Effects of a Gaze-Based 2D Platform Game on User Enjoyment, Perceived Competence, and Digital Eye Strain

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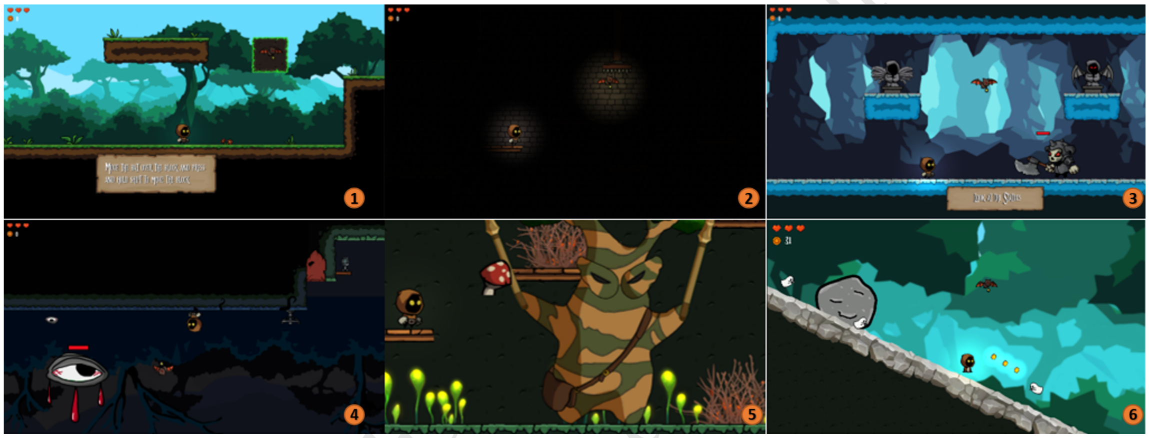

Fig. 1. The six levels of "Shed Some Fear". (1) shows the hold and move interaction applied to a square representing an obstacle. In (2), the eye gaze is used to illuminate parts of the level. A boss fight is depicted in (3), where statues can be gazed upon to inflict damage or heal one's own figure. (4) shows the mirrored level *Upside-Down* while (5) shows *Fairy Garden* and (6) the level *Stone Slope*.

Gaze interaction is a promising interaction method to increase variety, challenge, and fun in games.We present "Shed Some Fear", a 2D platform game including numerous eye-gaze-based interactions. "Shed Some Fear" includes control with eye-gaze and traditional keyboard input. The eye-gaze interactions are partially based on eye exercises reducing digital eye strain but also on employing peripheral vision. By employing eye-gaze as a necessary input mechanism, we explore the effects on and tradeoffs between user enjoyment and digital eye strain in a five-day longitudinal between-subject study (N=17) compared to interaction with a traditional mouse. We found that perceived competence was significantly higher with eye gaze interaction and significantly higher internal eye strain. With this work, we contribute to the not straightforward inclusion of eye tracking as a useful and fun input method for games.

CCS Concepts: • **Human-centered computing** → **HCI theory, concepts and models**; **Empirical studies in HCI**; • **Applied computing** → **Computer games**; • **Software and its engineering** → **Interactive games**.

Additional Key Words and Phrases: eye-gaze, 2D platform, digital eye strain, gamification

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1 INTRODUCTION

Time spent on digital media by US American adults is close to 13 hours per day as of 2021 [28]. The recent COVID-19 pandemic increased the usage of digital devices by 78% during curfew [2]. Elongated exposure to screens can harm the users' eyes—leading to symptoms like dry eye or digital eye strain (DES) [22, 23]. Declining eye health through DES has various causes rooted in digital media, such as close viewing distances, glare, and screen brightness of digital devices [6], or poorly designed interfaces [23]. To date, there are only a few suggestions to alleviate DES, like lowering the screen's brightness or looking away from the screen every 20 minutes [22, 23]. Studies on the widely distributed hypothesis that blue light filtering can reduce DES symptoms are inconclusive, and strong empirical support for DES improvement through these filters is currently missing [47, 55]. Despite the potential negative impact of screen exposure on DES symptoms, about 95% of children between 2 and 17 years in the USA play video games [19]. This is not likely to cease but, more realistically, to even increase.

Regarding game design, one input modality that has increased in popularity and has already been employed in different games is *eye gaze*. Games employ eye gaze mechanisms using external tracking devices, often as a supporting modality. Eye gaze, especially in combination with other input modalities, enables a variety of novel interaction concepts. Previous work has used eye gaze to enable additional user groups to participate, thus, increasing accessibility [68], was employed as an interaction mechanism for leisure [65] and for serious games [72], as well as for measurement purposes [38, 41]. However, despite these promising approaches, eye gaze interaction has not fully reached the maturity of other game input mechanisms. This is due to various reasons; for example, research from non-gaming contexts has suggested that eye gaze interaction can induce DES [5] potentially due to long fixation durations.

Nonetheless, besides providing an alternative to traditional input, eye gaze introduces novel challenges that potentially increase fun, enjoyment, and perceived competence (e.g., by using foveal and peripheral vision or smooth pursuits).

Currently, there is a gap in our understanding of how eye-gaze interaction affects players. Notably, there may be a trade-off between player experience (e.g., by trying to provide challenge through complex input) and eye strain (e.g., a result of having to follow complex movements as part of the game mechanics). While some countermeasures were proposed for VR Head-Mounted Displays (HMDs), alleviating DES still remains a challenge [23]. As such, there is a need to study how gaze-based interaction affects player experience variables as well as eye strain.

To evaluate the effects of a gaze-based interaction, we developed the 2D platform game "SHED SOME FEAR". "SHED SOME FEAR" incorporates eye gaze for moving a companion avatar in the form of a bat. This bat is used in various ways throughout the game, for example, for selecting objects or lighting the dark. This companion metaphor based on eye tracking introduces a metaphor for both foveal and peripheral interaction.

Additionally, as the eye gaze interaction can create DES, eye exercises are incorporated in a game-coherent and gamified way. For this, we use rather generic eye exercises known especially from VR. These eye exercises should be included to counter DES-inducing tasks (e.g., reading as a task of long fixations should be countered with rapid eye movement exercises). However, in the current form, the eye exercises that we included in the game context are not targeted at a specific eye strain cause (e.g., long fixation) because games usually incorporate a multitude of different elements and, therefore, it might be difficult to assess the actual source of eye strain. We implemented those approaches as an exploration for gaze interaction that may counteract some of the strain caused by the game itself as well as the induced eye strain during the day. In a between-subject, longitudinal, five-day study with N=17 participants, we compared the effects of the eye gaze interaction combined with the keyboard to the combination of mouse and keyboard. We found that the interaction with eye gaze was enjoyed by the participants and led to higher perceived competence. Nonetheless, it also led to increased DES compared to the baseline with mouse interaction. Qualitative feedback suggests that this is also due to the low performance of eye tracking.

