Exploring the Effects of Gaze Awareness on Multiplayer Gameplay

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Abstract
During tabletop gameplay, players monitor each other's gaze throughout, providing a form of implicit nonverbal communication. A player can infer the intention and potential strategies by estimating the gaze of another, especially in co-located gameplay. This early work-in-progress paper details an exploratory study design that explores the effects of gaze awareness on gameplay, in particular when the gaze of one or more players is augmented over the game and revealed to others. We believe that players may very well change their strategies when gaze becomes 'common knowledge', but can also be used as a form of deception. We will explore these effects with the same game in two settings: a screen-based digital version with players in separate rooms and a co-located tabletop board game version augmented with a projector. This work evaluates the effects of gaze awareness in both settings, providing new insights towards the emerging research of EyePlay.

Author Keywords
Eye tracking; Gaze tracking; Co-located play; Multiplayer; Tabletop games; Board games; Video games; Cognitive strategies; Gaze awareness; EyePlay

ACM Classification Keywords
H.5.m [Information interfaces and presentation (e.g., HCI)]: Miscellaneous; K.8.0 [General]: Games

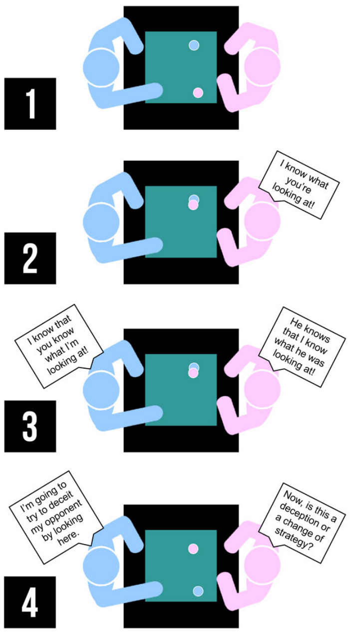

Figure 1: Illustration of deception when gaze is visible to both players in a co-located multiplayer gaming environment.

Introduction

Gaze is a very powerful nonverbal signal. It signals dominance, attraction, shared attention, filiation, intention, among other social effects. It is also a very informative signal in gameplay, as players monitor each other's gaze during gameplay [7]. This is evidenced by poker players' common practice of covering their eyes with sunglasses to hide any "tells" [14]. It also plays an important part in turn-taking by indicating when it is another player's turn [11]. However, in conventional social interactions, gaze is largely invisible. This project aims at exploring what happens in the game when we make this invisible signal visible.

This paper seeks to understand the effects of gaze awareness on gameplay in two types of multiplayer games i.e. tabletop board games and multiplayer screen-based digital games. On tabletops, players are encouraged to interact face-to-face with one another by engaging in collaboration, competition or cooperation depending on the game. Speech and gestures are well-known modalities used for communication during gameplay, typically during one's turn in a turn-based game. Gaze happens throughout the game providing a form of visual evidence towards intention and insights into potential strategies. Gaze also plays an important part used for communication cues for turn-taking and can decrease by up to 25% when absent [11]. Tabletop games in particular demand constant attention, requiring regular thought processing and frequent changes to short and long term strategies. Explicit gaze can provide insights into these processes, changing the dynamics of gameplay.

On multiplayer digital games, the gaze of players is absent, varying aspects of gameplay especially if the game was originally designed for co-located gameplay. Players are still able to guess based on previous actions but without social cues, it may prove to be somewhat difficult. This difficulty is exacerbated when gameplay is purely visual (e.g. poker). With the advancement of current eye tracking technology, the gaze of another player can be made explicit on their respective screens, potentially bridging this gap. We look towards EyePlay, an emerging field of research which refers to the playful experiences that take input from the eyes [8, 9]. Our work aims to extend this body of literature by demonstrating that gaze can be used to different ways to create new experiences in multiplayer environments.

Background

In games that employ social gaze mechanics, the adaptive AI can change aspects of the game based on a player's gaze [12, 13]. If a computer can perform such actions, it is possible for humans to adapt and make changes to strategies as well once gaze information is made visible. Infants within the first 18 months of life develop mechanisms of joint visual attention (looking where someone else is looking), a natural behaviour [2]. Gaze plays a major role in social aspects of our lives. Researchers in both areas of psychology and HCI have investigated the role of multiuser gaze behaviour, patterns and awareness during communication (e.g. [10]). However, there is a lack of investigation specifically on gaze behaviour in multiplayer games and none on the effects of gaze explicit during gameplay in both digital and co-located contexts. Gaze can be visualised on surfaces in several ways such as by using *scanpaths*, *heatmaps* dominantly used in usability studies that employ eye tracking or by displaying the real-time gaze point [3].

