Exploring Gaze Interaction Design in Games: Playing with Vision

Argenis Ramirez Gomez
Lancaster University
United Kindgdom
a.ramirezgomez@lancaster.ac.uk

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Abstract
Gaze interaction in games is rapidly increasing with examples in mainstream franchises. This research focuses on investigating new opportunities for gaze-enable game design moving away from sensing-based dynamics grounded in gaze pointing and consider a user-centred approach which has its starting point in visual capabilities and metaphors of looking. This approach will lead to the development of examples that illustrate novel and playful experiences that can be designed thinking about how the players see rather than where and what they look at. This research aims to contribute to the understanding of how to create playful gaze-based experiences by providing a design framework and inspire designers to engage in the conversation to shape the future of gaze interaction in play.

Author Keywords
Gaze Interaction; Games; Game Design; Play; Eye Tracking

CCS Concepts
•Human-centered computing → Human computer interaction (HCI);

Context and Motivation
Eye trackers have become a compelling input device for game interaction. They are a now affordable technology that has been integrated into mainstream games targeted

to the PC gaming community. The number of commercial games enabled with gaze interaction is rapidly increasing, with 142 released games to date (June 2019), including popular game franchises such as *Assassin's Creed, or Tomb Raider* [26, 16]. Gaze interaction promises enhanced gameplay experience. Players, with eye tracker, can aim at targets; control the camera movement [19]; tag opponents [6, 27]; or point guns [34, 8], just by looking at the game scene. In esports and game streaming, athletes can share with their audience where they are looking to show their strategies during gameplay.

Overall, literature is crowded with gaze interaction techniques based on gaze pointing. Moreover, gaze interaction in games moved from being a tool for accessibility [30] to be at the core of the mass gaming market. Gaze interaction offers to complement the game controller for performance and enhance the experience with greater immersion. Gaze signals interest because we intuitively look at the objects we seek to interact with [25]. In research games, gaze interaction is coupled with looking, and it is aligned with where the eyes point and are attentive to trigger interaction [31, 32, 18]. In mainstream games, gaze interaction is presented as a bonus feature that supports other controllers implicitly. Inevitably, gaze interactions become secondary to the game, and maybe redundant in the play experience.

We propose to move beyond the gaze interaction paradigm *"What you look at is what you get"* [11] because this use of gaze is obvious and when used to support other controllers might provide no challenge. For example, if we seek to shoot an enemy in a gaze-enabled game, generally we just need to press a button, and the gun will be automatically aiming at the location where our eyes are looking. First, we argue that gaze can offer much more than support in gaming and that designers can develop engaging and playful experiences that rely on the eyes. On the other hand, our research challenges gaze pointing paradigms.We aim to explore new ways to design gaze interactions in play and widening the design space of gaze by looking at vision capabilities and metaphors related to sight. Finally, we aim to contribute a new perspective on understanding the opportunities to design playful gaze-based experiences.

Research Objectives

Our research aims to provide insight into the future of gaze-enable games with the following objectives:

- Identify the design space of playful experiences around using vision capabilities.
- Investigate what types of narratives and metaphors related to vision can support gaze interaction mechanics in play.
- Illustrate with gaze-based game prototype examples of novel experiences that move away from traditional eye pointing and controller support and are engaging and fun.
- Develop a design framework that aides the design of novel playful gaze-based game experiences beyond gaze pointing and based on the insights gained from the study of the prototypes.

Related Work

The main thrust of interaction mechanics in gaze-enabled games range from the use of gaze to control the camera viewpoint [24, 19]; graphics rendering [7]; to adapt the difficulty of the game based on the player's gaze behavior [17, 1]; avatar movement control [10, 23]; to aim at targets [9, 4]; among others. Overall, the main concept is to use gaze pointing as the mechanism for the selection of objects of interest. Gaze has been used to enhance the feeling of immersion by adjusting visual graphics or augmenting other

Figure 1: *Twileyed* game.

Figure 2: *SuperVision* game.

input devices to improve their performance [29]. Our work is in contrast, proposing to use gaze interaction as a relevant-to-the-game mechanic, without which the gameplay would not make any sense, and in consequence, the user would not be able to play it.

Other creative uses of gaze in games that are aligned to our research objectives focus on designing dynamics based on eye movements other than fixations, such as pursuits [33, 12]; winks [3]; pupil dilation and closing eyes [5]; multi-player gaze [21, 2]; or communication between players [14] in collaborative [15] and competitive [20, 13] games. The underlying dynamics in these examples is to leverage the use of gaze and vision, exploring new and compelling ways to use gaze that are challenging by design. Our work follows these examples and aims to create game dynamics that inherently make the interaction more challenging and push the limits of vision and attention.