Contribution Statement: This work contributes (1) the game "SHED SOME FEAR", which incorporates a keyboard combined with a mouse or eye gaze as input modalities to enable studying the effects of eye interactions in 2D platform games. (2) Eye gaze-based interactions drawn from previous work in game design and including DES countermeasures (DESC) in VR HMDs. (3) The results of a longitudinal study (N=17) with regard to player enjoyment, perceived competence, and DES. These results show that while eye gaze interaction was enjoyable, DES was increased. Alterations in perceived competence were likely due to the higher difficulty using the eye gaze interaction.

Our findings provide guidance for game developers on how to integrate various eye interactions using a companion avatar (i.e., the bat). The results also warn of the potential harm caused by using eye-based interaction without appropriate countermeasures. While still increasing DES compared to a baseline with mouse interaction, this work serves as a foundation for enjoyable and potentially healthier eye-based interaction in games.

2 RELATED WORK

Our work builds on prior work in the design of (platform) games, eye tracking in games, and measuring and countermeasures for DES.

2.1 Eye Gaze — Technical Adoption in Games

As eye tracking based on webcams and integrated cameras (e.g., smartphone front camera) is still in the development stage, the gaze is usually recorded with an external eye tracker (e.g., Tobii Eye Tracker 5 [61]), which offers a reliably high eye detection accuracy. However, due to the expensive acquisition costs and the still limited application possibilities, a wide distribution of these eye trackers in the end user sector has not been achieved yet. For example, although 167 games (e.g., Assassin's Creed Valhalla, Far Cry 6, Project Cars 2, Farming Simulator 17) support the industry leader Tobii, these games have either an optional or only minor integration of the gaze direction as input [62]. While previous research on eye gaze interaction mostly was done for workstations [7, 20, 26], to the best of our knowledge, currently, a multitude of eye gaze interaction research occurs in VR HMDs as these readily include eye trackers (e.g., [23, 35]). This also shows the necessity to reduce dependencies on additional hardware and could be an explanation for relatively low adoption in the mass market. However, some games today also work purely with the gaze as an input modality (e.g., Blind Love [48]). Classic eye-tracker functions are Extended View (changing the in-game camera by gaze direction) or Aim on Gaze (aiming, e.g., with a bow and arrow, by gaze direction) as well as adapting mouse interactions via gaze (e.g., the greater the distance from the eye gaze location to the mouse pointer, the faster the mouse movement will be [66]). Velloso and Carter [65] identified five game mechanic categories: Navigation, Aiming & Shooting, Selection & Commands, Implicit Interaction, and Visual Effects. Often, eye tracking interaction is focused on areas of interest such as game objects (e.g., other characters or menu items), but other methods such as mapping eye gaze via trajectory matching have been proposed (called “pursuits”) [70]. Other implicit interactions include using eye gaze of other characters, for example, in a poker game. Finally, gaze can be used to adapt the visual effects, for example, by blurring or blinding players where the gaze point could be used to hide objects [65].

2.2 Eye Gaze as an Interaction Modality

Eye tracking as a pure interaction technique has a long history in Human-Computer Interaction. Already in 1990, Jacob [33] proposed interaction techniques such as gaze-based selection (eye gaze selects an object and key press simulates a click), object movement, text scrolling (when arriving at the bottom of the text, the text is automatically scrolled), or menus. The main body of work researched eye gaze input as an accessibility tool or to complement and enhance traditional input methods [29–32, 50, 60, 66] or for increasing immersion, for example, via adaptive rendering [21]. Additionally, eye gaze was used to adapt game difficulty [4], or automated aiming [13]. Besides the gaze point, also blinks [15], winks [10], or peripheral vision [51] were employed.

Classical approaches often describe approaches for gaze metaphors for interaction.

Often, the classical gaze paradigm “"What you see is what you get” [51], that is, using the foveal vision region to interact with an object (e.g., selecting/aiming at objects) has been used. For example, Istance et al. [31] implemented two and three-legged gaze interactions, meaning that the gaze needed to either perform two or three distinct movements (e.g., go up, diagonally to the left, and back to the original position for a three-legged interaction). They found that the three-legged approach required approximately double the time of the two-legged. When using the two-legged gaze interactions in World of Warcraft, these gestures performed well for events but badly for continuous interaction, such as moving a character. Lankes et al. [40] proposed using the eye gaze direction as a clue to guide players in exploration games. If the player’s central view or the gaze came close to a relevant object, a vignette of varying size would indicate the closeness. By leveraging the eye gaze, experience and performance were improved. Kocur et al. [35] used eye gaze to enhance the bullet magnetism mechanism [67] for multi-object scenarios. This interaction, however, was not empirically evaluated.

Besides “"What you see is what you get”, there have been different attempts to leverage eye interaction possibilities.

Ramirez Gomez and Gellersen [52] proposed “not looking” as a game metaphor. For example, a character is continuously moved with regular eye movements (i.e., follows the gaze) but can be teleported to the location of eye gaze after having the eyes closed. Participants found the interaction, in general, challenging but fun. Lankes and Berger [39] proposed “Blind Spot”. In their art installation, the observers’ foveal vision region is obstructed, forcing the observer to rely on peripheral vision. Ramirez Gomez and Gellersen [51] also included peripheral vision. For this, they included different tasks (e.g., retrieving information about objects in the periphery for decision-making or peripheral interaction, i.e., interacting with objects via keyboard) and challenges or rules (e.g., “Objects must not be looked at” [51, p. 3]) which were then incorporated into the game via metaphors. The authors found that this created an “engaging and playful experience” [51, p. 1]

Incorporating deliberate challenges into the design, Ekman et al.’s *Invisible Eni* and Vidal et al.’s *Shynosaurs* illustrate gaze interfaces with considerable difficulty. For instance, in Invisible Eni [15], players are required to manipulate game elements by means of controlling their pupil dilation, while Shynosaurs [69] places players in a predicament between maintaining eye contact with monsters and coordinating their hand movements effectively.

Nacke et al. [44] evaluated direct (e.g., eye gaze) and indirect (e.g., heart rate) physiological game interaction to augment traditional controls. The authors showed a preference for direct interaction among the users. Eye gaze as an interaction method was implemented as follows: when activated, the eye gaze would temporarily freeze enemies and moving platforms (thus, accurately named Medusa's Gaze).

Finally, prior work has also been incorporated and evaluated in multi-player settings, for example, to enable inferring intent of others [46] with the real-time heatmap being preferred. The visualization can then be used as a game mechanic, for example, to deceive other players [45].

Regarding the performance of eye gaze interaction compared mouse with gaze interaction, Dechant et al. [11] found that "mouse was the fastest technique and gaze was both the slowest and most error-prone" [11, p. 1].

2.3 Eye Gaze Interaction Classifications

Regarding gaze-based interaction, Isokoski et al. [29] defined four technical ways to adapt video games to use eye gaze as an interaction modality: (1) using dwell time as a substitution for, for example, mouse input, (2) using additional software to register events to the game, (3) adapting the source code of the game, and (4) developing a game from scratch. This taxonomy, however, becomes less relevant with the proliferation of game engines such as Unity that enable easy creation of games.