When the gaze of all players is revealed, gaze becomes 'common knowledge', a term used in game theory with regards to logic that affects strategy assuming that all players are rational [6]. For example, take two players, P1 and P2. P2 looks at the gaze point of P1 and P1 now knows that P2 is looking at her gaze point. In this situation, multiple rational scenarios may occur. One possible scenario is the act of deception where P1 can shift her gaze to another part of the surface and potentially confusing P2. This 'I know that you know that' concept is illustrated in Figure 1. Such deception techniques go back to World War 2 spycraft [5], for example, signalling left but turning right to deceit a shadowing vehicle. This touches on theories of 'shared awareness' from behavioural sciences [4].

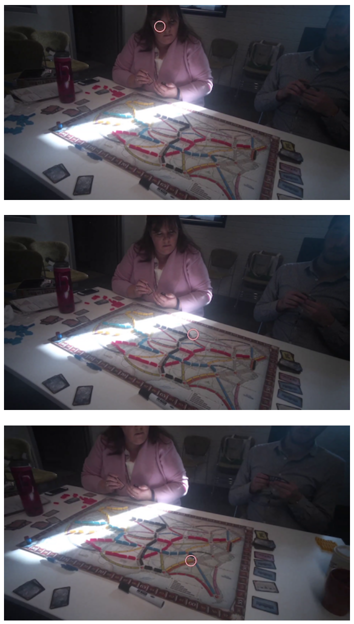

Figure 2: Demonstration of joint visual attention analysed from our feasibility study. Top: The subject glances at the gaze direction of another player. Middle: The subject looks at the area that he/she thinks the other player is looking at. Bottom: The player's gaze shifted further and the subject's gaze follows accordingly.

Study Designs

Following our feasibility study, we designed two studies to determine the effects of gaze in both traditional and digital versions of the same board game. Results from a study that compared both versions of the same game showed that when the digital version is a direct adaptation of the traditional version, there is little subjective difference between them [1]. We believe that by making gaze explicit on both versions, the results will be different, and we will compare these results accordingly. Therefore, we have chosen a board game that is identical in both versions and designed two studies in accordance, testing effects of the play setup (remote *x* co-located) and type of gaze visualisation (real-time *x* averaged over time).

One of the many insights we hope to gain from comparing both versions is whether gaze awareness has any effect at all especially in the co-located setup. The eyes of the opponent are present in this setting, and players can infer from the each other's eyes in addition to the exposed gaze on the interface. In contrast, players have to rely on actions and the gaze visualisation (if present at all) in the remote setup. We intend to explore concepts of gaze awareness further, including drawing comparison between the both.

Board Game

We selected *Ticket to Ride*[1], a 2-5 player board game that can be learned in under 15 minutes and have chosen to use North American edition in which the physical and digital versions are almost identical. In *Ticket to Ride*, each player must build railroads connecting specific cities on the map that has been randomly drawn by each player. In general, the longer routes the better but there are a number of ways to score or keep points. Players do not know which cities their opponents are meant to connect and must do their best to hide their goals, as other players might cut their railroad off. Therefore, players must balance building their own railway, hiding their intentions, and trying to discover their opponents' goals to prevent them from winning.

Feasibility Study

To test the technical feasibility of the study, we conducted a pilot exploratory study. We recorded and analysed the eye-tracking data of a single player using the Tobii Pro Glasses 2[2] eye tracker during a hour long gameplay session with four players. Our analysis has already identified several interesting behavioural patterns during gameplay. In many instances, the player was attempting to infer the area of the board in which another player is looking through joint visual attention (see Figure 2). With regards to eye tracking on conventional desktops (e.g. PC), we know from the EyePlay literature that gaze can be tracked effectively using consumer-based low-cost remote eye trackers. Another finding is that the player's gaze shifts quickly between the cards in his hands and the board when he does not have a strategy before hand or needs to change it during his turn. The player will determine the best possible move without taking too long, primarily so that other players are not kept

[1] http://www.daysofwonder.com/tickettoride/en/
[2] http://www.tobiipro.com/product-listing/tobii-pro-glasses-2/

waiting but it is possible that he/she is attempting not to give away his potential strategies as other plays are watching.

Study 1: Remote Gameplay

In our first study, we examine the effects of gaze with two players using desktop computers seated in separate rooms. Each desktop will be fitted with a Tobii EyeX[3] eye tracker with data streaming to each other. The gaze visualisation will be augmented onto the game using a custom built application that runs in the background. The following conditions will be tested:

1. Gaze is not visible to either player (baseline).
2. Both players can see each other's gaze, and both players know that the other player can see it (symmetrical aware).
3. Both players can see each other's gaze, but both believe that only they can see it (symmetrical unaware).
4. Only one player sees the other player's gaze, but the other player does not know that the other player can see it (asymmetrical unaware).

