Gaze-Based Onlooker Integration: Exploring the In-Between of Active Player and Passive Spectator in Co-Located Gaming

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ABSTRACT
In co-located gaming, a player is often watched by another person who has no direct interaction with the game. For such a potential onlooker, the game setting is mainly experienced with ones eyes by looking at what happens on the screen. An integration of an onlooker's gaze into the game could potentially improve the game experience of player and onlooker. In this paper we report a study based on an interaction concept that uses the gaze of a second observing person during a co-located gaming situation as an input modality to assist the player. Our study investigates the effects of different levels of gaze-based onlooker integration and their influence on the player's and the onlooker's experience. With our research we want to address the "in-between" design space of being an active player or a passive spectator. Our findings show that gaze-based onlooker integration can address this "in-between", and change the game experience for both player and onlooker for the better.

Author Keywords
Gaze-based Interaction; Co-located Games; Game Experience; Social Interaction; Embodied Interaction

ACM Classification Keywords
H.5.2. [Information Interfaces and Presentation]: K.8.0 [Personal Computing]: General - Games;

INTRODUCTION
When games are watched by an audience or another co-located person, the interaction between players and their audience shapes the overall gameplay experience. Even in single-player situations where only one person is "in-control", a potential *onlooking* person impacts the player's experience and performance [18]. Often, the onlooker tends to compensate their lack of input by giving spoken commands (e.g., "jump over there!" or "watch the enemy on the right!"). In challenging situations of high workload for the controlling person, the observing person can take a special role and be a helpful source of advice. Thus, these experiences with two people sharing the same screen can be highly collaborative even if only one person holds a controller. This symbiotic relationship [14] between player, game and audience leads to a "social experience of play" [15] that strongly affects play in co-located scenarios. The resulting social experiences are important to understand when designing for co-located gaming scenarios as this player-audience relationship has a major impact on how the game is actually experienced [15]. Prior research studied the influence of an audience on a players' performance [18] and on the relationship between the player and potential onlookers [21]. Besides this social facet, the aspect of having another person physically present in co-located settings affects both player and audience. In that regard, Kappen et al. [15] investigated the influence of different types of co-located audiences (i.e., silent, positive and negative) on the actual player experience in a multi-player setting. Their findings show that an active audience increases the engagement of players.

Based on that, we want to specifically explore a single-player situation with a co-located onlooker in order to better understand this onlooker role and to gain an understanding of this person as being a potential "non-controlling player". We define such a "one person audience" with the term *observer* and aim at exploring how to integrate this person into the game experience via gaze-based input. For a potential onlooker, such a setting is mainly experienced with the eyes. Therefore, we wanted to give this natural role of spectatorship an in-game representation and explore an observer's gaze as an input modality for a game. With this approach we aim at transforming an audience member into a potential non-controlling player and enable actions on a level beyond conventional controller-based input.

In line with prior research [10], we argue that there is a design space between being an active player and being a passive "onlooker", which we want to address with our concept of gaze-based onlooker integration. We think that in better understanding this "in-between" and the role of the observer, we can create collaborative game designs beyond conventional

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controller-based input. If we better understand the interplay between player and audience, our ability to design for such co-located scenarios can be improved [15].

With our work, we are building on and extending the prior line of research by exploring the influence of an observing person assisting a player utilizing gaze-based input in a co-located game setting. We developed a prototype game setup that uses the gaze of an onlooking person (i.e., the observer) during a co-located gaming situation as an input modality to assist the player (e.g., spatial referencing within the game). We conducted a first exploratory study to investigate the effects of different levels of gaze-based assistance: 1) no observer input, 2) spatial referencing via gaze, 3) combining player input and observer gaze input and their influence on the player's and the observer's experience. Our hypothesis is that with an increased amount of possible observer input, both participants are more engaged in the overall gaming experience. We design different forms of embodied audience integration in order to create a social coupling between player and audience. Accordingly, we utilize the game as a mediatory artifact generating this coupling.

In this paper, we present the design of our prototype, a game that aims to harvest the potential of gaze-based observer input. Our game setup acts as a proof of concept and is an important step to inform the design of cooperative game mechanics based on social interaction between potential onlookers and players. We show different ways to integrate an onlooker into the game experience to explore the "in-between" design space between active player and passive onlooker.

BACKGROUND

There is a spectrum of different levels of game engagement, ranging from *passive spectatorship* to *active play* [15]. Downs et al. [10] found out how audience member's experience changes as they become more active. Hence, they suggest looking at design opportunities in-between "purely active players and passive audience members". To address this design space, we want to study different (embodied) forms of audience integration in order to inform the design of games that enable active audience members.

Related Work

Gaming as a collaborative practice

By looking at games in a broader context and defining them as a *situated collaborative practice* [29], the meaning of a game's social setting gains relevance. Gaming experiences are often driven by a certain social context and setting where the presence of others affects the players enjoyment ([16], [11]). Research done by Kappen et al. ([14], [15]) studied the aspects of co-located gaming and its inherent social interactions, whereas Bowman et al. [5] point out the influence of other physically present persons on a player's in-game performance. Besides the audience influence on the player's performance, also the player's enjoyment itself can be defined as a function of social setting [7]. This especially applies to co-located gaming where the experience is often directly related to social interaction with another person (e.g., via the game as a shared interaction space).