Ramirez Gomez and Lankes [53] introduced a framework for interaction with gaze with four dimensions: Identity; Mapping; Attention; and Direction. In "SHED SOME FEAR", we focused on the Identity *player*, the Mapping *gaze*, the Attention *direct*, and Direction *the players' (second) avatar*.

Almeida et al. [3] categorized work on eye tracking into input and visual attention studies for video games. In "SHED SOME FEAR", we focus on the input mechanism.

Velloso and Carter [65] provide a list of 112 individual game mechanics. They present a taxonomy regarding the *eye movements* (fixations, saccades, smooth pursuits, compensatory eye movements, vergence, and optokinetic nystagmus; see also [3]), *input type* (discrete-Only, continuous-only, discrete+continous), *game mechanics* (navigation, aiming & shooting, selection & commands, implicit commands, and visual effects with subcategories). In "SHED SOME FEAR", we incorporate several of these, for example, fixations, smooth pursuits, as well as discrete or continuous input.

2.4 Eye Strain and Countermeasures

In the development of gaze-based video games, developers must take into consideration the potential for increased ocular strain and the phenomenon known as digital eye strain (DES). DES is a well-documented issue among users of digital interfaces [59] and may be caused by a variety of factors, including exposure to intense light, poorly designed interfaces, and active gaze-based interactions.

Screen brightness can exacerbate the problem, especially in VR HMDs as the displays are close to the eyes [23]. Poorly designed interfaces can also contribute to DES, particularly when they include flickering, unpleasant color combinations, or a high number of interactive visual components [22]. Active gaze-based interactions can also contribute to ocular strain due to the unnatural eye movements and behaviors required for these interactions [22].

Symptoms of DES may include internal symptoms, such as strain or headache, and external symptoms, such as irritation, burning, or dryness of the eye [22, 23]. Additionally, dry eyes, which may lead to a decreased blinking rate [57], can also be a symptom of DES.

There are a variety of potential treatments for DES, including blue light filters [9], "night mode" interfaces, and the "20-20-20 rule" [34] (focusing on an object 20 feet away for 20 seconds every 20 minutes). However, the effectiveness of these treatments is not well understood, and further research is needed to determine the most effective solutions for addressing DES, particularly in the context of gaze-based interactions [9, 23]. Given the increasing prevalence of DES and evidence of digital screens potentially increasing its harm, we need to incorporate DES as a metric in the evaluation of gaze-based game interaction.

2.5 Player Experience

Evaluating gameplay is important for game development and HCI Games research with player experience being an essential aspect to measure [1]. Player experience is considered the subjective and individual experience during and after playing games [74]. This concept is widely studied from different perspectives and usually understood as a multi-dimensional construct [1, 27] related to similar concepts like flow [1] or enjoyment [43, 71]. Good player experience can be conceptualized as the satisfaction of psychological needs [1], for example, according to the three basic needs in Self-Determination Theory autonomy, competence, and relatedness [12, 58]. Especially, competence (i.e., the need for challenge and a feeling of effectance [58]) is relevant for our study. Overcoming challenges is an essential aspect of many games [17, 58] with a new unknown interaction technique like eye gaze potentially being perceived as more challenging and thus affecting the player experience through perceived competence. This is also because player experience is understood as a consequence of the player's interaction with a game at different levels (e.g., mechanics, dynamics, aesthetics) [1, 25], where the different interaction approaches will ultimately affect the player experience. Thus, player experience is an important lens for evaluating gaze-based interaction as a novel interaction technique in games, potentially affecting aspects of the player experience, such as perceived competence and game enjoyment.

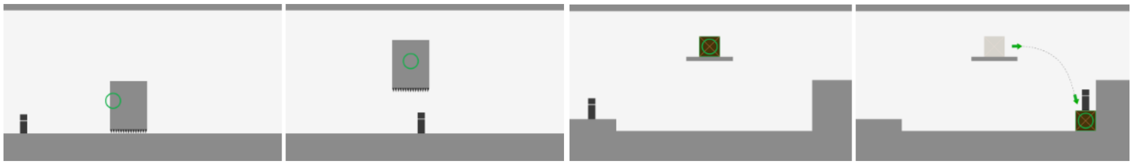
2.6 Summary and Research Gap

Our work lies at the intersection of eye gaze interaction in games, DES, and game development. Therefore, we introduced various settings of gaze interaction in games (e.g., accessibility, VR HMDs, multi-player games) and presented different interaction mechanisms (e.g., using peripheral vision, "not looking", multi-modal approaches). Despite this existing research, there is not enough evidence about how eye-gaze interaction affects player experience and DES, which is essential for gaze-based interactions in games that are fun but do not negatively affect the players' health. Therefore, we implemented "Shed Some Fear", a 2D platform game incorporating eye gaze interactions. With "Shed Some Fear", we provided an implementation to evaluate the effect on DES in a longitudinal study over five days.

3 GAME DESIGN

To study the effects of gaze interactions in 2D platform games, we developed "Shed Some Fear". "Shed Some Fear" incorporates game mechanics from previous work regarding peripheral vision [39, 51] or challenging gaze hand movement coordination [69]. Additionally, we included some eye exercises from previous work on DES in VR HMDs [23]. By incorporating a companion bat as a constant character controlled by gaze, we were able to unify the later described game mechanics (see Section 3.1) in one metaphor. Specifically, we designed three game mechanics based on eye exercises proposed by Hirzle et al. [23]. We included the exercises in the game mechanics because these directly fit the 2D platformer game narrative. The three eye exercises are saccades, smooth pursuit, and static fixation [23].

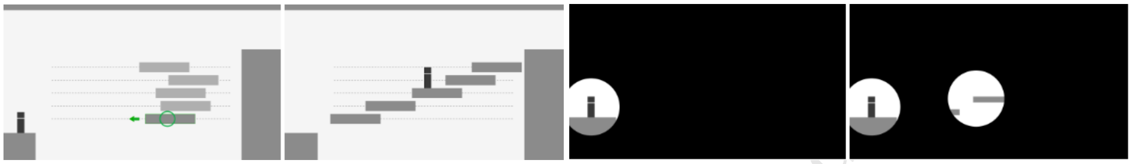
Players navigate six 2D platforming levels (see Figure 1) varying in complexity and difficulty. In these, the player has to avoid enemies, has to jump around platforms, and can collect coins. The player can use classical actions consisting of jumping and striking with a sword or a bow and arrow. Players have three lives at the beginning of the game, which is



(a) Lifting a block by holding the gaze (green circle) on it. This represents a fixation interaction.

(b) The player can hold and move the block freely by gazing upon it and pressing the shift key. This represents a fixation, smooth movement, and challenging gaze hand movement coordination [69].

Fig. 2. Conceptual drawings of the hold and move mechanics.



(a) As long as the player's gaze is upon the platform, it moves. This represents a fixation plus smooth movement.

(b) The player's character and viewpoint have a light source, allowing them to navigate in the dark.

Fig. 3. Conceptual drawings of the move and reveal mechanics.

indicated by hearts in the top left corner together with the collected coins. "Shed Some Fear" incorporates numerous game experiences such as exploration and action. The game engine used in this project is Unity version 2021.3.3f1.

