 Virtual Reality V.R.

While monitors provide a window into a digital realm, virtual reality headsets immerse them in one. The most significant appeal of integrating eye-trackers into V.R. headsets is that it enables designers to observe the user gaze behaviour within the digital environment while simultaneously providing the tool to create gaze-interactive applications that would otherwise not be possible. One practical aspect of integrating eye-trackers into virtual-reality headsets is that the device is strapped onto the user’s head, providing stability and an environment of comparatively little variability.

Once the designer has chosen an appropriate eye-tracking method and housing, they can proceed to investigate varying eye-tracking techniques that have emerged from previous interaction design and HCI efforts

2.4 Eye movements as interaction techniques

As previously mentioned, how the eyes move and behave is mainly subconscious and involuntary to the individual. However, if we want to use a person's gaze as input, we must be able to foresee how their eyes will behave. Furthermore, knowing about the eyes' motions allows for a more methodical approach to design work because they can be accounted for deliberately in the designs and concepts. This section will present common eye movements and behaviours with a particular emphasis on natural ones.

2.4.1 *Saccades*

Saccadic eye movements describe a ballistic jump from one fixation point to another (see figure 4) (R. J. K. Jacob, 1995, p. 4). Young and Sheena explain that the eye's velocity throughout a saccadic motion resembles a bell curve, distinguished by its high acceleration and deceleration (1975, p. 397). The range of a saccade is between 1-40 degrees, and head motion is commonly involved when it exceeds 30 (Young & Sheena, 1975). The saccade also holds temporal characteristics, such as a delay between subsequent saccades (minimum 100-200ms), latency between receiving stimuli and jumping to a new location (100-300ms), and travel time between two points (30-120ms, depending on the magnitude of the motion) (Young & Sheena, 1975).

2.4.2 Fixations

Fixations typically follow saccades and represent a brief period (100-600ms) of high visual acuity (R. J. K. Jacob, 1995, p. 5). While fixations initially limit a person’s field of view, they gradually widen to take in their surrounding scenery. When desiring prolonged fixations, imperceivably small and steadying shifts of the eye help prevent degradation of the visual acuity, namely microsaccades (see figure 4) (Young & Sheena, 1975, p. 398). Unlike regular saccades, the movement of microsaccades is a subconscious consequence of trying to retain focus, meaning that eye-trackers generally perceive them as unwanted jitter that needs to be filtered out by the software. Consequently, despite helping extend the periods of fixations, microsaccades are incompatible as an interaction technique.

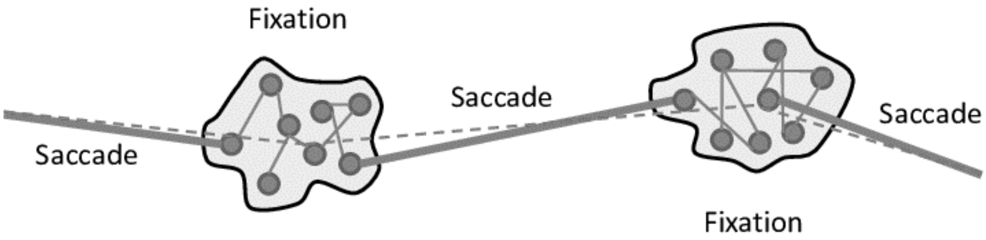

Figure 4 Depiction of saccades, fixations, and micro-saccades[5]*. (Krueger et al., 2016) Copyright © 2016, IEEE*

2.4.3 *Smooth Pursuit*

By trying to move our gaze smoothly, we instead perform a series of small saccades that cover the span of the desired trajectory, a phenomenon sometimes referred to as *"gliding"* (Klein & Ettinger, 2019, p. 983). Smooth eye movement is only achievable when we pursue moving targets with our gaze, which can easily be tested simply by looking at a finger in motion. Although the behaviour is involuntary, it has potential in interaction design applications since the smooth motion allows for calibration-free eye-tracking (Klein & Ettinger, 2019, p. 987), which is especially useful in public installations.

2.5 Eye-tracking concepts

Numerous eye-tracking related concepts have emerged over the decades of eye-tracking research. This section will highlight the ones pertinent to this project, which mainly include the degrees of overtness, as described by Majaranta and Bulling, and various concessions of the technology that designers need to consider when creating and evaluating eye-tracking applications.

2.5.1 Degrees of overtness

In their discussion on applications of gaze interactions, Majaranta and Bulling mention how eye-tracking differs from other digital input peripherals due to the potential to vary the degrees of overtness (2014, p. 51). The proposed overtness continuum draws inspiration from a concept created by Fairclough that demonstrates varying levels of intentionality in physiological computing systems (2011, pp. 7–8). In their examples, higher levels of overtness represent conventional input devices with high levels of intentionality, such as mice and keyboards. In contrast, passive devices

[5] Smaller movements inside of the fixations.

represent more covert examples with lower levels of intentionality, such as monitors for heart rate and blood pressure (Fairclough, 2011). For the eye-tracking context, Majaranta and Bulling propose four categories of overtness, ranging from applications that require direct gaze input from the user to those that only monitor the user's gaze passively (see figure 5) (2014).

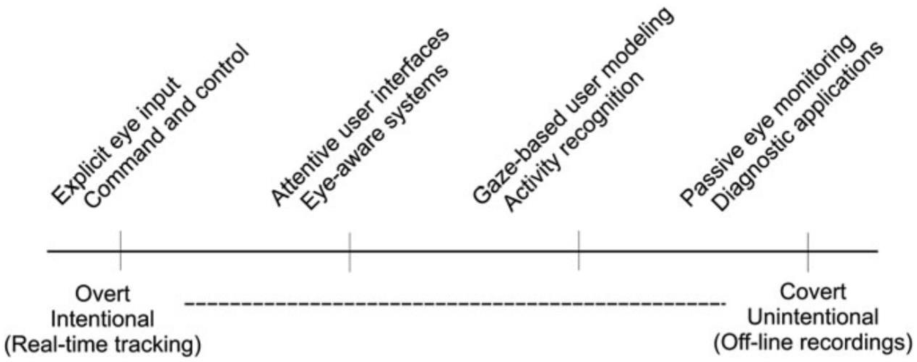

Figure 5 The four categories of overtness presented by Majaranta & Bulling (2014). Copyright © 2014, Springer-Verlag London

Majaranta and Bulling suggest four levels of overtness for eye-tracking applications (2014, p. 51). The most overt of the four categories they present is *"explicit eye input",* which necessitates that the user deliberately interacts with the eye-tracker to input commands, such as actuating gaze-interactive components by either dwelling on them or blinking (2014). Then there are *"Attentive user interfaces,"* which describe gaze-aware systems that passively observe the user's gaze, responding appropriately to the user's actions without necessitating the presence of a conventional command-based user interface. Applications of such displays can be seen in research projects such as Starker and Bolt's *"gaze-responsive self-disclosing display"*, where the application provides users contextual information about the items they are fixating on (1990). The two mentioned categories are especially well-explored within interaction design and HCI domains due to their ability to establish a dialogue between the computer and the user. On the other hand, the two remaining categories are comparatively passive, and as such, it is less apparent how designers might use them to create conscious interactions.

"Gaze-based user modelling" explains how eye-trackers can monitor the behaviour of users and adapt an application's processes accordingly (Majaranta & Bulling, 2014). Unlike attentive user interfaces whose chief concern is the user's gaze, user modelling systems examine the thoughts and cognition of their users through pattern recognition, perhaps responding to visual behaviours associated with reading or distraction by adapting the user's environment accordingly. Finally, they present *"passive eye monitoring,"* which refers to the statistical collection of gaze data for diagnostic purposes with no immediate impact on the user experience. This concept has been used frequently for user research, where heatmaps are especially common (2014).

2.5.2 Calibration and drifting

External factors such as lighting conditions and the distance between the user and an eye-tracker's camera may influence the appearance of the eyes, which can affect the accuracy of the device's gaze estimation. While some eye-trackers do not need calibrating (Kohlbecher et al., 2008), most require it to provide a reliable user experience. The need to calibrate eye-trackers is central to the devices' usability and several well-known eye-tracking applications, such as Windows Eye Control, provide calibration tools for convenience. However, demanding users to calibrate eye-trackers creates a barrier to the human-computer dialogue that may be inconvenient for some applications, such as public installations or smartwatches, due to the disproportional amount of time spent configuring the device rather than interacting with it. Furthermore, gradual changes to the eyes' appearance from the camera's perspective cause the gaze estimation's accuracy to decrease over time, necessitating regular recalibration of the devices.

2.5.3 Inflated excitement

According to several researchers, the novelty of eye-tracking interactions may overshadow the research's subject of interest since testers tend to reflect on the technology rather than the prototype utilising it (Isokoski et al., 2009, p. 14). The testers' feedback may be misdirected, but it can also show inflated excitement, portraying the prototypes as disproportionally enjoyable. Consequently, when interviewing test participants, it is critical to pay attention to how questions are framed and remember that enthusiasm is closely linked to the novelty of the technology (Vertegaal, 2002).