Due to the collaborative nature of games, it is important to understand how to design for cooperative game mechanics that engage people in such a social setting. To evaluate such mechanics Seif el Nasr et al. [28] developed a methodological approach that investigates cooperative games and introduced Cooperative Performance Metrics (CPM) that can be mapped to cooperative in-game patterns that caused them. Toups et al. [34] state the importance of enabling players to "share information and direct action by engaging with game systems." They investigated different games for their in-game possibilities to communicate with other players, e.g., via in-game actions and propose to aim at *designing for communication* to create immersive experiences that deepen the players' involvement in the game.

Thus, a designer's ability to specifically design for communication in games is closely related to a game's ability to engage people. For instance, sharing and synchronizing an interface can foster storytelling and encourage collaboration [1]. Other research by Rocha et al. [27] describes common design patterns in cooperative games such as shared goals between players and synergies of abilities. Further, Zagal et al. [38] point out common pitfalls and design considerations when designing cooperative mechanics by looking at the domain of board games. Especially in board games and other co-located game settings the physicality of another person adds an additional layer of (non-verbal) interpersonal communication. The influence of social presence [7] or mocking gazes from potential spectators [12] on the player's engagement, also shows the close relationship between player and audience.

Gaze-based Interaction

One of the most important non-verbal cues in communication between persons is eye contact, building the foundation for social interaction [19]. Eye contact regulates for example information flow [17] and allows insights on the relationship between communication partners. Specifically in the context of mediated communication, eye contact correlates with higher levels of co-presence (e.g, [2]). Capturing and utilizing this non-verbal behavior as a communicational resource, has proven to be important to support collaborative interaction [32].

Eye-based interaction as game input is more and more part of recent research. Existing game related research ranges from aspects of effectiveness of eye-based game inputs [30], to using gaze as a supplemental input [36] to fully controlling player characters via gaze input ([24], [25]). However, there is little research on collaborative game settings that use gaze as input. Lankes et al. [20], for example, investigated the effects of utilizing gaze input on the perceived in-game presence of the player and showed that it promises great potential for game designers. They highlight the ability of gaze input to facilitate presence on three different dimensions (i.e., Embodied Presence, Spatial Presence: Self Location, Spatial Presence: Possible Actions).

The concept of using "shared gaze" in a co-located setting has been investigated in other domains before (e.g., using gaze for collaborative in-car navigation [22]). Similar research indicates the importance of gaze for collaboration by stating, “People can coordinate collective behavior using shared gaze alone” [6]. Research from other domains [4] experimented with a setting where two agents with partial knowledge had to collaborate via gaze in order to complete a task. They based their experiment on a setting with one person in the role of *the informer* and the other as *the manipulator* demonstrating that the vision of another person’s gaze can significantly improve performance in a cooperative task.

We argue that such a setup also applies to co-located gaming scenarios with one person in control and another person as the onlooker. We aim at harvesting and exploring the potential of gaze-based onlooker integration for gaming and give the onlooker the special “informer role”. With this in mind, we investigated the potentials and usage of shared gaze as a means of assistance and onlooker integration in a co-located gaming situation.

Embodied Interaction

Embodied Interaction as a stance towards interaction design has been introduced by Paul Dourish [9]. In its core, the notion is to design interactions, which are meaningful for humans as social creatures with sentient bodies, who interact through their bodies with their surrounding social and physical world. In a similar direction, the perspective of sensorimotor couplings describes how the human senses influence cognition and action. Based on that, Van Dijk et al. [35] describe the relevance of social situatedness and sensorimotor couplings for understanding a user’s behaviour in a specific context. They show how the *social* and the *sensorimotor* aspects of embodied interaction are part of “one integrated sensemaking process” and debate the importance for designers to be aware of this fact. They propose to intervene more directly into the socio-sensorimotor loop to find new design opportunities and understand user behaviour. They describe cognition as an “ongoing achievement of social coordination” where ”physical artifacts function as mediating objects in the way people deal with each other in the context of a situated practice” [35].

We argue that this perspective of a collaborative sensemaking process in a situated practice can also be applied to co-located gaming, with the game itself in a special role as a mediating artifact generating a social coupling. The design discussed in this paper uses different embodied representations of a persons gaze for in-game collaboration. With this we aim at changing a social game setting for the better and making use of existing human non-verbal communication skills (i.e., rooted in interpersonal interaction and eye-contact) towards embodied interaction in play.

INTERACTION CONCEPT AND GAME SETUP

Our interaction concept is based on the idea of integrating an observer during a single-player game via gaze input. In our setup, both participants (i.e., player and observer) have a direct link to the game, but on different levels (player→controller-based; observer→eye-based). By capturing the observer’s gaze, we gain the opportunity to give the gaze-point a certain “body” and graphical representation within the game. This enabled us to either change the gaze representation’s physical dimensions (changing it’s size, form, etc.) or semantical dimensions (its meaning within the game world). In doing so, the graphical representation of the gaze-point becomes a design element, giving it different visual abstractions and forms, more or less related to the game world itself. For instance, using an abstract point visualization compared to using another game character as a graphical representation of the gaze-point. Another dimension in the design space is to change the affordance of the gaze as a tool (i.e., giving it a specific meaning within the game).