Condition 1 serves as the baseline, reflecting the conventional gameplay with no gaze visualisation. In this condition we will only record the gaze data. In Condition 2, players have both the knowledge of the other player's gaze and that the other player also can this player's gaze. This condition is analogous to the co-located version, where the game happens on a shared board. In Condition 3, both players will see each other's gaze point, but each will believe that they are the only ones with this power. In this condition, we are interested in whether players will be able to discover that the other player can see their own gaze simply by their gaze patterns and changes in game strategy. Finally, in

[3]http://www.tobii.com/xperience/

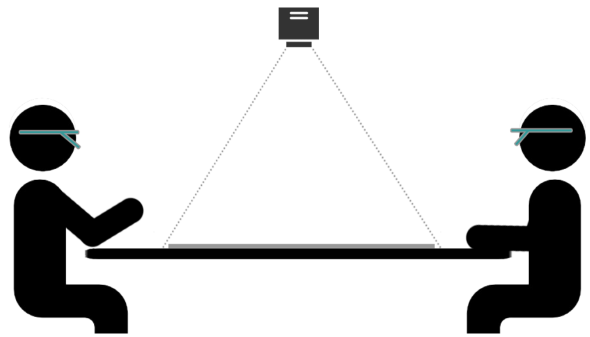

Figure 3: Study 2 Configuration.

Condition 4, we are interested in what happens when the game is tipped in favour of a single player, who can see the opponent's gaze point.

Study 2: Co-located Gameplay

In this study, two players will play the board game version of *Ticket to Ride* on a tabletop. We will equip both players with Pupil Pro[4] wearable eye trackers which streams gaze data to a single computer connected to a top-down projector (see Figure 3). Gaze information will be processed, and its visualisations will be projected from above, augmenting both the board and the game objects. We note that this is a major technical challenge i.e. registering the play area to the eye tracker and ensuring the projections corresponds to the correctly gaze points of both players. As both players share the same surface, we will only test conditions 1 and 2. By augmenting gaze in this setup, the dynamics would be very different. For example, it is possible actions such as deception may arise more evidently as one player is able to tell whether the opponent is engaged in following their gaze as both players share the same play area and view.

[4]http://pupil-labs.com/pupil/

Procedure
For both studies, we will recruit experienced players from the local board game club and we will form random pairs. Both players are required to fill up a consent form and a demographics questionnaire. Once completed, each player will perform the respective calibration procedure. The pair will start by playing the game once they are calibrated with the condition where gaze is not visible to create a baseline. In the co-located setup study, as only one other condition can be applied, the pair will be asked to play two rounds under the second condition. In the remote setup study, we are able to test all conditions, therefore requiring the pair to play four rounds in total. The second and third conditions will be tested sequentially. For the last condition, we will tip the favour of the player with the lesser wins. We would like to determine if condition has clear advantageous benefits to the player. We estimate each game to take a maximum for 30 minutes, but on average lesser, as the players will be familiar with the game. After completing all the required conditions in either setting, we will evaluate the views of the pair. The type of gaze visualisation will be cycled through for each pair. We will take observation notes during the sessions and which includes the time stamps for evaluation purposes. In addition to the screen and eye tracker recordings, we will record the gameplay using a top-down camera and various angles afforded by our observation lab.

Evaluation & Measures
The *selective cued recall* research methodology will be used immediately after each pair has finished playing the necessary rounds and conditions. They will be asked to report what they were thinking in that moment as we show them clips from the study. In particular, sections of the video that we have noted down during our observation. We will attempt to find out the points in which players changed their strategy or deceived their opponent through the gaze information provided by our system. Participants will be prompted for further discussion, i.e. which gaze visualisation they found useful and their views on the particular condition given. This data will form the basis of our qualitative end of our evaluation. As for quantitative data, we will measure the gaze against the actions of the users and the what the user was looking at. This includes the player's own tracks, future tracks, and the tracks that they believe the other player will build on. Moreover, we will analyse our data collected in order to quantify the amount of time the player has spent on determining their own strategy, their opponent's strategy and percentage of time that they spent looking at these two types of places in their turn compared to other players turn. This will be compared across the conditions employed. In the second study, we are able to measure beyond the board itself such as by determining the percentage of time the other player spent looking at other player's hands, faces or eyes. At this point, we remain unsure which gaze visualisation technique works best to enable gaze awareness between the players. We will take this into account through the performance of the players.

Conclusion
By making gaze explicit and aware to players in multiplayer gaming environments, we have opened up numerous questions with regards to its effects upon gameplay. This includes the type of gaze visualisations employed, the awareness of players and the differences between co-located and remote settings. This work hopes to provide new insights and contribute towards the emerging research of EyePlay.

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