2.5.4 Midas Touch

Early eye-tracking research discovered that using the same modality to interact and perceive is problematic since the eye-tracker might interpret the user's casual viewing as an attempt to input with the computer. R. J. K. Jacob coined the term “*Midas touch”* (1995, p. 15) to describe the problem, relating it to the story of King Midas, whose touch turned its subjects into gold. While some researchers have attempted to take advantage of Midas touch by treating it as a desirable design attribute (Elmadjian & Morimoto, 2021), the body of research proposing solutions that diminish the effects or attempt to solve it is comparatively large.

The implementation of *“dwell,”* I.E., only treating gaze as input after registering a prolonged fixation, was one of the first devised solutions to mitigate Midas touch (R. J. K. Jacob, 1991, p. 162). Its effectiveness has been proven over the years as it remains the go-to solution whose implementation is seen in most eye-based user interfaces. Other solutions have emerged over the years as well, such as a *“clutch”* that toggles gaze interactivity on and off (Istance et al., 2008) and gaze gestures that register a sequence of dwells to actuate a single nuanced input (Istance et al., n.d.) Whether treated as a problem or a property, it is necessary to take Midas touch into account when designing eye-tracking enabled applications.

2.6 The state of consumer eye-tracking

As far as consumer eye-trackers are concerned, few options exist whose prices are comparable to high-end versions of peripherals such as mice and keyboards. Tobii[6] is the dominant market leader, even more so in the domain of video games, where they are the only company that provides tools to implement eye-tracking features for widely used engines such as Unity and Unreal. *"The eye tribe"* [7] was another eye-tracking manufacturer that aimed to compete with Tobii by creating eye-trackers that they marketed as *"available for everyone at an affordable price"* (*The Eye Tribe*, n.d.). However, Oculus bought the company in 2016, leaving Tobii without competition in the market space yet again. While Tobii's efforts to create easy-to-use development tools for their devices are commendable, and the price-to-quality ratio stands out from other options, the lack of market contenders has reduced the need for iterative improvements and price adjustments while simultaneously giving them the sole responsibility of developing innovations that hook new users.

The eye-tracking features implemented in contemporary games are similar to those present in the first games released when Tobii initially provided developers with the necessary development tools, showing that little innovation has happened within the space and that the full potential eye-trackers remain untapped. Table 1 shows only a small number of games supporting Tobii's eye-trackers, yet the features presented are nearly exhaustive, further illustrating the lack of innovation.

	Dying Light	Assassins Creed: Valhalla	Watch Dogs: Legion	Microsoft Flight Simulator	Star Citizen	Agents of Mayhem	Rise of the tomb raider	The Division 2	Desperados 3	Hitman
Extended view	■	■		■	■	■	■	■		■
Aim with gaze	■	■	■			■	■	■	■	■
Mark with gaze	■	■					■	■	■	
Clean UI			■			■		■		■
Dynamic light		■				■	■			■
Interact with gaze		■	■					■	■	
Social gaze	■	■	■			■				
Highlight with gaze		■	■			■	■			
Bungee Zoom									■	
Auto pause										■

Table 1 Commercially released games and their implemented gaze features.

For brevity's sake, only two of the more frequently occurring gaze implementations will be summarised, namely *"extended view"* and *"aim with gaze."* The most frequently occurring feature is *"extended view,"* which

[6] https://www.tobii.com/group/about/
[7] https://theeyetribe.com/theeyetribe.com/about/index.html

generally involves players being able to pan the game's camera further in any direction while their avatar retains their original trajectory. "*Aim with gaze*" usually exist as a complement to existing aiming controls that utilise a target reticule, i.e., the play can fire in the direction of their gaze immediately rather than having to adjust their avatar's aim first. Other features mentioned in the table are either comparatively self-explanatory or have little promise as an interaction technique.

2.7 Related works

Researchers have previously examined the aesthetic qualities of gaze interactions and how social presence perception can be linked to gaze-enabled cooperative games. This section will present previous works that have inspired this thesis to situate its project with existing research in the field.

2.7.1 Aesthetics of gaze interactions

Gomez and Lankes describe the aesthetic qualities of gaze interaction and propose the *"Eyesthethics"* framework to assist game designers in conceptualising and evaluating a game's gaze implementation (2021, p. 5). The research builds on the field's state of the art, complementing other gaze-related research such as the EyePlay framework (Velloso & Carter, 2016, p. 171) by taking aesthetic and experiential qualities into account in addition to the more formal elements, such as mechanics and player goals (Ramirez Gomez & Lankes, 2021, p. 4). Additionally, the paper analyses several games developed by researchers and the industry, documenting discovered gaze mechanics before distilling them into the four core components of the proposed framework (Ramirez Gomez & Lankes, 2021, p. 6).

They also discuss how current gaze implementations outside of research fields do not fully exploit the technology's potential to design new and novel forms of gaze interaction. Furthermore, they acknowledge Tobii's market dominance by recognising the scope of their supported games library and the lack of competitors in the field. However, they do not address the barriers to entry that developers must overcome to implement gaze interactions into their games, which will be discussed later in this thesis and the implications of the difficulties.

2.7.2 Gaze in cooperative games and the perception of social presence

Several papers have linked gaze responsiveness in games to an increased sense of social presence, such as Lankes' *"Social gaze in minimalist games"* and Vidal's *"The Royal Corgi"* in singleplayer settings (2020; 2015), and Lankes et al.s' *"Socialeyes"* and Maurer et al.'s exploration of the in-between in multiplayer settings (2018; 2015). Generally, players are paired with eye-tracking devices, and the game world or its characters respond to the player's gaze input, creating the perception of social presence. The described setup assumes that the players have complete control over the game, with gaze input complementing conventional input methods. A setup involving a player with standard input whose game is influenced by observers wearing eye trackers is a less explored option. The described scenario is explored by Maurer et al., in which the player controls Mario in a modified version of a hacked Super Mario game that uses an observer's gaze as input to influence the player's game experience (2015). In doing so, they recognise a gap between the traditional roles of participants and observers, creating an in-between role that alters the player's game experience.

Having recognised the gap, Maurer et al. explore its breadth by altering how much influence the observer's gaze has over the game and quantitatively analysing the players' experiences in the different modes (2015). Conclusively, they assess that a higher degree of observer influence increases the engagement of both parties while simultaneously facilitating the creation of new and novel game designs. The research's learning outcomes are foundational to this thesis, as it presents a relatively unexplored design space with evidence-backed promise. This thesis will build on Maurer et al.'s work by exploring novel player-observer configurations and game mechanics to formalise the in-between while providing exemplars in the form of games that explore its boundaries.

3 Methods

Several methods help structure the project's development. These methods emphasise the design-oriented nature of the project through the acquiring and unpacking of qualitative data while following an interaction-driven design approach which highlights its explorative aim. They also account for the prototypes being eye-tracking enabled games by using Fullerton et al.'s playcentric design approach and Gomez and Lankes' Eyesthetics framework, which provide tools for creating games and gaze-based applications. Although, a quantitative evaluation of the prototypes will also be performed to make the data easier to compare with Maurer et al.'s results (2015).

3.1 Expert interviews

Two professors with extensive experience in eye-tracking were interviewed for this project—Dr Oleg Špakov of Tampere University and Dr Michael Lankes of the University of applied sciences Upper Austria. Špakov provided valuable historical information about the technology's evolution and several references about the technology's back-end and earlier explorations. Lankes, on the other hand, has investigated several use-cases uniquely fit for eye-trackers in the domain of games for several years and helped provide an overview of the field's state-of-the-art. Furthermore, references, obstacles, and opportunities mentioned by Lankes were instrumental in discovering the central research question and scoping the project. Later on, this thesis will show the most critical insights generated from the Lankes interview.

3.2 Eyesthetics framework

The Eyesthethics framework by Gomez and Lankes provides the means to discuss and conceptualise gaze interactions. It comprises four dimensions of gaze interactivity: *"gaze identity"*, *"gaze mapping"*, *"gaze attention type"*, and *"gaze direction"* (see figure 6) (2021). Although the dimensions contain numerous nuances, this section will summarise them briefly.

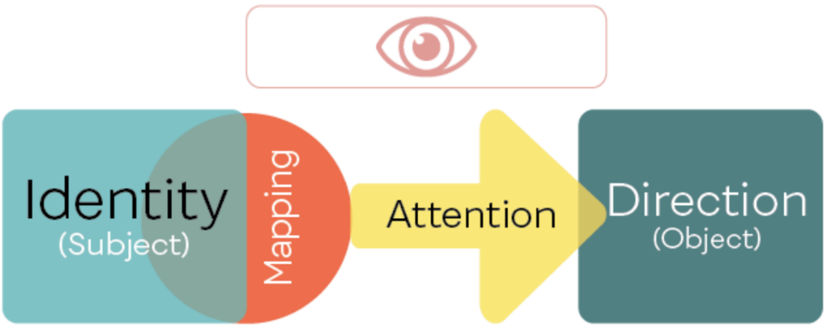

Figure 6 The Eyesthetics framework's four dimensions (Ramirez Gomez & Lankes, 2021, p. 7).

Gaze identity asks whose gaze interacts with the game scene (see figure 7). Gomez and Lankes propose two identities, the *"avatar"* and the *"player"* (2021). The player would embody the avatar's gaze in the former identity, implicitly controlling where the avatar looks. On the other hand, the player identity suggests that the player and the avatar can coexist in the same game space, allowing the player to interact with the game world without using the avatar's gaze.