Based on that, our interaction concept presents two different gaze-based input conditions: one simple gaze representation with no semantics associated within the gameplay other than being a pointing device (see C2 in Figure 1), and the other one with a specific affordance and meaning within the game (see C3 in Figure 1). These visualizations of the observer’s gaze (i.e., utilizing where the observer is looking) enable different levels of input. By coordinating each others input, both participants create a social coupling, i.e., a link between motoric skills and sensory system of two different persons within a common task. The game itself acts as a mediatory artifact generating this coupling, which results in a potential enhancement of the existing symbiotic relationship between game, player and observer.

During a co-located game setting, we investigated how the visualization of the observer’s gaze is used to collaborate within the game and how this integration of a second co-located person affects the game experience of both participants. We provided three different levels of possible observer input: 1) no direct input, 2) spatial referencing via gaze and 3) using the observer’s gaze as a tool (see Figure 1).

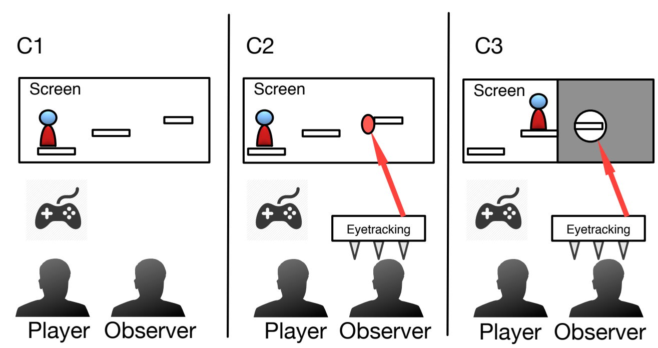

Figure 1. Different conditions of utilizing the observer’s gaze. C1) no direct input, C2) spatial referencing via gaze and C3) observer’s gaze acts as a “virtual flashlight” uncovering greyed out areas of the game world.

Condition 1 - no observer input

In this baseline condition, the observer has no direct input for the game. We investigate this setup to see if the observer is actually trying to compensate the lack of direct input by assisting the player via, e.g., verbal input and/or pointing gestures.

Condition 2 - gaze input for spatial referencing

In this condition we augment the game by visualizing the gaze-point within the game, enabling the observer to use the gaze for input purposes, e.g., by providing spatial cues to the

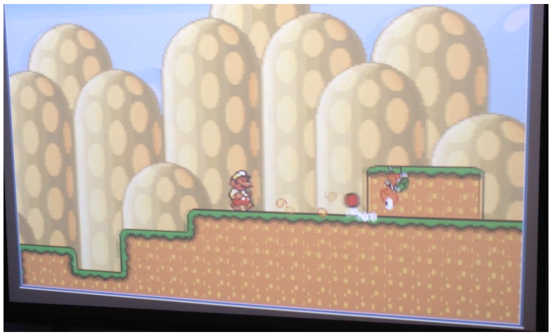

Figure 2. Condition 2 with gaze-point visualization. The red dot indicates where the observer is looking (used to e.g., warn the player from approaching enemies).

Figure 3. Laboratory setup showing the player with game controller, the eye tracking cameras for the observer and the game with gaze visualization utilized as "virtual flashlight".

player in order to warn of approaching enemies or pitfalls. The point itself consists of a red point with a black border, to ensure that it will be clearly visible within the game.

We chose a simple point visualization as it has no inherent semantic meaning and is an abstract means of communication (i.e., it doesn't provide any additional information besides it's location). Our assumption was that this input modality is either used consciously by the observer to communicate information by, e.g., pointing on things or unconsciously based on unintentional or intuitive movement of the gaze point. By augmenting the interface with the observer's gaze point, we want to explore if the observer's awareness for his/her own gaze rises and if this new means of in-game communication is consciously used in our experiment.

Condition 3 - utilizing gaze as a tool

The third condition of our setup is based on greying out the right area of the game world, which can only be made visible by the observer's gaze input (see C3 in Figure 1). The observer's gaze acts as a "virtual flashlight"[1] and uncovers the greyed out areas to make the parts of the gameworld visible. Without the help of the observer, the player cannot see forthcoming obstacles, platforms, or enemies within the game world. Thus, the gaze is used as a specific tool with an affordance and semantic within the game. This gives the observer a certain "expert role" related to the notion of being an onlooker and using the eyes as a tool. The movement of the avatar and the gaze of the observer have to be coordinated to succeed in the game. The result is a coupling between the avatar movement done by the controlling player and the eye movement of the observer. Thus, we give the "observer" a role that fits the real world notion of being an "onlooker" in this setting. The observing/scanning nature of the observer's eye movement is utilized and becomes a relevant input and tool for the game.