3.1 Interaction Concepts and Mechanics

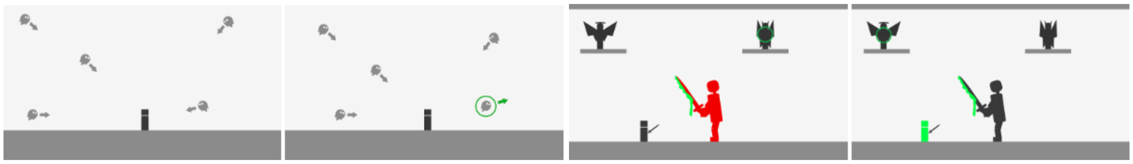
From the start of the game design, we included **eye gaze** mechanisms as an essential interaction method. Non-eye gaze versions are possible as the eye gaze can be substituted via mouse movements, for instance. We refrained from designing the game to require three input mechanisms to avoid overwhelming players. An example would be to use the left hand to jump, the right hand to use only the sword, and the gaze to move the companion bat. This means that "Shed Some Fear" is playable with traditional input. However, if eye gaze is enabled, the game cannot be successfully played without using the eyes. The eye gaze is visualized in the game as a companion bat compared to a more abstract representation in the form of a circle by Lankes et al. [40]. Players also simultaneously control an avatar using a keyboard with the traditional WASD control. Thereby, "Shed Some Fear" enables us to study the effects of gaze interactions effectively. We implemented six gaze-based interactions:

Move / Hold on Gaze: The player can lift (see Figure 2a) or move a block by continuously gazing upon it. When looking away, they will fall or stop moving. To lift some blocks, they have to be looked at and the key shift has to be pressed (see Figure 2b). There are also platforms that only move forward upon gaze (see Figure 3a). Holding an object represents static fixation (see E7 in [23]) and moving represents a smooth pursuit (see E5 in [23]).

Reveal on Gaze: The only lit areas are the player figure and the bat controlled via gaze (see Figure 3b).

Repel on Gaze: Enemies follow the player and damage them by touch. With the player's gaze, these game objects can be scared away, retreating in the opposite direction. This represents a smooth pursuit (see E5 in [23]).

Damage on Gaze: Holding one's gaze on the opponent will damage them slowly over time (see Figure 4c). As opponents move, this represents a smooth pursuit (see E5 in [23]).



(a) The player scares away ghosts with their gaze (green circle). This represents a fixation. Additionally, the character has to be moved using peripheral vision.

(b) Gazing upon the devil statue damages the enemy, gazing upon the angel statue heals the player.

(c) Gazing (green circle) upon the enemy damages it.

Fig. 4. Conceptual drawings of the mechanics.

Indirect Damage / Heal on Gaze: Some game objects, symbolized by a devil statue, can be used to damage enemies by gazing at them. An angel statue has the opposite effect and heals the player (see Figure 4b). This represents having a rather static fixation (see E7 in [23]).

Follow with Gaze - Jumping: The player has to follow a game object that jumps randomly. This requires the player to quickly change their point of gaze (see Figure 5). This interaction is based on Hirzle et al. [23] where "a sphere is presented that jumps to random locations in the user's inner and outer field of view" [23, p. 23] (see E4 in [23]). Participants' opinions about this eye exercise were unclear, as some saw the exercise as very positive, others negative and others saw it as neutral [23].

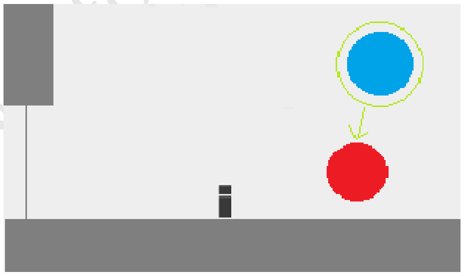


Fig. 5. "Follow with Gaze - Jumping". Upon eye gaze (symbolized by a green circle), changing position randomly (blue to red).

Follow with Gaze - Smooth: The player has to follow a game object, which starts to move when the player's gaze is upon it. The object will move in a fluent and smooth motion (see Figure 6). This interaction is closely based on Hirzle et al. [23], where a user had to follow a sphere gliding across the screen smoothly (see E5, smooth pursuit, in [23]).

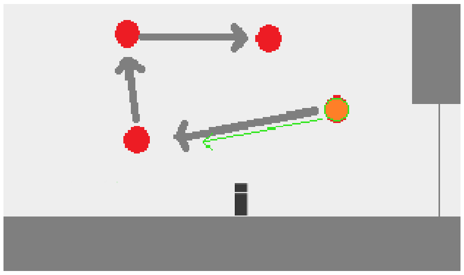


Fig. 6. "Follow with Gaze - Smooth" gazeable interaction. Orange represents the starting point of the game object. The red dots, indicating the next positions, are invisible to the player. By focusing the player's gaze, the object slowly moves to its next position.

3.2 Levels

We implemented six different game levels. In the main menu, the player can choose the level, buy items in the shop, or press the question mark button to view the controls. We designed the six unique levels:

- 1.*The Forest* (Tutorial; see Figure 1 (1)): The level contains basic Jump 'n' Run action, fighting enemies, and the gaze-based mechanic "move/hold on gaze", letting the player lift or move a block. When the player looks away from the block, it will fall or stop moving. The goal is to move the block to complete the level.
- 2.*Dungeon* (see Figure 1 (2)): In a dark environment, players must make their way through a dungeon. Controlled with the player's gaze, the bat companion can light the way with the interaction "reveal on gaze". Here, the player has to search the area with their gaze first to see the right path and to solve riddles. Additionally, "move/hold on gaze" has to be used to move platforms or blocks to create paths.
- 3.*The Ice Cave* (see Figure 1 (3)): Along with the Jump 'n' Run sections of this level and the previous gaze-based interactions, there are opponents above the player shooting at them. These enemies can be defeated by the gaze-based interaction "indirect damage", which allows the player to hold their gaze on the opponent and damage them slowly and indirectly. There are also two boss fights. The first, smaller boss can be defeated by hitting them with a weapon, or the player can flip a switch with their gaze to make the boss opponent fall into a pit filled with thorns. The second boss at the end of the level, however, can not be damaged with physical attacks. To defeat it, the player has to navigate their bat companion with their gaze on a devil statue in the upper right corner of the screen. This will damage the opponent indirectly. On the other side, if the boss hits the player, the player is poisoned and will receive damage over time. By moving the bat to the angel statue in the upper left corner, this damage can be healed. The level can be completed after defeating the second boss.
- 4.*Upside-Down* (see Figure 1 (4)): The screen is rotated 180° and the keyboard controls are inverted. In this level, there are numerous ghosts haunting the player. To defend themselves, the player has to use the interaction "repel on gaze" so that the bat can fear away the ghosts.
- 5. *Fairy Garden* (see Figure 1 (5)): This level features a mystical garden setting with plant creatures and fairies. The level design includes features such as large mushrooms and trees that serve as gameplay elements. The player starts in front of a large tree trunk and must navigate through the level using gaze-interactable mechanics from the "Forest" level, such as holding their gaze on a block to lift it and walk under it. The player must also navigate through tunnels, collect coins, fight enemies, and avoid obstacles such as spikes and bees. The level includes six different gaze-interactable mechanics and a boss fight before reaching the level's destination.