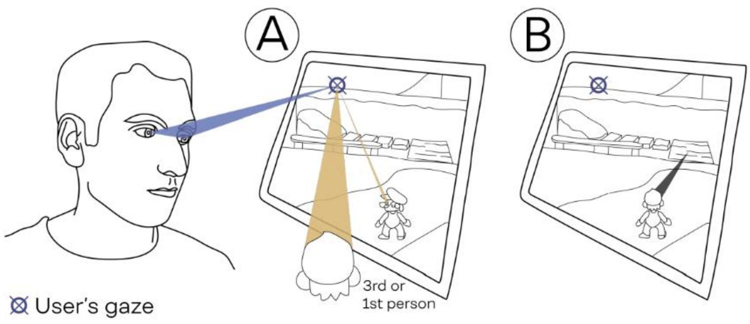

Figure 7 Gaze identity: A) The player's gaze may be integrated into the game world, B) or it may be independent of it (Ramirez Gomez & Lankes, 2021, p. 8).

Gaze mapping describes how the game embeds the player's gaze (see figure 8). For example, the player might control the avatar's gaze *(“gaze type”)*, manipulate or direct objects *(“object type”),* or even move the avatar by using the player's gaze as a controller *(“body type”)* (Ramirez Gomez & Lankes, 2021). The overlap between some combinations of gaze identity and gaze mapping is worth noting, although they do not conflict with the framework's ability to map out gaze interactions for games.

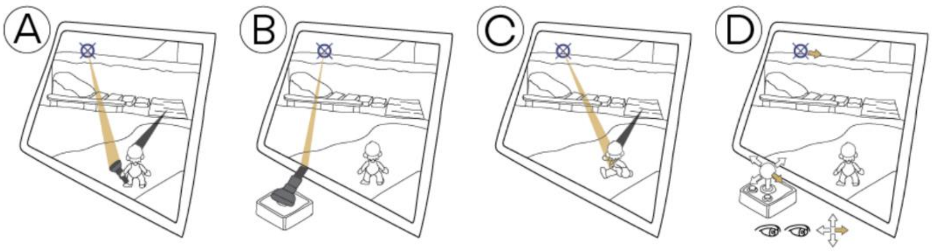

Figure 8 Which game element is the gaze controls. A) Objects of the avatar, B) Objects in the real world, C) The avatar's gaze, D) Using gaze to steer the player avatar (Ramirez Gomez & Lankes, 2021, p. 11)

Gaze attention type refers to how to player looks at the game (see figure 9). A commonly occurring example is the *“direct”* attention type which describes the traditional use of eye-trackers, i.e., dwelling on gaze-interactive components to actuate them. “*Avoidance"* is the opposite. It instead asks players to avoid looking at elements of the game. Although related to gaze, the direct and avoidance types can also be more tangible by asking players to move away from the eye-tracker or present themselves to it. The *“Behavioural”* gaze type represents eye-related behaviours that are more deliberate and cognisant than those associated with ordinary gaze interactions, such as blinking and pupil dilation. Finally, *“joint attention”* describes two or more entities looking at the same game object. These entities can be arranged in several ways, such as both being players or only one being a player while the other is an observer or a non-player character (NPC).

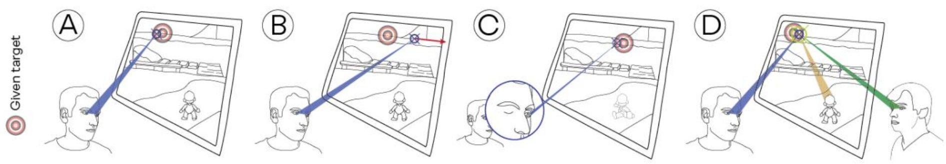

Figure 9 Four attention types describe how the gaze-user interacts with the game's mechanics. A) Interacting with gaze-interactive elements, B) avoiding the aforementioned elements, C) Blinking or winking to actuate commands, D) joint gaze between two or more parties (Ramirez Gomez & Lankes, 2021, p. 12).

The final dimension, *“gaze direction”*, informs what aspects of the game scenes are gaze interactive (see figure 10). An obvious one is the *“game world”*, such as its environment or the objects placed in it. Another candidate is the *“user interface”*, which has been used several times to hide informative graphics that are out of focus. Another direction is characters of the world, such as the player's "*Avatar*", the world's *"NPCs,"* or, in the case of multiplayer games, *"co-players"*.

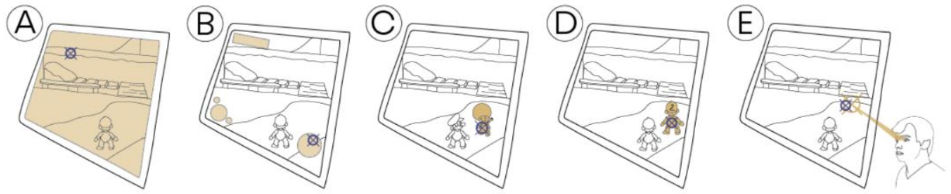

Figure 10 The subject of the user's gaze. A) The game world, B) The game's user interface, C) NPCs, D) The player avatar, E) other parties' gaze marker

3.3 Interaction-driven design

The interaction-driven design approach, as described by Maeng et al., suggests that designers can use desired interactions as a point of departure for their design process, rather than the affordances of technologies or the needs of users (2012). They argue that because the interaction-driven design process is less concerned with the feasibility of the design goals, more creative and innovative solutions may emerge. In addition, they contrast the interaction-driven design process with the technology-driven and user-driven alternatives, concluding that projects can branch off in a comparatively large number of directions, resulting in a less rigid and deterministic outcome (2012). Interactions of interest in this project include how gaze interactions are implemented in the game and how the participants and observers communicate

3.4 Fullerton's playcentric design process

Fullerton et al.'s *"Game Design Workshop"* (2004) covers several game-design and development aspects. Two sections are especially relevant to this project: one explaining iterative game development and another discussing how to prepare and conduct playtesting. Both will be described briefly before being related to the project's design process in its entirety.

3.4.1 Iterative game design

The playcentric iterative design process consists of four repeating stages: ideation, manifestation, playtesting, and evaluation (see figure 11). Because game development's chief concern is the game experience, such an approach is necessary as it is unlikely to perfectly predict how players will interact with and experience the game. For this project, the design process' *"playtesting"* phase is synonymous with *"pre-testing"*, that is, testing performed either by the developer themselves or with their close associates. Pre-testing ensures that the prototype's fidelity draws the playtesters' attention to areas pertinent to the project's research questions, increasing the likelihood that their feedback is relevant (Fullerton et al., 2004). For this project, a prototype is deemed ready for playtesting once it is functional and highlights desired aspects of the game's player-observer cooperation and gaze implementation.

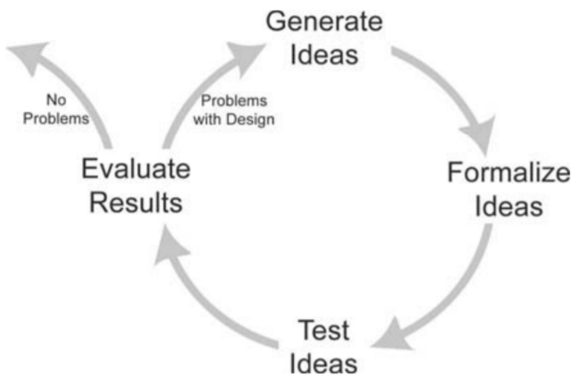

Figure 11 Illustration of the iterative process described by Fullerton et al. (2004).

3.4.2 Playtesting

The procedures for conducting playtests may be simple, yet they have to be followed with care because poor planning or management can easily result in irrelevant or useless feedback. Fullerton et al. recommend including four steps in every playtest session. An introduction, a warm-up discussion, playing the game, and discussing the game experience (2004, p. 253).

The introduction should contextualise the playtest briefly by expressing the nature of the project - simultaneously - it is appropriate to ask the playtesters whether they are willing to have the session recorded. In the warm-up discussion, they suggest profiling playtesters by asking simple questions about their gaming experiences and habits (Fullerton et al., 2004), such as how much time they spend playing or what their favourite games or genres are. The next step is to conduct the actual playtest. Fullerton et al. emphasise the importance of only intervening when necessary and asking the players to think aloud while playing the game (2004). Finally, they suggest having a short discussion after the playtest to assess the players' game experiences.

One thing worth noting is that it will be challenging to ask players to think aloud while playtesting the prototypes due to their need for cooperation, something which might take form vocally. However, for the same reason, the suggested think-aloud method will be implicitly through the players' communication as they will see the need to inform each other to succeed at the game. Although, the game experience of the individual players might not be conveyed through such dialogue and will have to be extracted through the post-playtest discussions.