Based on these different conditions, we want to investigate how player and observer experiences changes when the observer as an audience member gets a means of input and assistance and how this influences the game experience for both participants. As a testbed for our concept, we used a web-based version of *Infinite Mario Bros.*[2] which is a clone of Nintendo's classic platform game *Super Mario Bros*. As this special implementation of the classic Super Mario Bros. procedurally generates the level while playing, the player doesn't know of platforms and enemies in advance (i.e., the player can't learn the levels). The increased difficulty of constantly having to face unexpected obstacles, also gives meaning to potential assistance done by the observer. We also chose this game due to its simple mechanics, its two dimensional movement and its free availability.

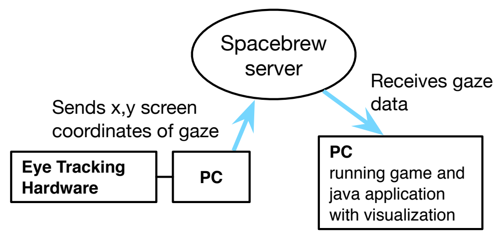

Figure 4. Technical setup: The Spacebrew server receives the gaze points X and Y coordinates from the PC handling the eye tracking hardware and sends them to another PC running the game and visualization.

Technical Setup

We capture the gaze of the observer person with a three camera eye tracking system[3] and visualize it within the game using the X and Y coordinates of the gaze. The player's input was done with a standard XBOX game controller. The game runs in a browser behind a separate java application that draws the visualization above the actual game. Communication between the eye tracking software and visualization was done via Spacebrew[4], which is a websocket-based prototyping framework. The Spacebrew server receives the gaze points X and Y in screen coordinates (intersection point of gaze and screen) and sends them to another PC running the game and visualization. To avoid disconcerting jumps in the

[1]A similar "flashlight metaphor" was also used in previous projector-based interactions by Rasker et al. [26]

[2]URL: http://rawrbitrary.com/arcade/infinite-mario-bros-in-html5/ Infinite Mario Bros. was also used by [33]; sourcecode available: http://julian.togelius.com/mariocompetition2009/

[3]http://smarteye.se/products/smart-eye-pro/

[4]http://docs.spacebrew.cc

visualization and to provide a smoother movement of the gaze point, we filtered the gaze values before sending them to the visualization application. In case of tracking losses where the tracking system would send zero, the last valid value was (re)sent instead. The visualization of the gaze point itself consisted of a red core point with a black boarder, to ensure that it will be clearly visible even for color blind participants. In order to receive accurate gaze data, the eye tracking hardware was separately calibrated for every participant using a pattern of 15 on-screen points that was utilized to calculate the user's gaze in relation to the screen. The game was played in a typical living room setup with both participants sitting in front of a large screen (see Figure 3). The technical setup is shown in Figure 4.

EXPLORATORY STUDY

Goal

With the above mentioned setup a user study was conducted to explore the effects of different levels of gaze-based observer input and its influence on the experience of both participants. For that purpose, we used the Game Experience Questionnaire (GEQ) [13], consisting of seven scales: positive affect, negative affect, flow, sensory immersion, tension, challenge and competence. In addition, we also used the Social Presence in Gaming Questionnaire (SPGQ) [8] to explore how our approach changes *empathy, behavioural engagement*, and *negative feelings*.

Procedure

Six gaming sessions with teams of two persons (between the age of 27 and 36; 4f, 8m) took place within our lab. After every condition both participants filled out the GEQ and SPGQ questionnaires. After finishing all three conditions, participants changed sides, making the observer the new player and vice versa. The order of the three conditions was randomized for every participant pairing. The overall questionnaire (combination of GEQ and SPGQ) included 50 items which could be answered on a 5-point Likert scale ranging from 1 (not at all) to 5 (extremely).

All sessions were observed by a researcher taking notes on how the participants used the gaze visualization and potential collaboration strategies emerging from the observer's gaze. These notes were collected based on a pre-defined scheme, including which modalities were used to communicate in every condition (e.g., only gaze, gaze in combination with verbal comments, or in combination with hand gestures), who communicated (i.e., player or onlooker), and game context of communication (i.e., in-game movement of avatar and gaze). The notes were then analyzed according to the basics of qualitative content analysis introduced by Mayring [23]. After the game sessions (about 50 minutes each, 5 minutes per condition), both participants were separately asked two additional questions: one regarding their overall level of gaming experience (high, medium, low) and one on what condition or "role" they liked the most. The researcher who observed gameplay also administered the questionnaires at the end of each experiment, but the participants filled out the questionnaires alone and without any interference of the researcher.

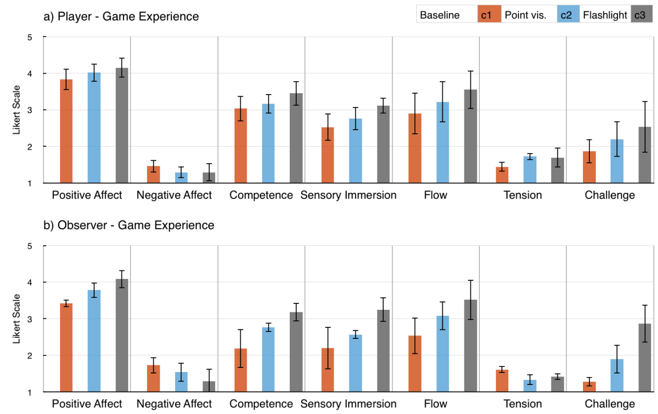

Figure 5. Results of the Game Experience Questionnaire for a) the player and b) the observer; measuring the scales positive affect, negative affect, competence, flow, tension and challenge in all three conditions. The plots show the means for the different scales (1 = not at all, 5 = extremely; error bars indicate standard deviation).