- 6. *Stone Slope* (see Figure 1 (6)): This level features a rocky cliff that the player must navigate down while being chased by a big rolling rock and two ghosts. The player must use a mushroom to bounce up a hill to reach an NPC enemy to fight. The player must then navigate a chasm by using moving platforms that are activated by the player’s gaze and were first introduced in the level "Ice Cave." The player then enters a cave where the environment is dark and the player’s gaze provides light and is also haunted by ghosts. The player must use the "Follow with the gaze - Bird" and "Follow with the gaze - Fairies" mechanics to open doors and defeat NPC enemies. The level’s destination is a house that the player reaches by standing in front of its door. This level includes 12 collectible coins, 4 enemies to defeat, and 5 different gaze-interactable mechanics.

3.3 Webcam-Based Eye Tracking

We developed a package for Unity to enable eye tracking with only a single webcam called “UnitEye”[1]. This builds on the work by Kong et al. [36] called EyeMU. Based on eye detection using MediaPipe Iris[2], the approach uses the “normalized coordinates of users’ eye corners and their head angles” [36, p. 3] and detects the yaw, pitch, and roll of the head. EyeMu uses a Convolutional Neural Network (CNN), which is trained on the GazeCapture dataset [37] and predicts the x and y positions of the gaze on the screen. We map these to the respective game objects. We exported their model to `.onnx` and added calibration (`None`, which only uses the raw neural network output of the underlying EyeMU model, `Ridge Regression` [24] which uses a weighted sum Ridge Regression to refine the gaze location, and `ML Calibration` where we use our own machine learning multilayer perceptron that we train when calibrating, filtering (`Kalman` filter [73], a simple `Easing` filter which is a weighted sum filter between the last and the current gaze location, combinations of those two and a `One Euro` filter [8]), and an area of interest system (both game objects via a *Gazeable* property or areas on the screen are possible). The API closely matches the Tobii API, therefore, the actual conversion from Tobii to UnitEye only requires changing one line of code.

As Tobii eye-tracking devices are not common, we built this eye tracker to enable a longitudinal study at the participants’ homes. The interactable objects’ size was adjusted to compensate for the eye tracker performance.

4 STUDY DESIGN

4.1 Research Questions

The following exploratory research questions guided our study.

RQ1 *What are the effects of eye gaze mechanics on player enjoyment and perceived competence?*

RQ2 *What are the effects of eye gaze mechanics on digital eye strain?*

Due to the exploratory nature of our study, no hypotheses were defined prior to the user study.

To evaluate and quantify the effects of our implemented eye gaze mechanics on player enjoyment and digital eye strain, we implemented a baseline. Instead of manipulating the bat companion with the eyes, in the baseline, the player manipulates the bat with a mouse. All other aspects of the game remained the same.

We chose a between-subject design despite the known inter-personal differences in eye strain [23, 75] as we (1) wanted to avoid challenges in participation by using a difficult study design, (2) wanted to avoid potential order effects, and (3) wanted to simulate a typical gaming experience at home. Therefore, participants were instructed to play the game *after* the workday. The experimental procedure followed the guidelines of the ethics committee of our university

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[1] Will be open-sourced.

[2] https://google.github.io/mediapipe/solutions/iris; Accessed: 13.09.2023

and adhered to regulations regarding the handling of sensitive and private data, anonymization, compensation, and risk aversion. Compliant with our university‘s local regulations, no additional formal ethics approval was required.

4.2 Measurements

4.2.1 Objective Measurements. “SHED SOME FEAR” includes logging the current position of the avatar and the bat companion with 50 Hz. Additionally, we logged whether participants were currently blinking, how far away their head was from the screen, head position, and head rotation.

4.2.2 Subjective Measurements. Participants provided demographic data about their age (in years), gender (woman, man, non-binary, prefer not to tell), education level (Secondary school, Middle school, High school, College, Vocational training), profession (student in school, student in college, employee, self-employed, jobseeker, other), screen time (in hours), video game time and playing of Jump’n’Run games (both: Daily, On working days, On weekends, Once a week, Once a month, Rarely), and video game enjoyment overall (1 - I don’t enjoy them at all to 5 - I love video games).

Before and after every gaming session, participants filled out a **DES** questionnaire based on Hirzle et al. [23] (see Table 13 in [23]). This included 21 items (Blurred vision, Burning eyes, Difficulty concentrating, Difficulty focusing, Dry eyes, Eye redness, Eye strain, Excessive blinking, Feeling of a foreign body, Feeling that sight is worsening, Heavy eyelids, Increased sensitivity to light, Irritated eyes, Neck pain, Seeing colored halos around objects, Sensation of hot eyes, Shoulder pain, Soreness of eyes, Tearing eyes, Tired eyes, Watering of eyes) with 7-point Likert scales from “Nothing at all” to “Very severe”. These can be combined to represent internal (mean over ’strain’, ’ache’, ’blurred’, ’double’, ’soreness’) and external (mean over ’burn’, ’irritated’, ’tearing’, ’watering’, ’hot’) eye strain symptoms.

Additionally, participants were asked to rate the **audiovisual appeal** as suggested by Abeele et al. [1], **enjoyment** [64], and **perceived competence** using the subscale of the Intrinsic Motivation Inventory [42] (see Table 1). Due to the study design with several gameplay sessions at home, we had to limit the number of player experience constructs that we could measure to prevent questionnaire fatigue and attrition. We chose these scales because we considered them a broad set of important player experience aspects, with competence being an essential aspect of a challenging novel interaction technique and game enjoyment as a general overall measure of player experience (see Section 2.5).

We used the enjoyment construct due to its conceptualization as enjoyment as a result of the player experience [1, 64], measured using the 5 items from the original PXI study Vanden Abeele et al. [64] consisting of the following statements: “I enjoyed playing the game.”, “I liked playing the game.”, “Playing the game was fun.”, “The game was entertaining.”, “I had a good time playing this game.” on 7-point Likert scales from 1 = Strongly agree to 7 = Strongly disagree).

Perceived competence was measured using the respective subscale of the Intrinsic Motivation Inventory as a validated measure for this construct [42]. Further, we measured audiovisual appeal as one specific aspect of the player experience to explore the audio-visual differences between conditions due to an interaction technique that directly affects where players can look.

Finally, participants could provide open feedback about possible improvements and aspects they especially enjoyed.

4.3 Procedure

Every participant was randomly assigned to one of the interaction methods keyboard and *eye gaze* or keyboard and *mouse*. First, participants provided informed consent, answered a demographic questionnaire, and received an overview of the study, including instructions for installing the game on their laptops or PCs. The instructions for the game were directly embedded in the tutorial. Participants were instructed to play the game for at least 15 minutes on five different

Table 1. Items of the dependent variables audiovisual appeal, enjoyment, and competence.