3.5 The Game Experience Questionnaire

Wanting to recreate Maurer et al.'s work (2015) to test the proposed observer-influence continuum while assessing whether degrees of observer-influence and social presence are inherently linked, it seems sensible to use the same evaluation method. The game experience questionnaire (Brockmyer et al., 2009) is extensive and comprises several modules. However, the only module of interest in this project is the one that evaluates the user's social presence perception. *"Empathy," "Negative feeling,"* and *"Behavioural engagement"* are the three metrics that the 17 questions help produce. They are self-explanatory, as their names describe what they represent, although there are some quirks with the system, such as high degrees of empathy sometimes causing negative feelings to increase (Brockmyer et al., 2009). One should apply caution and not read too deeply into the meaning of the number of these metrics. However, they are still proven effective at depicting social presence perception at large.

3.6 Capturing data

Capturing data for this project is a simple process. Nevertheless, it bears mentioning. During pre-tests, notes are taken along with the sporadic and informal user-testing. Video is recorded during the formal playtests when testers play the game prototypes, and audio is recorded during the post-playtest interviews. Naturally, all testers will be anonymised, and permission for recording will always be asked in advance.

4 Design work

The early explorations of the design process involve making several decisions regarding what technologies to use and what seating arrangements are appropriate for the playtesting. Another aspect of the early explorations is using insights generated from early playtests of existing singleplayer games and an expert interview to define the research question and the project's scope. After that, the proposed observer-influence continuum will be explained before using it to evaluate two cooperative game prototypes that aim to exhibit varying degrees of observer influence.

4.1 Early explorations

Before developing prototypes that can evaluate the link between influential observation and social presence perception, choosing an eye-tracker and a compatible game engine is necessary. On another note, the laptop running these prototypes has a small screen that observers must sit in front of to use the eye-tracker. Thus, it is necessary to find a suitable seating arrangement that allows both users to have an uncompromised user experience. This section will present the process leading up to deciding what technology and co-located configuration to use for the project.

4.1.1 Choosing an eye-tracker and game engine

Because screen-based eye trackers were of interest, two technologies, IR-PCR trackers and webcameras, were compared and evaluated. Because the technologies are compatible with different development environments, testing the eye-trackers' ease of use and reliability requires using different game engines: GDevelop for webcameras and Unity for IR-PCR trackers. This section will compare the testing results of the two eye-tracking methods and explain why using the infrared trackers in combination with Unity was the better option for this project.

When testing the web camera solution, it was necessary to consider its sensitivity to environmental variables and its reliance on high refresh rates and resolutions to achieve adequate results. The camera used to test the method was a Logitech StreamCam[8], chosen because of its ability to record 1080p footage at 60hz. The game, made using the GDevelop[9] engine, employed the WebGazer library to give the camera eye-tracking capabilities. A visualisation of the player's gaze-point was projected onto the game scene to determine the webcam's gaze estimation accuracy (see figure 12). The results were then compared with an IR PCR tracker — the Tobii 4C [10].

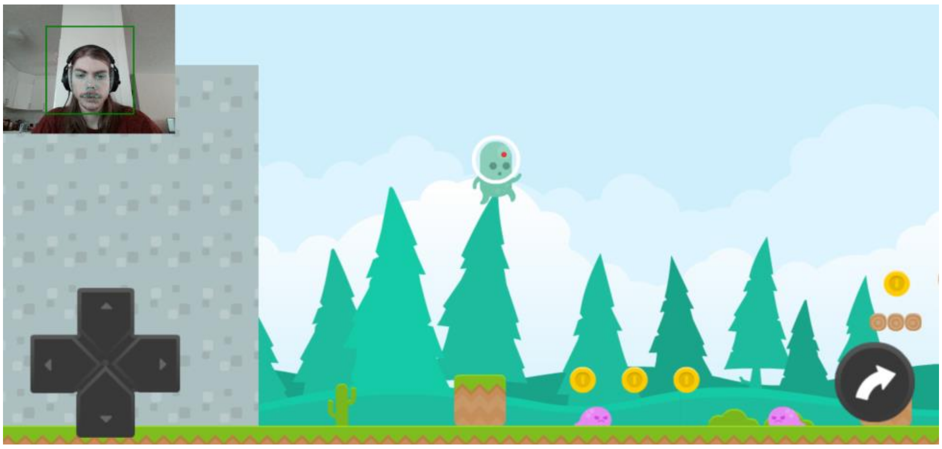

Figure 12 Integrating the WebGazer library into an existing game template developed for GDevelop. The red dot represents POG

The tests evaluating the performance of the Tobii 4C were comparatively simple at first since Windows supports built-in gaze interactivity, which can help in assessing the eye-tracker's accuracy. However, testing the hardware in a game engine is comparatively complex because of the need to get a license from Tobii, allowing the use of their development kit to create gaze interactions in Unity. Although, once the development kit is acquired, it is

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[8] Specs: https://www.logitech.com/en-gb/products/webcams/streamcam.960-001281.html#specs (*Logitech StreamCam - Full HD 1080p Streaming Webcam*, n.d.)

[9] List of features: https://gdevelop.io/features (*Features | GDevelop*, n.d.)

[10] Specs: https://help.tobii.com/hc/en-us/articles/213414285-Specifications-for-the-Tobii-Eye-Tracker-4C (*Specifications for the Tobii Eye Tracker 4C*, n.d.)

simple to perform a similar gaze visualisation test as with the webcam using the included samples.

Despite having ideal conditions and high specifications of the webcam, several performance issues arose related to gaze estimation accuracy and the game's framerate. The gaze estimation was noticeably sensitive, especially compared to the Tobii 4C, repeatedly yielding vastly different results when fed with similar inputs. Users could make the webcam's sensitive characteristics even more erratic through seemingly subtle movements, further demonstrating their need to remain still. Two built-in laptop cameras supporting at least 720p resolution at 30hz were tested to ensure the StreamCam was not faulty[11]. Both performed noticeably worse in terms of accuracy and sensitivity.

The Tobii 4c did not exhibit similar problems once calibrated, and it provided a more reliable user experience even in suboptimal environments. Although an IR PCR tracker being more reliable and accurate than webcams matches the expectations set by previous research, the difference in performance was more noticeable than expected. Consequently, the Tobii 4C was chosen as the eye-tracking peripheral for this project.

4.1.2 Choosing a co-located configuration

In the first prototyping stages, it became apparent that the observer would occupy a disproportional volume of space since they need to be in the centre of the eye-tracker's field of view to use it sufficiently. Thus, the laptop's limited screen space became an issue needing a solution that would provide both the observer and participant with an unobstructed view of the game while retaining the co-presence aspect associated with the co-located setting. Two configurations, one employing an additional monitor and the other streaming video footage between two computers, were tested and compared. The evaluation concludes that local screen-sharing solutions are necessary, as online streaming is currently unfeasible because of decreased performance, which negatively affects the user experience.

A quick solution to the problem that the observer might have to obfuscate the screen to operate the eye-tracker was to employ an additional monitor for the participant to use while playing the games. The participant's monitor is placed closeby to the laptop, ensuring that both testers remain close to each other to maintain the ability to socialise as they ordinarily would. The main problem with this approach is the compromised peripheral view which makes it more difficult to see the other tester simultaneous to the screen. While early testers expressed that the difference between sharing one and using two

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[11] https://support.hp.com/us-en/document/c06191191 (*HP Spectre X360 - 13-Ap0002no Product Specifications | HP® Customer Support*, n.d.) https://mysupport.razer.com/app/answers/detail/a_id/3936/~/at-a-glance%3A-razer-blade-15-base-%282020%29-%7C-rz09-03519 (*At a Glance: Razer Blade 15" Base (2020) | RZ09-03519*, n.d.)

monitors felt noticeable, it also gave them a greater sense of freedom in navigating around the screen since they did not have to share their space.

The initial solution, which was comparatively involved, entailed using two computers, with one streaming video footage while the other sends inputs. Even though such software solutions exist and have become increasingly efficient in recent years, neither of the ones tested could provide a user experience that was similarly responsive to the solution that did not necessitate online connectivity. Thus, the local solution of using an additional monitor seemed more appropriate.

4.2 Insights from technical testing

Before creating the prototypes, it was necessary to ensure that the chosen eye-tracker and seating arrangement worked in practice by testing them on existing games. Several games were tested, including the samples provided in Tobii's development kit for Unity and *"The Channeler."* The playtesters played the games performing each of the two roles, participant and influential observer and provided feedback on their experiences throughout testing and a short post-game discussion. This section will present insights yielded from the playtesting sessions, including how they affected the project and research questions.

"Action game" is the most elaborate sample in Tobii's Unity development kit. It is a small sandbox designed with one player in mind that primarily showcases features that table 1 mentioned. Before swapping roles, the testers were asked to play until they got bored, which averaged between 5 and 10 minutes.

In Action game, observers could pan the camera slightly in any direction with their gaze (see figure 13). Players commented that giving the observer control over the game's camera was undesirable since it compromised their sense of agency while simultaneously giving them motion sickness. While the motion sickness was an unfortunate side effect that permeated Action game's testing, it was interesting to note how strongly players were against delegating features that compromised their independence.

Figure 13 Example of extended view. Gaze may shift the camera in any direction, for example, to the left (left image) or to the right (right image). The Center image is the normal viewing angle.