RESULTS

Analysis of Quantitative Data

In the following, we report the analysis of the quantitative data collected in the study using questionnaires. First, we present general trends based on graphical presentations of the data. Then, results will be interpreted based on fitting a statistical model to the data.

General Trends

The plots of the frequencies in our data (see Figure 5 and Figure 6) show clear tendencies and differences between the three conditions. The data supports our initial assumptions considering the level of observer-based input and its influence on the overall game experience. Moreover, there seems to be a synchronization of player and observer experiences.

The scorings for *positive affect*, *competence*, *flow*, *sensory immersion*, and *challenge* increased continuously from condition one to three for both, players and observers (see Figure 5). In condition three, scores by observers are elevated to similar values than those reported by the players. Looking at the graphical presentation of the data, one can also confirm that with an increased amount of input capabilities for the observer, the scores concerning social presence received higher ratings (see Figure 6).

In condition three, similar scores are reported for *competence* by players and observers. This is especially interesting as only one person has actual input for the game (i.e., controls the movements of the in-game character) and the observer can only assist (i.e., using the flashlight). Hereby assistance can take different forms. It can mean that the observer "holds" the flashlight right in front of the game character, but it can also mean that the observer guides the player actively by moving the flashlight. This further points towards the fact that when giving the observer an "expert role" within the game, the in-between design space of active player and passive audience member can be addressed. Thus, to an extent the observer can become a co-player.

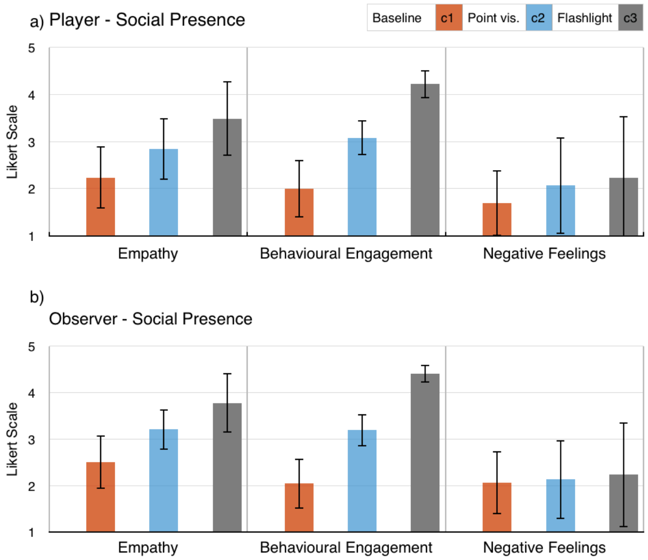

Figure 6. Results of the Social Presence in Gaming Questionnaire for a) the player and b) the observer; measuring empathy, behavioural engagement and negative feelings in all three conditions. The plots show the means for the different scales (1 = not at all, 5 = extremely; error bars indicate standard deviation).

Furthermore, in conditions with gaze input the player's and the observer's scores for empathy (e.g., sharing the same feelings) increased comparably. Integrating the observer into the game renders the game experience more social, explaining why both persons feel equally empathic for the co-located human and their actions. The increasing interdependencies between players and observers results in higher, continuously increasing ratings of *behavioural engagement*. That is, not only does the player feel more dependent on the actions of the observer (i.e., locus of observer's gaze), but also observers seem to feel more dependent on the actions of the player. Consequently, player and observer create an environment, where each (to some extent) enacts the others ideas and intentions.

Low scores were reported by players and observers for *negative feelings* (e.g., feeling revengeful). However, there is a slight increase in reported *negative feelings* by players, indicating that the increase of observer input has some potential for increased *negative feelings*. This could be interesting to consider for game settings, where pairs of players and observers have to play against each other.

The result of the self-reported questions on the participants' gaming experience was as follows: five participants rated themselves as having a *low* gaming experience, two rated *medium* and five reported having a *high* gaming experience.

In summary, the trends visible in the data indicates that our approach of gaze-based onlooker integration changes the gaming experience, as well as social presence for the better. A detailed overview of the general trends considering the dependent variables: perceived *empathy*, *behavioural engagement*, *negative feelings*, *positive affect*, *negative affect*, *competence*, *sensory immersion*, *flow*, *tension*, and *challenge* is plotted in Figure 5 and Figure 6. In the next paragraph, we back up these insights by reporting results gained from a statistical analysis of the quantitative data.