Moreover, *Velloso et al.* [28] provided a survey on commonly used gaze mechanics in games, creating a taxonomy of gaze interaction, highlighting the compelling future of gaze in games. Their approach is based on eye-tracking input types and sensing capabilities, illustrating the scope of gaze interaction in games from a technical perspective. In contrast, we propose to think about gaze capabilities rather than the limitations of the eye tracker to develop a design framework based on what it means for the user to interact with the eyes, from a user-centred point of view.

Methods

The research approach in this work is design-led. We developed games that showcase a different use of gaze interaction beyond gaze pointing that try to leverage human vision capabilities. We consistently use as a development tool metaphors to illustrate each work and contextualise the use of gaze in the game. The collection of design iterations in this research helped to develop a constellation of game narratives that support the concept of playing with vision, and what we can do with the eyes.

Our work aims to move away from the technical design approach presented in previous research and develop a conceptual and design framework based on the user experience of "looking" in play.

1) Playing with Tension and Attention: Twileyed
We designed the game *Twileyed* (*Figure* 1) with three mini-games that explore commonly used forms of adapting gaze for interaction. In the games we investigated *Gaze Selection*; *Gaze Navigation*; and *Gaze Aiming*. We added tension to these gaze mechanics in the form of inaccurate gaze mappings and ambiguous gaze interaction dynamics, making them anti-intuitive. The games play with two different ways to play with the eyes that need to be balanced at the same time, posing, for example, attention dilemmas. All three games use the keyboard arrow for the character navigation and gaze for modulation, and they are illustrated with characters from literature that represent some duality, using this as a reference to explain the ambiguity of gaze interaction. With a user study, the games served as data to reflect on the challenges of this research proposed design space.

2) Playing with Peripheral Vision: SuperVision
We designed the game *SuperVision* (*Figure* 2) to illustrate *playing with peripheral vision* as a novel conceptual framework [22]. *SuperVision* is used as an umbrella application containing three mini-games with narratives and metaphors from literature and pop culture characters that experience a gaze challenge and require the player to assume their gaze hurdles and use their peripheral vision to solve the game tasks. Each game presents a challenge to the player to understand the game objects that appear in the scene while

keeping their eyes away from looking directly at them. If they look, they get penalised during gameplay. Each challenge is based on mouse manipulation and visual perception sorting tasks that push the player to leverage their innate capabilities on peripheral vision perception.

Results

We used the Twileyed games as data and the device to reflect on the gaze design space, challenges, questions and dimensions of gaze gameplay during a user study with twelve participants. We asked them to play the games and observed their experience and strategies. Based on the observations we discussed through 5 themes, the questions and opportunities to create engaging and playful gaze-enabled games. The resulting discussion arose topics on the challenge of using gaze for both sensing and action, with a focus on attention to understanding the ambiguity of the interaction, and visual dilemmas. Moreover, we discussed the use of ambiguity and metaphors to create engaging and playful experiences. Finally, we identified how playing with gaze interaction opens up the space to design with gaze taking different identities. We refer to "identity" to what or which game element the user's gaze controls. With *Twileyed* we aimed to engage the gaze-enabled games research community to think out of the box.

SuperVision [22] was studied with twenty-four users and a follow-up study with 5 participants. We evaluated the gameplay concept and the participants' peripheral vision capabilities before and after playing the games, to test for skill development. The results confirmed the high level of challenge involved in playing with peripheral vision, and that this can provide an engaging and enjoyable experience. Participants were proficient in overcoming the game challenges, developing clear strategies to succeed. Moreover, We found a significant improvement in object recognition in the participants' peripheral vision after playing the games. This greater awareness gain could be a good asset, for example, to train athletes or design notifications that could be picked up without looking for safer driving. Finally, we discussed how the games posed not only a visual perception challenge but were also related to inhibition control of the impulse to look at objects that attract our attention. Through gameplay, players were able to learn how to control the impulse showing that the games could offer a gamified alternative to psychology tests with similar dynamics.

Future Work

In future work, we are exploring the use of other looking metaphors, and we are working on a game that relies on blinks for gaze interaction. We plan to investigate this mechanic previously used for accessibility as the primary control in a playful application. Finally, we aim to generalise the findings of all three-game design iterations into different design models that create both a conceptual and design framework based on metaphors of looking and modelling players' gaze behaviour.

Contributions

In summary, this work will contribute to provide a new conceptual framework to design playful gaze-based experiences around the capabilities of gaze and metaphors of looking. We aim to extend the current understanding on gaze-enabled game genre with this new approach, opening up the space to new opportunities for game designers and researchers. Our work is contributing to gaze-enabled games interaction research by providing a new conversation agenda. Moreover, we aim to contribute to game theory by proposing a design framework to guide designers to create future work that engages in this new approach. Finally, we are providing practice examples that illustrate the use of the framework to design playful gaze interaction experiences.

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