Players and observers alike remarked that several features in Action game made communication more efficient. Examples include gaze-interactive NPCs and objects reacting to the observer's fixations (see figure 14). Using joint attention and visual cues to make communication more efficient is thoroughly explored in CSCW research. However, it was interesting to hear testers explain that the participant-observer interaction using such tools felt like a natural inclusion in the game; rather than something that compromised the player's experience.

Figure 14 Example of social gaze. The gaze-responsive NPC on the right looks back at the player to meet their gaze.

The final important insight partially inspired the main research question: the observer's influence can have aesthetic or practical ramifications. Whereas the previously mentioned features showcase how an influential observer can cause visual alterations to the game scene, the "shoot at gaze" command, which allows players to fire their weapon at the POG (see figure 15), is an example of a feature with practical use-cases. Thus, there is a distinction between whether the observer has an indirect or a direct impact on the game. While both categories may facilitate collaboration, it may be the case that an observer who impacts the game directly is inherently more influential than one who does not.

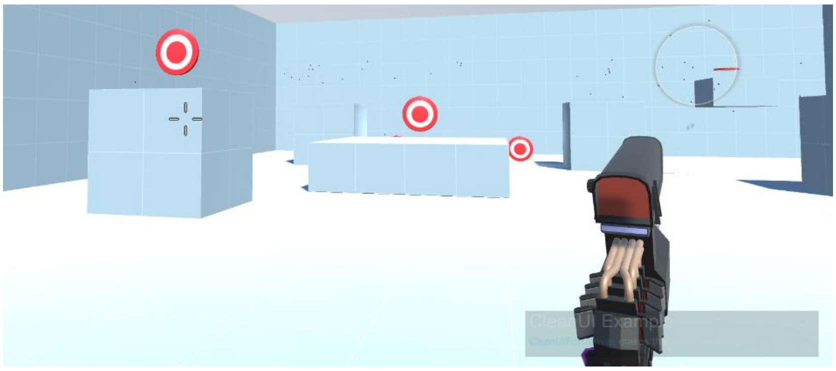

Figure 15 The weapon is aiming toward the gaze point instead of the player's crosshair

In The Channeler, the game asks players to play several mini-games and solve gaze interactivity puzzles. Unlike Action game, a narrative leads players through the game. Consequently, the game regularly instructs players to either walk between points of interest using conventional peripherals or to operate their in-game superpowers with the eye-tracker. Rarely do both activities coincide. Hence, what follows is a turn-taking gameplay loop that asks one party to play while the other waits. Testers remarked that the turn-taking made the game less fun because of the waiting and reduced emphasis on cooperation, highlighting the need for participants and observers to interact with the game simultaneously.

4.3 Insights from an expert interview

Concurrent to the early playtests, Michael Lankes provided valuable insight about designing gaze-interactive games through an hour-long interview. The dialogue helped contextualise several of the discoveries found during the technical testing, and the sources and comments provided throughout were instrumental in defining the project's scope and direction. This section will highlight and connect particularly influential excerpts with the research questions and previously discovered insights.

One of the things mentioned was the distinction between an observer who directly impacts the game experience and one who influences it comparatively passively, which is similar to the Action game findings. A deeper discussion on the subject can be found in the article on the aesthetics of gaze interactions in games (Ramirez Gomez & Lankes, 2021). However, it primarily provides tools to map the gaze's origin, direction, and intention rather than the direct or indirect character of the observer's impact, which the to-be-discussed observer-influence continuum seeks to address.

Another question regards the representation of the observer's gaze. For instance, the gaze can be invisible and interactive or visible and non-interactive. Although, other mediums can also represent it. For example, the game might respond with sensory or auditory cues rather than visual ones or activate physical artefacts in the real world. While interesting, such explorations would further widen the scope of the project. Although mentioning it also helps define the project's direction and delimitations, emphasising a strictly digital focus.

Lankes stressed the importance of the gaze implementation having a purpose in the interview. In this project's previous tests, participants and observers shared inputs in singleplayer games developed with one player in mind. Those experiments remain valuable since they helped demonstrate what to avoid and include while highlighting the player's desire for agency. Nevertheless, Lankes emphasises how the gaze implementation needs to feel valuable to both parties. Even if the observer has a more passive influence, their user experience needs to be accounted for in the game's design, much like the players.

4.4 Mapping the degrees of an observer’s influence

To answer the main research question, how social presence perception is affected by different degrees of observer influence, the observer-influence continuum must first be clarified. Maurer et al. presented three categories of gaze implementations (2015), and in this section, they will be mapped on the proposed continuum, which resembles Majaranta and Bulling's Fairclough-inspired approach (2011; 2014) (see figure 5).

The proposed observer-influence continuum comprises three categories that describe the character of the observer's impact, namely, "No impact," "Indirect impact," and "Direct impact" (see figure 16). More overt observer-influence implementations are placed further along the continuum in the category whose character best describes it. Whereas a covert gaze implementation might have aesthetic implications, one that is overt might also affect the game on a mechanical level. As previously mentioned, observers who impact activities directly are likely more influential than those who do it indirectly, not to mention those who do not impact them at all, hence the order of the three categories. Reflections on whether that is the case will be presented after the playtesting evaluation.

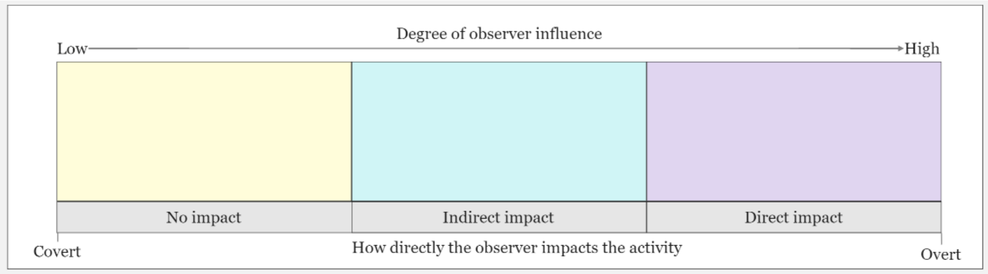

Figure 16 The proposed observer-influence continuum

The three gaze implementations that Maurer et al. used in their project are *"no input," "gaze visualisation,"* and *"flashlight"* (2015). In the no input mode of their game, observers did not have any influence as there was no gaze implementation. In the gaze visualisation mode, the game represents the player's POG in the form of a dot. Finally, in the flashlight mode, observers can illuminate a concealed area of the game scene with their gaze. The three mentioned modes have been placed in the continuum to illustrate how it operates in practice (see figure 17).

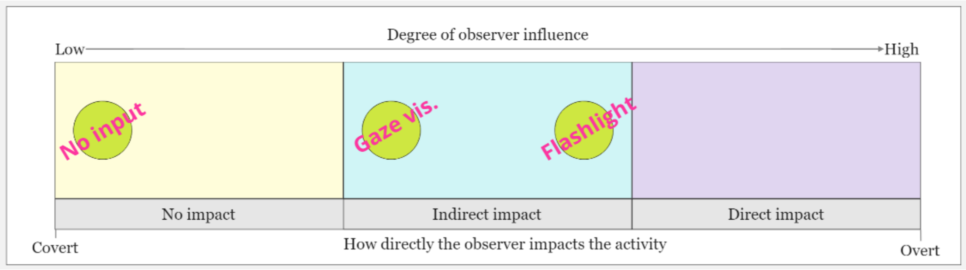

Figure 17 Maurer et al.'s gaze implementations in the observer-influence continuum.

None of Maurer et al.'s gaze implementations allowed observers to impact the game directly, and thus, the direct impact category remains empty. Seeing as the no input mode does not have any gaze implementation and that observers serve no meaningful role in the game, it means that the observer is non-influencing, hence its placement to the far left in the continuum. The two remaining modes - gaze visualisation and flashlight - indirectly impact the game to different extents, the former less so than the latter due to the comparatively small size of the visualisation and the observer's non-essential role in shaping the player's outcome. However, in the flashlight mode, the observer serves a vital role in helping the player succeed. The visualisation of their gaze is also comparatively significant, giving two reasons why the mode is further along the continuum.

The following sections will use the proposed continuum to chart how much influence observers are expected to have over the game. A cooperative game where observers have no impact will be created as the project's first prototype to see whether the social presence perception is any different from a game with no impact and no influence (see figure 18).

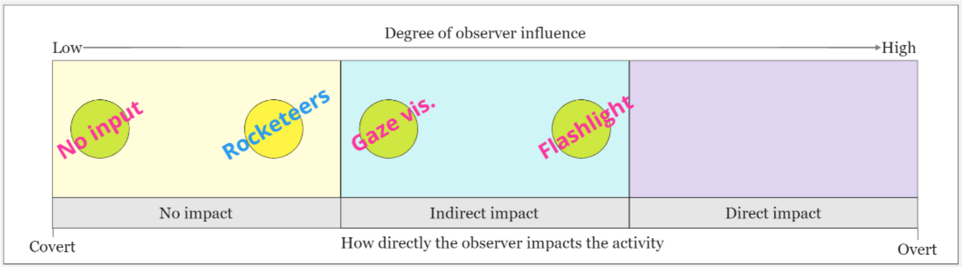

Figure 18 Depiction of the first prototype game to be made. One where observers have no impact but are still noticeably influential.