Statistical Analysis

We conducted non-parametric Friedman tests of differences among repeated measures. Friedman tests are suitable when comparing several conditions (i.e., six conditions constituted of three different observer conditions and three different player conditions) with the same participants taking part in each condition and the data being non-normally distributed. Post hoc tests were used with Bonferroni correction applied to identify the pairs of conditions with significant differences. Table 1 presents an overview of the results gained form the statistical analysis. The overall effect on dependent variables such as *positive affect*, *competence*, etc., from Friedman's ANOVA was significant for those with a p-value less than 0.05, which are marked in the table with a (*) symbol.

Pairs of conditions with significant differences are presented on the last column of the table. We use abbreviations for conditions to save paper space (e.g., we refer to condition one of players as playerC1 and to condition one of observers as observerC1 respectively). Furthermore, boldface was used for comparisons of conditions within the player and observer category, while regular font was used for comparisons between players and observers.

As expected, significant differences were found mainly between observer conditions, i.e., differences on perceived *sensory immersion*, *challenge*, *empathy*, and *behavioural engagement*. The results indeed back-up previously mentioned tendencies based on the graphical data; that is, higher values were reported with increasing level of observer integration into the game. Although Figure 5 suggests a potential difference between conditions observerC1 (i.e., when observer gaze was not represented in the game) and observerC2 (i.e., when observer gaze was represented as a graphical point), our data shows no statistical difference between these two conditions. The effect between conditions observerC1 and observerC2 does not seem to be large enough to be identified as significant with the number of participants used in the study. Statistically significant differences were found mainly between conditions observerC1 and observerC3 (when observer's gaze is utilized as a flashlight, highlighting the locus of the observer's gaze), and between observerC2 and observerC3.

The level of observer integration into the game, which is provided by condition observerC3 seems to be mandatory for significantly heightened perceived experiences (i.e., *sensory immersion*, *challenge*, *empathy*, and *behavioural engagement*) of observers. Moreover, perceived *empathy* and *behavioural engagement* were significantly different, not only from condition observerC1 but also observerC2, suggesting that the difference between observerC1 and observerC2 is less than the difference between observerC2 and observerC3. This could be due to a specific level of observer integration, which needs to be reached in order to observe significant differences. However, we believe that it is more probable that

Dependent variable	χ^2	p-value	Significant differences in post hoc analysis
Positive affect	χ^2=11.86	p=.036*	
Competence	χ^2=15.01	p=.01*	(playerC3-observerC1)
Sensory immersion	χ^2=26.41	p<.001*	(playerC1- observerC3), (playerC3 - observerC1), **(observerC1 - observerC3)** , **(observerC2 - observerC3)**
Flow	χ^2=15.27	p<.01*	(playerC3 - observerC1), **(observerC1- observerC3)**
Negative affect	χ^2=5.56	p=.35	
Challenge	χ^2=31.97	p<.001*	(playerC1- observerC3), (playerC3 - observerC1), **(observerC1 - observerC3)** , **(observerC2 - observerC3)**
Tension	χ^2=3.99	p=.54	
Empathy	χ^2=24.68	p<.001*	(playerC1 - observerC3), (playerC2 - observerC3), **(observerC1 - observerC3)**, **(observer C2 - observer C3)**
Behavioural engagement	χ^2=46.94	p<.001*	**(playerC1 - playerC3)**, (playerC1 - observerC3), (playerC3 - observerC1), **(observerC1 - observerC3)**, **(observerC2 - observerC3)**
Negative feelings	χ^2=9.55	p=.09	

Table 1. Overview of results of statistical tests based on Friedman's ANOVA and post hoc tests with Bonferroni correction applied.

the levels of observer integration effect experiences in a continuous but non-linear fashion.

Considering an effect of the different playing conditions on experiences of players, we found that only *behavioural engagement* was significantly different when players played with observers with no representation of their gaze compared to observers, which could use the gaze as a tool (i.e., condition 3) to guide and constrain the locus of the player's gaze within the game play. As argued in the general trends section, this result underlines the interdependencies between players and observers in condition three. Moreover, we argued that players and observers create a (social) environment, where each (to some extent) enacts the other's ideas and intentions. While we suspect players and observers enact each other's ideas, we have not found statistically significant evidence for it. Rather, it is possible that they also reject ideas and intentions in situations of interdependencies.

Significant differences were also found between participants' experiences (i.e., *sensory immersion*, *challenge*, *empathy*, and *behavioural engagement*) when playing the game in condition 3 compared to being the observer of the game in condition 1, and vice versa. These results, show that experiences are in general significantly elevated in condition 3 compared to condition 1.

In summary, the statistical analysis backed-up some of the general trends presented, but also animated us to reflect on results which were despite tendencies in the data analysis surprisingly not statistically significant. In the following, we describe the results of the qualitative data analyses providing more insights on reasons.

Analysis of Qualitative Data

The qualitative data consists of data based on the observations and questions asked at the end of the game sessions, complementing the data gained from questionnaires. The hypothesis of observers compensating their lack of input proved true, especially in constellations where one person had more playing experience than the other. Even in condition one (no direct observer input), some observers tried to assist the player by giving verbal cues or trying to point to obstacles or enemies.