Dependent Variable	Items
audiovisual appeal [1]	“I enjoyed the way the game was styled.” “I liked the look and feel of the game.” “I appreciated the aesthetics of the game.”
enjoyment [64]	“I enjoyed playing the game.” “I liked playing the game.” “Playing the game was fun.” “The game was entertaining.” “I had a good time playing this game.”
perceived competence [42]	“I think I am pretty good at this activity.” “I think I did pretty well at this activity, compared to others.” “After playing this activity for a while, I felt pretty competent.” “I am satisfied with my performance at this task.” “I was pretty skilled at this activity.” “This was an activity that I couldn’t play very well.”

days within one week. We did not enforce this limit strictly but report the play duration in Table 3. Before and after every play session, participants answered a questionnaire. After all five days, participants had to upload their logs.

Participants could take part in the study from home. They were instructed to complete it in the evening, as their eyes would be more strained from daily life and the use of digital devices throughout the day. We chose this time for two reasons. First, having a dedicated time frame increases comparability between the participants, i.e., if some would play in the morning and some in the evening, the eye strain of the participants in the evening would most likely be stronger. Second, we chose the evening over the morning because video games are mostly played afternoons and in the evenings both during the week and on the weekends [63]. Participants were instructed to calibrate the eye tracker every time prior to using it. Participants received a compensation of 25€.

5 RESULTS

5.1 Data Analysis

Before every statistical test, we checked the required assumptions (e.g., normality distribution). For non-parametric data, we used aligned rank transform (ART) using the ARTool package by Wobbrock et al. [76] and Holm correction for post-hoc tests. R in version 4.3.2 and RStudio in version 2023.09.1 was employed. All packages were up to date in December 2023. All descriptive data per interaction modality is shown in Table 2.

Table 2. Table of scores regarding the input methods.

Variable	Input Method	n	Min	q_1	$\tilde{x}$	$\bar{x}$	q_3	Max	s	IQR
visual appeal [1]	Eye	30	1.00	1.00	2.17	**2.24**	2.67	5.33	**1.25**	1.67
	Mouse	60	1.00	1.00	1.33	**2.00**	2.17	6.33	**1.42**	1.17
	combined	90	1.00	1.00	1.33	**2.08**	2.67	6.33	**1.36**	1.67
enjoyment [64]	Eye	30	1.00	2.80	3.40	**3.51**	4.15	7.00	**1.43**	1.35
	Mouse	60	1.00	1.60	2.40	**2.73**	3.65	6.40	**1.39**	2.05
	combined	90	1.00	2.00	2.90	**2.99**	3.80	7.00	**1.44**	1.80
perceived competence [42]	Eye	30	2.00	4.50	5.17	**4.97**	5.92	7.00	**1.17**	1.42
	Mouse	60	1.00	2.46	3.58	**3.89**	5.29	7.00	**1.84**	2.83
	combined	90	1.00	2.83	4.50	**4.25**	5.67	7.00	**1.72**	2.83
differences in internal ocular symptoms	Eye	30	-0.60	0.00	0.20	**0.32**	0.55	1.40	**0.47**	0.55
	Mouse	60	-0.40	-0.20	0.00	**0.03**	0.20	0.80	**0.26**	0.40

	combined	90	-0.60	0.00	0.00	**0.13**	0.20	1.40	**0.37**	0.20
differences in external ocular symptoms	Eye	30	-0.60	0.00	0.00	**0.23**	0.40	2.40	**0.58**	0.40
	Mouse	60	-0.60	0.00	0.00	**0.09**	0.20	0.80	**0.27**	0.20
	combined	90	-0.60	0.00	0.00	**0.13**	0.20	2.40	**0.40**	0.20
differences in eye dryness	Eye	30	-1.00	0.00	0.00	**0.73**	1.75	4.00	**1.23**	1.75
	Mouse	60	-4.00	0.00	0.00	**-0.05**	0.00	2.00	**0.98**	0.00
	combined	90	-4.00	0.00	0.00	**0.21**	0.00	4.00	**1.13**	0.00

5.2 Participants

We determined the required sample size via an a-priori power analysis using G*Power in version 3.1.9.7 [16]. To achieve a power of .8 with an alpha level of .05, 18 participants should result in an anticipated medium effect size (0.27 [18]; similarly found in previous work such as [11]) in a mixed design with two groups and five measurements (one per day).

Therefore, we recruited 25 participants. Of these, 17 answered all five questionnaires. Therefore, our final sample (N=17) consisted of seven women and 10 men with an average age of *M*=29.47 (*SD*=9.25; range: 21 to 49) years. Fisher's exact test showed no significant difference in gender distribution (p=1.00). Twelve reported being students, three are employees, and two are self-employed. On average, they have a screentime of *M*=8.25 (*SD*=3.14) hours per day. No participant worked in shifts; instead, all had standard 9-5 working patterns. Particularly, no participant worked at night regularly. Regarding their gaming experience, seven participants stated to play daily, four on weekends, four rarely, two once a week, and one monthly. For Jump 'n' Run games, twelve stated that they played them rarely, two monthly, two on the weekends, one once a week, and one daily. In general, participants stated to like playing games (on a 5-point Likert scale; *M*=4.33, *SD*=0.97). Kruskal Wallis tests found no differences between the groups in terms of age ($\chi^2(1)$=0.31, p=0.58), screen time ($\chi^2(1)$=1.50, p=0.22), or whether they like to play games ($\chi^2(1)$=1.01, p=0.32). All participants had normal or correct-to-normal vision. Six participants finished all five questionnaires in the eye gaze and 11 in the mouse version of "SHED SOME FEAR".

5.3 Competence

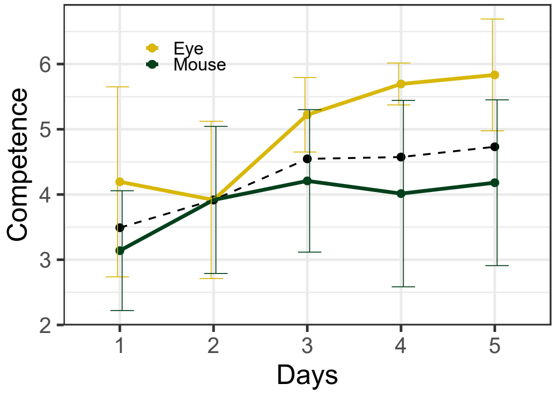

Fig. 7. Interaction effect on competence.

The ART found no significant main effect of input method on perceived competence ($F(1, 16) = 2.01$, p=0.18, r=-0.143, Z=-1.36). The ART found a significant main effect of days on perceived competence ($F(4, 64) = 7.75$, p<0.001,

r=-0.435, Z=-4.13). The ART found a significant interaction effect of input method × days on perceived competence ($F(4,64) = 3.95$, p=0.006, r=-0.288, Z=-2.73; see Figure 7). Perceived competence was always higher in the eye tracker version. However, the difference in the perceived competence first became smaller (Day 2) and then larger by day.