4.5 Prototype 1: Rocketeers

The first prototype aims to achieve several goals. The first goal is to create a solid foundation from which all of Maurer et al.'s gaze implementations and new ones can be tested while gaining familiarity with the tools and work environment. The second goal is to demonstrate how observers unable to impact the activity can still influence it and thereby increase players' success rates in a game constructed with a cooperative player-observer configuration.

4.5.1 The concept

At the start of the design process, it was essential to generate an idea with the potential to grow to accommodate the research questions' scope. A lengthy brainstorming session, utilising the interaction-driven design process to devise participant-observer dialogues, produced three sketches (see figure 19) with such potential. The strongest of these sketches, inspired by the interactions between driver and co-driver in rally, is a simple cooperative game about navigating a spaceship while collecting points and avoiding obstacles. In this iteration of the game, the participant's view of the game scene will be restricted with the help of an eye-tracker, giving the observer the role of looking at parts of the screen out of the player's view to provide them with valuable information.

Figure 19 Rocketeers (the chosen sketch). El compadre - a 2D platformer where the observer embodies a companion-like entity. Viral agent - a puzzle game where players navigate mazes while avoiding looking at viruses.

Having sketched a rough outline for the game, including the intended participant-observer interactions, the process' next step was to clarify the game's mechanics. The Eyesthetics framework was used when conceptualising gaze mechanics to provide a more detailed view of the implementation in preparation for building the prototype (see figure 20). A green-coloured transparent field, the *"safety zone,"* represents an area where the player is allowed to look freely. If the player's gaze leaves the green zone, it will turn red until their gaze returns, causing their ship to get damaged. Upon receiving too much damage, the ship blows up, but the player can also fly into green barrels to restore a chunk of the ship's integrity. The game's main objective is to collect points while avoiding collisions with any semi-transparent planets or running out of health. The hypothesis is that because the players need to look in the direction they are steering, the influential observer will have to intervene and provide directions, thus becoming an instrumental part of the player's success.

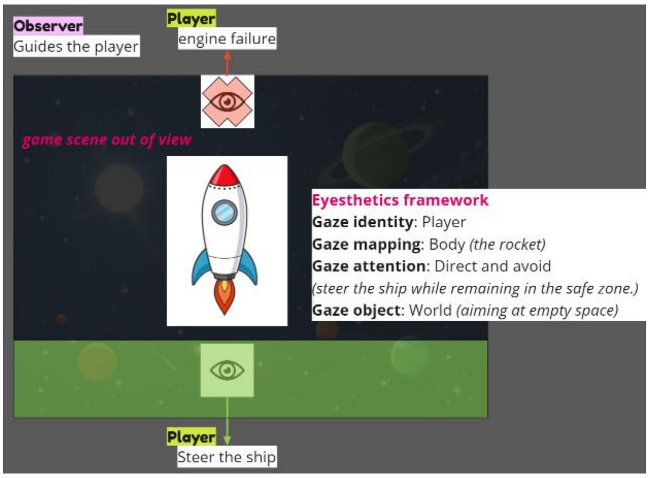

Figure 20 A later iteration of the Rocketeers concept.

4.5.2 Development

In order to develop the game, it was necessary to gain familiarity with Unity and how Tobii's software development kit operates within it. Adding gaze interactivity was relatively simple, and the development kit's features shared several similarities with the engine's most prevalent ones. Therefore, most designers with some experience in programming or Unity are likely able to integrate Tobii's eye trackers into their games. While a significant portion of the game's logic was created from scratch, most visual and audible assets, including sprites, animations and particle effects, and music, were purchased and purposed to fit the desired concept. Although, as is to be expected, concepts rarely work out as imagined in practice, leading to the next section that will highlight some of the adjustments made during the pre-testing phase of the game's development.

4.5.3 Conducting the playtests

The pre-tests were performed sporadically by several testers informed about the project in an informal setting throughout the prototype's development to improve its functionality. The comparatively formal playtesting was conducted across two sessions with two and three testers, respectively, who did not have previous knowledge about the project or any experience using eye-trackers, including fellow university students and relatives. Every tester participated as both parties, the influential observer and the participant, and a short interview followed the playtesting sessions' conclusions. Because this prototype requires the player to use the eye-tracker instead of the observer, the seating arrangement consisted of the player sitting in a chair while the observer was spectating and giving instructions over their shoulder (see figure 21).

Figure 21 Image captured during the first playtest, shown here to demonstrate the seating arrangement. The observer stands behind the participant, giving instructions as the game is being played.

4.5.4 Insights from pre-testing

Before deploying the game to discover insights related to the research question, it was essential to ensure that it was functional enough that potential flaws would not distract from the inquiries of interest. One problem that emerged early in the pre-testing was related to the size of the game's objects and the imprecise nature of the eye-tracker's gaze estimation. The collectable stars and barrels were easy to see when in the player's view, but when players looked at the objects to steer the ship toward them, it regularly stopped just short of picking them up. Consequently, players had to look *"through"* or *"past"* their desired destination to pick up the items, which they reported feeling strange since they expected looking at the object would be good enough. After making minor adjustments to increase the size of the ship and the collectables, players reported the game feeling more intuitive to play, thus mitigating the distracting aspect.

Another distraction that could not be entirely solved, only somewhat reduced, is the ship drifting in either direction for some players. Because it only flies in a straight line when the player is looking at the centre of the screen, the gaze estimation's inaccuracies may cause the game to interpret the player's intent as steering slightly to the left or right instead, causing the drifting. Widening the game's centre-point tolerance helped mitigate the frequency and potency of the ship's drifts, but drifting remains for some players, and it is a complicated issue to solve.

The player's gaze has to remain within the safety zone. However, the restriction can cause eye strain and feelings of claustrophobic unease if the area is too narrow. Although, the game becomes considerably easier to play with even minute adjustments, diminishing the need for the influential observer. Several iterations of the game were created to find the best balance between comfort and difficulty. The outcome suggests that a bigger screen would be necessary for the game's functionality to improve.

The final major aspect that required multiple testing iterations was the game's failure mechanic. Initially, the ship would explode if the player looked outside the safety zone three times. However, the players' gaze would exit the safety zone despite their conscious efforts not to, sometimes causing the ship to explode seemingly spontaneously. The implemented fix involves shifting away from the strike-based solution to one that punishes the player gradually instead, allowing them to look outside the safety zone at the cost of their health draining rapidly until their gaze returns to the safety zone.

4.5.5 Feedback from playtesting

Testers reported that they understood the eye and how it behaves considerably better after playing the game. For example, they regularly found themselves steering the ship into the planet-like obstacles because of how habitual it is to look at things they desire to avoid. Over time, they learned to optimise their gameplay by extensively utilising their peripheral vision to prevent such accidents. They also grew familiar with the nature of saccades, which they reported becoming more conscious of when they could not steer the ship smoothly since their gaze jumped from one point of fixation to another. Although an unintended outcome, the prototype shows that games or interactive gadgets with gaze-tracking features can be powerful tools for learning about the eyes' behaviours in a practical manner rather than a theoretical one.

When asked whether it helped to have an influential observer assist in playing the game, answers varied between the testers. Some claimed the influential observer's guidance was critical, while others said it was just required until they became comfortable with the game, while others stated they were not needed at all. Testers who noted that the influential observer was helpful generally had drifting issues with their ship, mentioning that they often had to correct the ship as it tended to fly in a skewed direction. Players who did not have any drifting issues had a comparatively easy time playing the game, and video footage supports the claim since the player-observer communication is noticeably lower among these testers. Although the drifting was not an intended feature, it became an essential quirk for the game to evoke the intended observer-participant cooperation.

Unsurprisingly, influential observers guiding players with drift issues reported feeling that their role was more satisfactory than observers who supported players without such problems. Overall, the player-observer collaboration played out as expected, with the players unable to see a large portion of the game view, for which the observers had to compensate. The players' success was tightly related to the observer's involvement if they had drifting issues, which was evident when they stopped advising a couple of turns, causing failure rates to rise in frequency. However, the observers commented that they did not feel included in the game even though they were a necessary part of it. For example, they thought that the game did not provide them with the tools needed to communicate expressively, and they resorted to giving directions like *“hard left”* or *“a little right,”* whose meanings can be open for interpretation. Reference marks on the screen were one suggestion that might alleviate the problem. The feeling of exclusion is also tied into the gameplay, as no mechanic affects how the observers participate. Suggestions to mitigate this problem include gradually darkening the screen the further up the player is looking and further randomising the transparency of the planet-obstacles.

4.6 Prototype 2: Rocketeers 2

The goal of Rocketeers 2 is to allow influential observers to affect the game using their gaze and document the players' and observers' cooperative behaviour and feelings of social presence perception using interviews and questionnaires that collect qualitative and quantitative data. More concretely, all categories of observer influence present in the proposed continuum will be tested using the same game as a basis, with the only tweaked parameter being the observer's gaze implementation.