In condition 2 the gaze visualization was mainly used in conjunction to verbal communication about possible collaboration strategies (e.g, how to use the gaze point). In settings where both participants had a high gaming experience the dot visualization was mostly used as a means to distract the player, rather than a means of assistance. On the other hand, in settings with an inexperienced player, the observing person tried to use the gaze visualization to warn the player about forthcoming enemies. In general, depending on the pairings' differences in playing experience, the meaning of the gaze-point visualization in condition 2 was a matter of negotiation between player and observer. We believe that this is due to the abstract nature of the point visualization. The more experienced the observer was in relation to the player, the more they used the gaze point as a means of assistance, for instance, to warn the player from obstacles and enemies. Further, the pairings learned to use and interpret the visualization over time. The participants created an own meaning for the gaze point within their social game setting.

In condition three, participants had to work together the most. As the player needed the observer's input to uncover potential obstacles and enemies, participants tried to "synchronize" their input and movement. For instance, both had to ensure that in the moment the avatar would jump to the next platform, the observer would look on the corresponding area on the screen to uncover the gameworld. Thus, observers learned to anticipate the avatar movement over time and tried to react accordingly. In this condition the avatar's movement was the primary means of communication to coordinate collaboration. This lead to an overall change in the player's in-game behaviour. Even players familiar to the game were moving the avatar more cautiously and tried to verbally advise the observer on where to look at in relation to the avatar movement. The observer had to work against the natural urge to focus on the avatar and force eye focus on a different spot to provide the player with the necessary information about obstacles and enemies.

Participants with more gaming experience or those that were already familiar with the game reported that they liked the role of being the observer in condition three the most. Respectively, people reported as feeling in a certain “expert” position. To illustrate this notion of being in an expert role a participant stated: “As an observer I was much more involved in condition 3 as I had my own distinct task within the game.” Player quotes such as, “The gaze point helps me to be aware of approaching enemies earlier.” or “Show me where to jump and what’s dangerous!”, underline this close collaboration between player and observer. This shows that our approach can be utilized to enable an “expert” to assist the player on a level beyond direct controller-based game input. On the other hand, our approach of gaze-based input can also be used to give a person unfamiliar with the game a natural means of communication and assistance. Surprisingly, players that were unfamiliar with the game or had little gaming experience stated that they liked condition three the most, even if it was the most difficult playing condition.

DISCUSSION

In summary, the observer participants wanted to assist the players and consciously used their new input opportunities. The more observer input was possible, the higher the scorings for empathy, engagement, and overall game experience. We conclude, that the more related the actions of player and observer were, the more fun and engaging the game was.

The gaze point visualization of condition two was differently used from person-to-person. As the gaze representation had no specific semantic meaning within the game, the gaze point’s meaning and usage was discussed by the participant pairings while playing. We believe that due to the more specific affordance and meaning of the “flashlight” condition, it was perceived as more engaging for the participants. We conclude that if the gaze representation presents a specific affordance (e.g., being a “tool”) for both, player and observer, the easier and more engaging the collaboration for both participants will be (i.e., input has to provide meaning within the context of the game).

Our approach of gaze-based onlooker integration showed that the level of input provided for a potential audience member changes the game experience for both the player and onlooker. We argue that gaze-based onlooker input can be an opportunity to engage an audience member in the game experience on a level between direct controller-based input and being completely passive. Even if condition 3 provided a large amount input for the observer and tied together the actions of player and observer the most, participants on the observer side didn’t see themselves as actual players. We think that this in-between of active player and passive observer can be a meaningful and engaging role during co-located gaming that a game’s design can specifically address.

Our study showed that the definition of the right “in-between” of active player and passive observer, strongly differs from person to person. Some would have liked more direct input for the games, others claimed to like the different onlooker conditions the most. As the eyes are a natural means of interpersonal communication, we argue that gaze-based input is an opportunity to integrate an audience member even if this person is unfamiliar with the game. This can lead to interesting new game designs that incorporate different levels of input, participation and expertise of people within one game experience. Our design gave the act of onlooking a meaning and representation within the game. We believe that this is a step towards meaningful onlooker integration beyond purely active play or passive spectatorship.

Embodied Interaction in Play

The interaction concept we presented in this paper aims to change a social gaming setting to the better by turning an observer’s gaze “tangible” through representing it physically/graphically on the screen and furthermore by transforming it into a tool (i.e., flashlight). While an in-depth theoretical discussion is beyond the scope of this paper, it was interesting to experience how the way observers’ gaze was embodied changed the observers’ gaze behavior. When the gaze was represented as a point on the screen, observers and players became more aware that they are part of a social setting with the observer not able to hide their gaze, but free to move their gaze on the screen. When the observers’ gaze was turned into a tool, social obligation dictated to support the player, rendering the social situation interdependent with players and observers having “no choice” but to collaborate. Some of the participants’ behaviour can be explained by referring to embodied and distributed cognition [35] . That is, by representing an observer’s gaze on the screen the player could use the gaze representation for distributed cognition (e.g., as a memory hook), reducing mental workload simply by associating the location of the observers gaze with a cognitive task (e.g., scanning for where the player’s game character needs to move next or indicators of opponents). One would have expected significant differences between players’ and observers’ experiences, especially when observers’ gaze is not integrated into the gameplay at all, as it was done in condition one. However, no significant differences were found. An explanation is provided by the notion of *embodied simulation* [3] and how humans create meaning by dynamically constructing mental experiences according to the perceived scene. That is, understanding the scene of a player playing a game means to simulate their experience, which would explain why observers reported similar experiences as players.