5.4 Visual Appeal, Enjoyment

The ART found no significant effects on visual appeal (input method: $F(1,16) = 0.25$, p=0.62, r=-0.052, Z=-0.50; days: $F(4,64) = 0.45$, p=0.78, r=-0.029, Z=-0.28; interaction: $F(4,64) = 0.35$, p=0.84, r=-0.021, Z=-0.20).

Enjoyment was higher with the eye gaze interaction (M=3.51, SD=1.43), than with the mouse (M=2.73, SD=1.39), however, not significantly ($F(1,16) = 1.96$, p=0.18, r=-0.141, Z=-1.34). The ART also found no significant effect of days ($F(4,64) = 0.76$, p=0.56, r=-0.061, Z=-0.58) nor an interaction effect ($F(4,64) = 1.24$, p=0.30 , r=-0.109, Z=-1.04).

5.5 Digital Eye Strain

5.5.1 Internal Differences. Eye strain, double vision, blurred vision, and eye aches or soreness are described as internal ocular symptoms.

The ART found a significant main effect of input method on differences in internal ocular symptoms ($F(1,16) = 11.12$, p=0.004, r=-0.303, Z=-2.88). With the eye tracker input (M=0.32, SD=0.47), the difference in internal ocular symptoms was significantly higher compared to the mouse input (M=0.03, SD=0.26). The ART found no significant main effect of days ($F(4,64) = 0.47$, p=0.756, r=-0.033, Z=-0.31) nor an interaction effect ($F(4,64) = 0.23$, p=0.92, r=-0.011, Z=-0.10) on differences in internal ocular symptoms.

5.5.2 External Differences. External ocular symptoms are defined as burning or hot eyes, irritated eyes, and tearing or watering eyes.

The ART found no significant effects on the difference in external ocular symptoms (input method: $F(1,16) = 0.63$, p=0.44, r=-0.081, Z=-0.77; days: $F(4,64) = 0.41$, p=0.80, r=-0.027, Z=-0.25; interaction: $F(4,64) = 0.60$, p=0.66, r=-0.046, Z=-0.44).

5.5.3 Dry Eyes. The ART found a significant main effect of days on difference in dry eyes ($F(4,64) = 5.65$, p<0.001, r=-0.362, Z=-3.44). However, a post-hoc test found no significant differences.

The ART found no significant main effect of input method ($F(1,16) = 3.29$, p=0.089, r=-0.179, Z=-1.70) nor an interaction effect ($F(4,64) = 0.85$, p=0.50, r=-0.071, Z=-0.67) on difference in dry eyes.

5.6 Logging Data — Blinking, Playing Duration, Distance to Monitor, and Distance Player to Companion

Due to technical difficulties regarding the logging, of the total of N=17 participants, we only report the game data of N=14 participants. Due to technical limitations, we also only report the eye gaze data of nine participants. Five of these used eye gaze as the input modality.

The ART found no significant effects on the amount of blinking (input method: $F(1,7) = 0.01$, p=0.92, r=-0.011, Z=-0.10; days: $F(4,28) = 0.57$, p=0.69, r=-0.042, Z=-0.40; interaction: $F(4,28) = 0.58$, p=0.68, r=-0.043, Z=-0.41). The ART also found no significant differences in the blinking frequency.

The ART also found no significant effects on the playing duration (input method: $F(1,7) = 1.80$, p=0.22, r=-0.129, Z=-1.23; days: $F(4,28) = 0.96$, p=0.45, r=-0.08, Z=-0.76; interaction: $F(4,28) = 1.83$, p=0.15, r=-0.152, Z=-1.44). For an overview, see Table 3.

Table 3. Table of mean and sd values for play duration per day in s.

Input Method	Day 1	Day 2	Day 3	Day 4	Day 5
Mouse	1724 ± 1764.06	945.5 ± 451.87	970.25 ± 312.25	922.5 ± 300.66	2144.25 ± 1565.98
Eye Gaze	970.8 ± 108.41	859 ± 430.32	1603.4 ± 1794.51	843.2 ± 452.8	733.2 ± 183.46

The ART also found no significant effects on the distance to the monitor (input method: $F(1,7) = 3.89$, p=0.089, r=-0.179, Z=-1.70; days: $F(4,28) = 1.00$, p=0.43, r=-0.083, Z=-0.79; interaction: $F(4,28) = 0.53$, p=0.71, r=-0.039, Z=-0.37; see Table 4).

Table 4. Table of mean and sd values for distance to the monitor per day in mm.

Input Method	Day 1	Day 2	Day 3	Day 4	Day 5
Mouse	471.15 ± 121.23	464.2 ± 161.55	493.86 ± 137.92	488.84 ± 161.43	490.96 ± 170.86
Eye Gaze	645.64 ± 99.05	661.81 ± 139.35	670.44 ± 100.14	681.14 ± 129.51	612.94 ± 116.24

Finally, the ART found a significant main effect of input method on the mean companion distance ($F(1,12) = 7.62$, p=0.017, r=-0.252, Z=-2.39; calculated via the Euclidean distance). The mean distance is the distance between the main character and the companion over the course of one game. was lower with the mouse (M=5.88, SD=1.38) compared to the eye gaze (M=8.37, SD=6.60).

5.7 Qualitative Feedback

We did not conduct a formal analysis of the participants' qualitative feedback. In the following, we report anecdotal quotes, summarizing the main points the participants reported. A majority of the participants (14 of 17 or 82.35%), including those who employed an eye tracker and those who used a mouse as an input method, reported positive sentiments towards the game's concept in their comments. A common point of praise among the participants was the intriguing nature of simultaneously controlling two game characters. One participant wrote: "I also found the concept of moving two characters at the same time very interesting as I have never tried something comparable before."

Most (12 of 17 or 70.59%) have also highlighted that they liked the visual appearance of the game. Also, some have written that they found the level design of the unique levels and their features positive (e.g., "I liked that there were several levels, each with special features.").

Participants who utilized an eye tracker as an input method expressed dissatisfaction with the functionality of the eye-tracking system. The majority of feedback for improvement from these participants centered around the eye-tracking system's capabilities. For example, one participant stated: "[I] had to measure out key points where the eye tracker did a good job. So I had to use these spots to get a little bit more control over the bat to make my way through the game."

One of the primary criticisms of "Shed Some Fear", in general, was the perceived lack of content. Suggestions for addressing this issue included incorporating hidden rewards or achievements within levels, as well as increasing the length and difficulty of levels. This was mostly mentioned by participants in the keyboard and mouse condition.

6 DISCUSSION

In this work, we evaluated the effects of gaze interactions on user enjoyment, perceived competence, and DES. To this end, we developed a novel 2D platform game called "Shed Some Fear". "Shed Some Fear" includes various eye gaze-enabled game mechanics that incorporate fixations, smooth pursuit, activation of peripheral vision, and interactions grounded in research on DES. In line with previous work, we found the gaze interaction to be challenging but fun [51, 69]. However, we also found that gaze interaction led to significantly higher internal ocular symptoms compared to the baseline. We discuss our findings in terms of game design opportunities, practical implications, and reducing eye strain.