The gaze implementations present in Maurer et al.'s (2015) game will be implemented similarly in Rocketeers 2 to create a more direct comparison. The testers will also answer the same questionnaire used in Maurer et al.'s project (2015) to produce directly comparable quantitative data. The results will give vital context to whether players and observers perceive that the direct impact category increases or decreases either party's social presence perception noticeably compared to the alternatives. Finally, Rocketeers 1 will be tested again and evaluated using the same questionnaire to compare its social presence perception results with a game of Rocketeers 2 where observers cannot influence it.

4.6.1 The concept

Since the ship always kept moving forward in the previous prototype, the player was constantly trying to stay safe with no noticeable periods of reprieve. As a result, the game played itself to some extent and always demanded the player's attention to avoid failure, leaving the observer comparatively unattended. In Rocketeers 2, it was essential to emphasise the cooperative elements of the game. Therefore, the game's movement system was redesigned to give players complete control of the ship's momentum and orientation. The hypothesis is that because the game does not constantly demand the player's attention, a gameplay loop comparable to a player-driven ebb and flow will emerge, causing momentarily hectic moments of gameplay contrasted by occasional calm. Consequently, the player-observer interaction becomes examinable in differently intense scenarios. The players are also given the ability to lower the game's intensity periodically to talk with the observer should they wish to. Finally, enemies were added to the game to provide more dynamic obstacles than the stationary planets, and they occasionally appear when the player reaches undiscovered parts of the game scene.

Rocketeers 2 supports four gaze implementations, three of which are adoptions of those presented by Maurer et al. (2015). A fourth one, *"gaze blaster,"* fits into the direct impact category of the continuum and allows observers to influence the game directly by destroying enemy ships with their gaze (see figure 22). The gaze visualisation mode represents the observer's gaze with an orange circle, and the flashlight mode conceals the game scene in a black layer that observers pierce to give players sight.

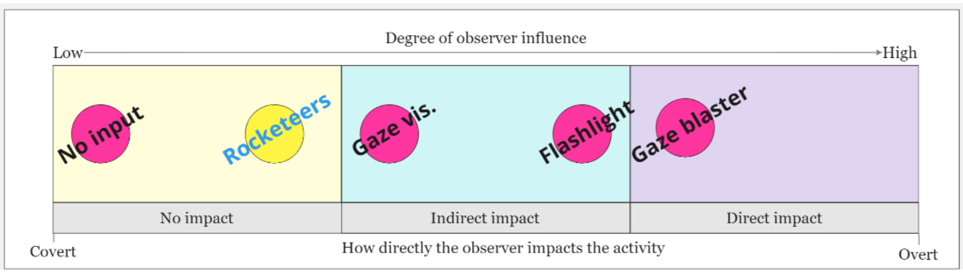

Figure 22 The four modes of Rocketeers 2 (in pink) and Rocketeers 1 (in yellow) placed on the observer-influence continuum.

4.6.2 Development

Because of its predecessor's development, a substantial amount of the new game was already finished. However, significant changes were made to the player's ship controls to allow unfettered mobility and the game's map to create an endless randomly generated playfield (see figure 23). Moreover, technical challenges emerged when creating the new gaze features. Some of the development kit's methods did not work, possibly because of the library's deprecated state, requiring some unintuitive workarounds to facilitate interactivity between the observer's gaze and the game's objects.

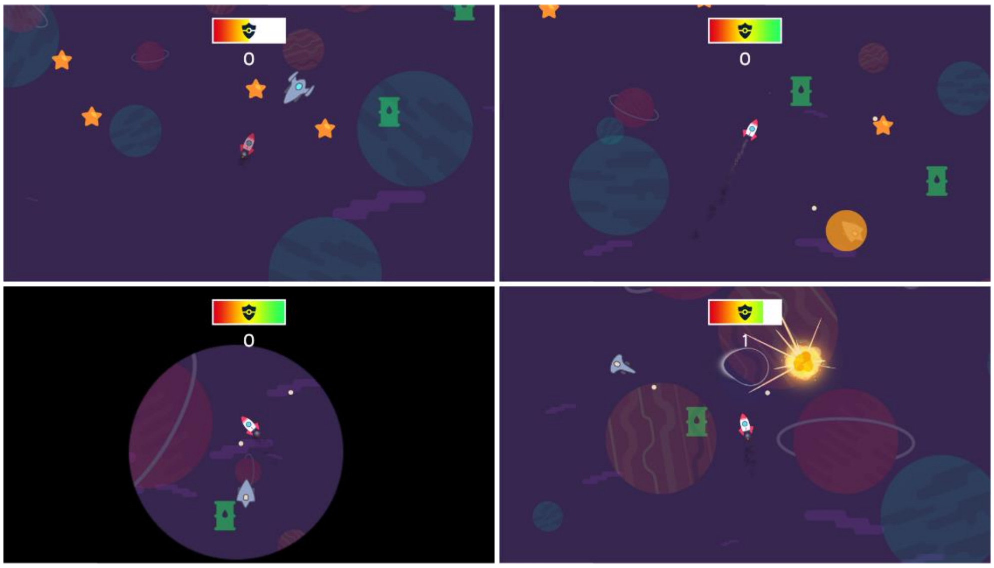

Figure 23 The four modes in ascending order of the observer's influence. From left to right; No input, gaze visualisation, flashlight, gaze blaster.

4.6.3 Insights from pre-testing

The circle size that shows the game scene in Rocketeers 2's flashlight mode was reminiscent of the safety zone in the previous prototype because of its sensitivity to balancing. Minor adjustments in either direction could mean that the player had a trivially easy or unreasonably difficult game experience - assuming the observer was cooperating. Finding a balanced size for the circle required several iterations, but the chosen dimensions seem to evoke the need for both parties to engage thoughtfully to succeed. Another tangentially related insight regards the observer's perception of the black area surrounding the circle. Testers from pre-testing reported that it felt natural to reveal the game scene using their gaze, suggesting both that the responsiveness of the technology was high enough for latency to be imperceivable and that concealing areas outside of the observer's fixation area does not cause noticeable discomfort.

Initially, the gaze blaster implementation entailed observers being able to destroy the enemy and friendly ships indiscriminately. The idea was to create a more thoughtful way of observing the game by not allowing observers to look at the player's ship. However, the rule did not make sense thematically, and those testing the prototype reported the Midas touch problem when they kept destroying the player's ship accidentally. More importantly, both the player and the observer felt that their defeat was unjustified because it was easy to look at the player's ship when in motion. While there were worries that shifting away from a design that could harm the player would make the game trivially easy, players seemed to increase the pace of their gameplay, thus encountering enemies more frequently, which counteracted the potential issue.

4.6.4 Feedback from playtesting

Playtesting for Rocketeers 2 involved five testers across two sessions, all of whom were asked to play each mode of the game as both the participating and observing roles. Testers also filled in the social presence module of the game experience questionnaire every time they finished testing one of the game’s modes. In the interviews, most of the discussions pertained to the game's flashlight and gaze blaster modes, seeing as the remainders were not as interesting according to the testers. On the subject of agency, participants and observers alike felt that the game's social presence was considerably stronger when the observer had more influence over the game. While all testers appreciated the cooperation-centric approach of observers being able to influence or directly impact the game, they also noted that the gaze blaster mode was the most engaging because it achieved the need for cooperation without compromising the player’s sense of agency. Unlike the flashlight mode, where players felt that they depended on the observer to succeed, the gaze blaster mode felt more like an addition that made the game less challenging while remaining possible to play alone.

Testers responded positively to the categories with high degrees of observer-influence, some even remarking that they had more fun partaking as an observer when asked which role they preferred. When asked to elaborate, those preferring to observe explained that they felt a fair power balance between the two roles and that more influence made them feel more involved in the game. They also compared the game's asymmetrical qualities to collaboration-focused games such as *“It Takes Two”* and *“A Way Out”* due to the similarity of providing two players with different tools before asking them to reach a goal in a combined effort. On the other hand, testers who preferred playing the game explained that it was because of the observer's influence that the game was made more fun to play, necessitating communication to improve their success rate.

Although the gaze implementations aimed to facilitate cooperation, observers found that they could also use them to hinder the player. In the gaze visualisation mode, one observer used the dot-representation of their gaze to conceal the player's ship, enemy ships, and minor planets. Moreover, said player remarked that using the gaze feature in such a way was more enjoyable than simply using it as a pointer. In the flashlight mode, players found it frustrating when the observers chose not to cooperate since it became virtually impossible to succeed at the game since the scene remains shrouded. In the fourth mode, gaze blaster, observers occasionally tricked the player into dangerous circumstances by rapidly eliminating appearing enemy ships before abruptly pausing. Overall, it seems as if observers were interested in discovering ways to disrupt the players' progress even though there is no incentive.

4.6.5 Results

Like in Maurer et al.'s project (2015), all testers filled out the social presence module of the game experience questionnaire after testing both roles for each of the modes (see figure 24). However, unlike Maurer et al., the quantitative data will not be developed and investigated further using data-analysis tools such as Friedman's ANOVA (Friedman, 1937) since the only goal is to establish whether it is possible to establish a general trend when comparing the two projects' data.