The design presented in this paper is a step towards utilizing an embodied interaction perspective for digital game design and co-located play. Based on that, we further aim at doing research in this direction to harvest the potentials of using physical and social space qualities as a game design material in order to create new forms of collaborative interaction within games.

Utilizing Observer’s Gaze For Future Game Designs

We believe that using gaze as a natural means of communication is promising as an input modality for collaborative game designs that enable audience participation. Potential game designs could be based around giving the observer specific tools or a unique role related to the eyes as a means of input that only an onlooking person can provide. This can result in interesting constellations with different roles for player and observer harvesting the potential of this distinct roles and input asymmetry (i.e., different input modalities for different people).

Another aspect that comes along with our approach of gaze-based collaboration is that it potentially creates awareness in people for their own gaze behaviour. The fact that most people are not aware of their own gaze behaviour in the first place, can lead to interesting game designs that require people to use gaze in unusual ways. For instance, a design based on gaze attention dilemma similar to the work of Vidal [36] could be interesting in a co-located multi person setting. Also the dynamic on-the-fly integration of onlookers (e.g., with changing roles) is a promising and challenging research topic for future work. For instance, scenarios where an onlooker might want to participate and could come in from time to time would open up new design opportunities. Games could react to approaching onlookers and switch between cooperative and non-cooperative mechanics as soon as the onlooker joins the game session (e.g., based on the detection of a second person's gaze). In that case it would be important to inform the player of this change in gameplay adequately, based on the amount of onlooker input and how closely player and onlooker would be connected via gameplay.

From a theoretical perspective, this also introduces the aspect of agency and ownership as a design element (i.e., who controls/owns what part of the gameworld or what game entity at a certain time). Zagal et al. describe the aspect of in-game ownership based on how game entities can own each other [37]. They point out how for instance in *Super Mario World* Mario can collect mushrooms (other game entities) and owns them for later use. Applying this to the design space discussed in this paper, game mechanics could be designed around the fact that an onlooker and player are sharing in-game ownership (e.g., onlooker collects something that the player who controls the avatar then "owns"). Besides this aspect of in-game ownership and whether the player or the onlooker has control over a specific game element at a certain time, there is also the aspect of real world ownership. In our design only the player can directly control the avatar. However, the player's actions are closely tied to the onlooker guiding and drawing the attention to obstacles and enemies. One could argue that the onlooker, in a way owns the player because of the way the gameplay ties them together. Hence, we are extending the aspect of ownership into the real world creating an interplay between digital and real world ownership within the game and the co-located setting it is played in.

Gaze-based onlooker integration can also be applied to settings with more than one onlooker (e.g., gaming on public displays). Public and pervasive displays often aim at enabling collaboration via generating social encounters. Our concept can also be applied to this domain as a mechanism to enable audience participation and give onlookers a specific role within a game. Potential game mechanics could be designed around people having to coordinate their gaze focus to achieve a specific game input. We believe that our approach enables design opportunities to integrate a number of audience members based on natural input, leaving one person in actual control. The other "non-controlling" players could provide assistive input (e.g., shooting enemies with their gaze).

With the growing amount of video game spectating that e.g., is manifested in the current "lets play" culture [31], a further design space opens up that makes the integration of distributed onlookers even more relevant. For such a distributed setting, an approach similar to ours could enable the integration of audience members via gaze. New dimensions of multi-player game experiences can emerge with distributed contributors and actors with different levels of input. Onlookers wouldn't be "in-control" but are still part of the experience on a deeper level than just watching the game (i.e., non-controlling players). This can also lead to a new definition and understanding what an *audience* in digital play can be, leading to audience members as being a material and resource for game designers to harvest. Based on our exploration and findings, we argue that enabling an audience member to be a "non-controlling player" leads to increased engagement for both sides, players, and audiences.

CONCLUSION

In this paper, we presented our approach to enable gaze-based onlooker integration in digital co-located play. We discussed how to realize varying levels of observer integration and game input, through different (embodied) representations of the human gaze. Our hypothesis was that an increased amount of possible observer input would improve the overall game experience for both participants. We explored this hypothesis by implementing two different representations of an observer's gaze as an input for a game and conducted an explorative user study, which was the base for a detailed reflection on the topic and our approach. With our approach we address the design space between active play and passive spectatorship. Taking a role in-between player and onlooker increases for example behavioural engagement and empathy for the onlooker and player which consequently influences the overall social gaming experience. Thus, the symbiotic character of the relationship between player, game and onlooker is increased with integrated onlookers. Moreover, the study findings present evidence that there is a positive influence to the overall player-audience experience when increasing the amount of possible onlooker input. We hope that our results and discussions will inspire practitioners and fellow researchers in designing gaze-based co-located games. In our future work we plan to apply our approach of integrating onlookers to other games and genres in order to explore how gaze-based player-onlooker collaboration is influenced by aspects like in-game movement, camera perspective or difficulty.

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