6.1 On the Joy of Difficult Interactions

We found a significant interaction effect regarding competence (see Figure 7), showing that perceived competence increased more over time with gaze input compared to mouse input. Previous work in other game fields has shown that there is joy in challenging interactions [56] as long as no overwhelming challenge leads to a feeling of being stuck [14]. The challenge is a common theme for eye gaze-based interaction [50] and is often attributed to its charm. While this challenge was also found in previous work [51, 69], we must also acknowledge that our eye tracking (see Section 3.3) is not on par with commercially (but costly) eye tracking. This would most likely alleviate some of the challenges.

While the eye gaze interaction led to higher DES, we also found a significant interaction effect on competence (see Section 5.3), showing that the perceived competence is higher with the challenging interaction via eye gaze. With this, there was a trade-off between increased DES and perceived competence. Higher perceived competence, in turn, is an important characteristic and design goal for user enjoyment in games. With this, it is an intriguing concept to integrate eye gaze interaction as a way to facilitate challenging and enjoyable gameplay. However, this may have unintended consequences in increased DES, which have not been considered in-game interaction research. Although DES is a well-known problem in the use of digital devices, it has mostly been neglected as a serious impact factor on designing interaction techniques in HCI. This is particularly relevant for gaze-based techniques. Highlighting this problematic trade-off, our results emphasize that while gaze interaction comes with novel challenges that are enjoyable for players, it also comes with a potential health issue that is currently largely neglected by the community. Thus, we recommend that DES should be considered when evaluating novel game interaction techniques that are based on gaze-based interaction. Future work, therefore, must test how much eye gaze interaction is acceptable with regard to DES but can be used as a game mechanic to increase the level of accomplishment for players. DES should, in our opinion, always be assessed as a dependent variable.

6.2 Design and Practical Implications

Similar to the game *Twileyed*, the eye gaze interaction in our game "SHED SOME FEAR" created "Visual Dilemmas" [50]. Players needed to pay attention to the bat, leading to a situation in which they needed to use peripheral awareness for events happening to the main character. On the contrary, in the mouse version, the peripheral awareness can be on the bat. Therefore, such eye-gaze interaction can impose a specific focus on game interaction. This usage of focus for the gameplay was also employed by Ramirez Gomez and Gellersen [51] and in the game Shynosaurs [69]. Our work supports these previous results in that it was found enjoyable. Nonetheless, we found that the constant usage of the eye gaze increases DES. Therefore, future designs should be mindful of the usage of these interactions, potentially, only as a supplement to traditional interaction techniques.

6.3 Game Opportunities

Previous work on eye gaze interaction, especially in the field of games, mainly focused on the usability and performance of the interaction [52, 54, 66]. A better understanding of the tradeoffs of player experience and DES guides game developers who want to integrate eye-gaze in existing commercial games as an additional interaction technique and new games that build on this technique as a core interaction. Our findings show that this interaction can satisfy competence, enable mastery, and thus provide an enjoyable experience by providing new challenges. However, this comes at a cost of potentially leading to higher internal eye strain. As such, integrating eye gaze as an interaction technique should be used cautiously. Some potential implications to be explored in future work could be better design guidelines for such interactions that minimize eye strain, potential warnings included in games, or further developing the approaches that integrate eye exercises into games to alleviate symptoms as they happen.

By focusing on other aspects such as DES, there is a variety of related work that could be included in the design of eye gaze interaction. We provide exemplary interactions loosely based on previous work by Hirzle et al. [23]. The incorporation of these interactions was found to be enjoyable and challenging. While not in the scope of this work, we assume that there is the potential to use such interactions to reduce DES, thus, leveraging eye gaze not only for user enjoyment but for health-related purposes. Future work should address this research gap by explicitly evaluating whether these derived interactions can be integrated in games in a way to reduce DES.

6.4 Difficulty in Digital Eye Strain Countermeasures

Our data suggest that internal ocular symptoms were higher with gaze interaction than with the mouse. There may be various reasons for this, including conceptual but also technical reasons. As our eye tracking was not capable of achieving the performance levels of commercial systems, this is the first challenge to be tackled. Additionally, based on previous games that included eye gaze-based interaction, including "not looking" [49], movements behind eye lids [52], closing one eye [54], or actively changing pupil dilation [15], the most effective method for reducing DES, which is closing one's eye, could be included in "SHED SOME FEAR". For example, one game mechanic would require players to close their eyes until enemies have passed them, otherwise, they would be attacked. Until now, we did not include this into "SHED SOME FEAR" as our main focus was on evaluating the effect of eye gaze-based direct interaction. Additionally, the current version of non-commercial eye tracking does not support some interaction mechanisms, such as detecting eye movement behind eyelids.

Additionally, while we were aware that these DESC must be targeted towards the relevant DES type, we included various types as in our externally valid setting, we could not find out how participants spent their time during the day. Therefore, we were interested in how these interactions would affect DES.

6.5 Limitations and Future Work

The UnitEye eye-tracking software, while functional, is not a professionally developed program and thus does not possess the same level of quality as established software such as Tobii. Additionally, the use of a standard webcam for participant tracking can introduce variability in the data. The sample size of this study is relatively small, consisting of only 17 participants. The study's design allowed participants to complete the task in an uncontrolled environment, which may have introduced variance in how the game was played (i.e., duration, levels, setting). Thus, while being of high external validity, the internal validity is reduced. The externally valid setting led to numerous possible confounding variables. For example, we did not account for working day patterns. Finally, the low number of participants who finished the five sessions in the eye gaze condition could be a finding in itself. However, we do not have enough data to elaborate more on this.

Regarding future work, we propose to evaluate DESC in other genres as well, both directly integrated as a control input (as in "SHED SOME FEAR") but also passively, for example, via character movement to trigger saccades. Also, with other genres, such as 2.5D games, other game mechanics, such as fixation shifts, are possible [23]. While previous work also already employed blinks [15], this was also proposed as a DESC [23] and could be a valuable addition to reduce DES.

7 CONCLUSION

Overall, we implemented "Shed Some Fear" to study the effects of a gaze-based 2D platform game on user enjoyment, perceived competence, and DES. "Shed Some Fear" includes eye-controlled game mechanics at the core of its game design. The eye gaze interaction was built upon previous interaction techniques, such as fixation and smooth movement. Additional eye gaze interaction mechanisms loosely based on DESC in VR HMDs were integrated to study their effect on DES in eye-based mobile applications. In a longitudinal study with N=17 participants over five days, we found that the keyboard plus eye interaction led to higher DES scores compared to the baseline in which participants used a keyboard and a mouse. Qualitative feedback suggests that this is due to the low performance of eye tracking. Nonetheless, the eye-tracking features were enjoyed by the participants. This work helps to include eye gaze interaction in 2D platform games and provides empirical insight into its effect on DES.

OPEN SCIENCE

Upon acceptance, "Shed Some Fear" will be made available to interested researchers. This will include source code, installation instructions, and information on required 3rd party Unity assets.

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