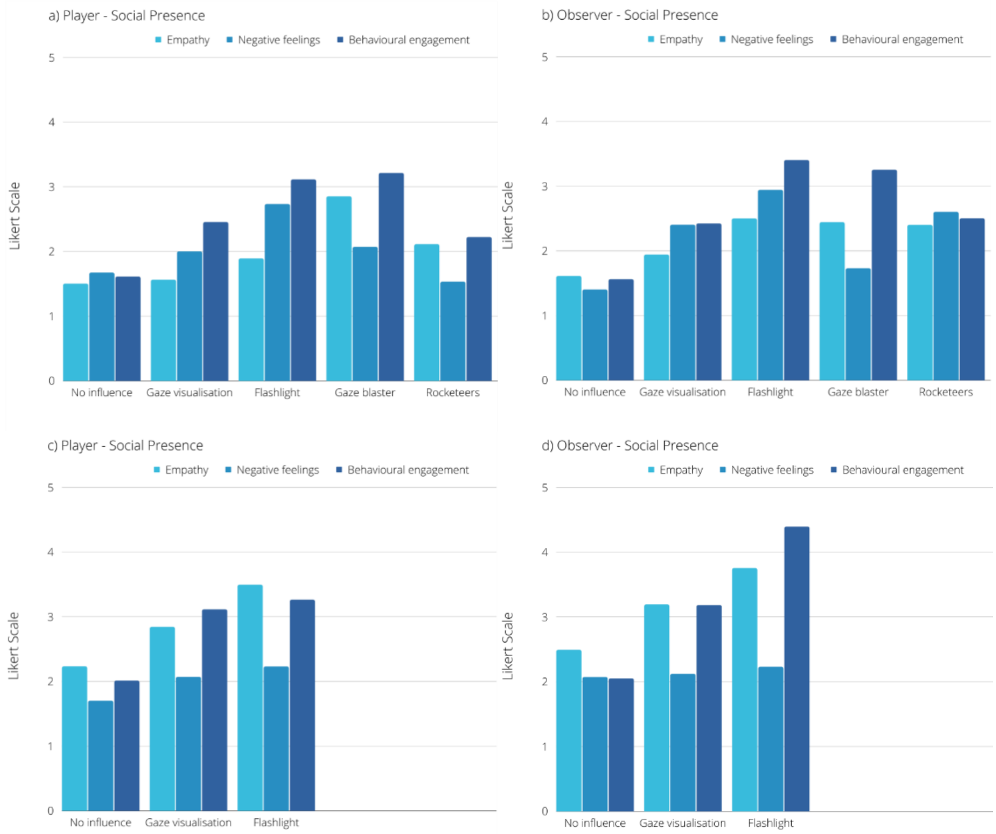

Figure 24 Results from the social presence questionnaires. a & b) Players and observers - Rocketeers 1 & 2. c & d) Players and observers- Maurer et al.'s gaze implementations. (2015)

The two projects share similarities as far as the trends are concerned, i.e., giving more significant influence to the observer yields a higher sense of social presence perception. However, there are several points among the results worthy of discussing, such as the differences regarding negative feelings between the two projects, the experiential differences between the Rocketeers 2's no input mode and Rocketeers 1, and the differences between the flashlight and gaze blaster modes. The following section will elaborate on such points to connect the project's outcomes to the research questions.

5 Discussion

This section will discuss the primary insight generated by the prototypes and relate their outcomes to the research questions. It will compare the quantitative results between this project's prototypes and Maurer et al.'s (2015), and differences and similarities will be grounded using qualitative data gained from interviews and participant observation. The thesis will assess whether notions of social presence perception and an observer's degree of influence are noticeably linked. The following sections include a reflection on the development process for the prototypes and a discussion on the challenges involved in developing eye-tracking applications and the methods used for the design work. Finally, concluding this section is a brief discussion on the project's implications and opportunities for future work.

5.1 Interpreting the results

There are signs of a correlation between experienced social presence perception and the observer's degree of influence in both projects, supporting what testers mentioned in the interviews and what can is interpretable from recorded video footage. There is also a strong resemblance between the two projects concerning testers' responses to the empathy and behavioural engagement questions. However, the third category, negative feelings, is a noticeable outlier that likely resulted from the observers' occasional want to disrupt the player from succeeding, which Maurer et al. did not report experiencing. As mentioned in the previous section, testers also remarked that the gaze interactivity mode was the most effective at evoking participant-observer cooperation, further supported by its comparatively low average on negative feelings. The noticeable difference between the Rocketeer 2's no influence mode and Rocketeers 1 suggests that eye-trackers can enable creative designs that give observers influence over the player's experience despite having no impact on the game. Finally, categories of empathy and behavioural engagement are similar between the flashlight and gaze blaster modes, suggesting that despite the difference in the category of impact, the aesthetic qualities of the game remain largely the same.

While increased observer impact on the game may indicate whether the game experience is more evocative of increased social presence perception, it is not a certainty, as can be ascertained by the negligible differences in the results between the flashlight and gaze blaster modes, as well as the noticeable difference between the Rocketeer 2's no influence mode and Rocketeers 1. However, although the observer-influence continuum is less detailed than Gomez and Lankes' Eyesthethics framework, it presents a sparse yet descriptive taxonomy that designers can use to explain how impactful the gaze implementation is on a mechanical level. Furthermore, although there are no apparent indications that indirect or direct impact affects the experienced social presence more than the other, a trend may emerge when similar tests are conducted using different games or gaze implementations.

5.2 Reflecting on the development

The constructed design process served the project well by allowing the concepts to evolve from simple sketches of participant-observer interactions to working prototypes while providing clear structure and direction. Rocketeers 1, in particular, significantly benefitted from the interaction-driven design since existing games of the desired configuration could not be found. By looking at real-life examples of cooperative interactions, such as the dialogue between driver and co-driver in rally, novel sketches could manifest and transform into game concepts that try to retain the essence of the inspiring collaboration's characteristics. Subsequent steps involving applying the Eyesthethics framework to the concepts helped formalise intended gaze interactions, and pre-testing made it possible to spot functional errors before the formal playtest sessions could begin. However, it is worth noting that the design process' success is likely to be attributed to the project's exploration-centric focus. Instead, if the intent was to solve a defined problem, it is reasonable to believe that the process could be problematic since potential constraints are not considered earlier in the design process. Furthermore, it would be even more problematic if the process necessitates defining a problem as well, for which this process has no tools to handle, unlike conventional methodologies.

5.3 Reflecting on the technology

Although it is possible to create eye-tracking supported prototypes using out-of-the-box technologies, it is mainly by using webcams whose accuracy and reliability are weaker than their IR PCR counterpart. Unfortunately, while well-respected webcams are inexpensive and libraries such as WebGazer are open-source, most eye-trackers in the IR PCR space are comparatively expensive. Furthermore, they require proprietary development kits because of the technology's black-boxed state. While Tobii provides a respectable entry-point by allowing designers to use their consumer-grade hardware for development, access to some of their development kits still necessitates contacting them in order to receive the kit and a license, which is a process that may take several days or weeks. Thus, IR PCR trackers are uniquely situated in an environment where hardware and software are inseparable. Unless designers can acquire the software strictly associated with their eye-tracker of choice, they have no development tools to use. Consequently, even though IR PCR eye-trackers are accessible on the consumer market, they remain unnecessarily complicated to use for development.

5.4 Implications and future work

While the context of digital games and toys are particularly well-suited to establish the link between observer influence and perceived social presence due to their inherently interactive characteristics, it is less clear how influential observation might affect other domains. Moreover, the prototypes presented in this thesis and those created by Maurer et al. focus on social presence in co-located settings. Although it seems reasonable to expect similar results in remote settings, it remains less whether that is the case. Results of social presence perception may also differ depending on the medium of the gaze feedback. As mentioned earlier, audio cues or real-world devices may actuate in response to gaze interactions taking place instead, which could shift the quantitative results or cause participants and observers to react differently.

This project tested the observer-influence continuum in five different observer-participant configurations that indicate the hypothesis correct, i.e., higher degrees of observer-influence correspond to higher levels of social presence perception. However, further testing is needed to ascertain whether games in different genres yield similar results using the same gaze implementations. Moreover, the third category of the continuum, direct impact, was only tested using one mode of gaze implementation. Further testing of the category needs to be done to establish whether there is a noticeable difference between it and implementations categorised as indirect impact with high degrees of observer-influence as far as social presence perception is concerned.

6 Conclusion

This thesis aimed to see if higher levels of social presence perception were associated with an observer's degree of influence, as Maurer et al. had discovered (2015). Two game prototypes, representing five implementations of gaze interactivity, were created to establish the link. Furthermore, an observer-influence continuum was proposed to help clarify how an observer can influence activities. Qualitative and quantitative results indicate a correlation between higher degrees of observer influence and increased social presence perception. However, it remains unclear whether the difference between categories of indirect and direct observer-influence implementations is noticeable. Novel forms of collaboration using eye-tracking technology have also been demonstrated by using the interaction-driven approach to design a unique concept. The concept utilises an eye-tracking device to allow observers who cannot impact the game to influence the activity cooperatively by giving the player guidance. Finally, the project helped conclude that it is possible to create eye-tracking prototypes using out-of-the-box technologies. Webcams are an accessible option with suboptimal accuracy, and IR PCR trackers are accurate devices made inconvenient to use for development due to the problematic acquisition of proprietary software and the potentially deprecated state of development kits.

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