

The Royal Corgi: Exploring Social Gaze Interaction for Immersive Gameplay

Mélodie Vidal¹, Rémi Bismuth², Andreas Bulling³, Hans Gellersen¹

¹Lancaster University, Lancaster, UK. {m.vidal}{h.gellersen}@lancaster.ac.uk

²ISART Digital, Paris, France. remi.bismuth@gmail.com

³Max Planck Institute for Informatics, Saarbrücken, Germany. andreas.bulling@acm.org

ABSTRACT

The eyes are a rich channel for non-verbal communication in our daily interactions. We propose social gaze interaction as a game mechanic to enhance user interactions with virtual characters. We develop a game from the ground-up in which characters are designed to be reactive to the player's gaze in social ways, such as getting annoyed when the player seems distracted or changing their dialogue depending on the player's apparent focus of attention. Results from a qualitative user study provide insights about how social gaze interaction is intuitive for users, elicits deep feelings of immersion, and highlight the players' self-consciousness of their own eye movements through their strong reactions to the characters.

Author Keywords

Eye tracking; Virtual agents; Immersion; Games

ACM Classification Keywords

H.5.m. Information Interfaces and Presentation (e.g. HCI): Miscellaneous

INTRODUCTION

Social gaze is a powerful medium of nonverbal communication in our daily conversations. We propose to apply it to HCI through what we call *social gaze interaction* as a way to augment user experiences. Social gaze interaction makes the computer react to the user's gaze in typical human-like reactions, with the aim to render interactions more immersive, natural, and make the user aware of the power of their own gaze. We explore this capability through a first-person social game we built for this purpose, where game characters are aware of the player's gaze and react differently depending on how the user socially looks at them.

Decades of psychology research have provided us with a deep understanding of the variety of ways human communication is influenced by the eyes. A look can indicate the desire to start an interaction, but gaze aversion can, in return, demonstrate the will to avoid said interaction, for example to resolve



Figure 1: The player is in conversation with the French ambassador. When the player looks to the side for too long, she interrupts herself and turns to follow the player's gaze.

right of passage at intersections [16]. Eye contact during a conversation can indicate attention [1]; but too long a look turns into a stare, which can be interpreted as trying to establish dominance and can result in reactions that range from aggression to submission [8]. Looking at an object during conversation can also confirm mutual understanding of what is being discussed - a process called joint attention [8]. Depending on the culture, maintained eye contact can also show a lack of respect [1]. According to Kleinke, gaze "influences evaluations of liking and attraction, attentiveness, competence, social skills and mental health, credibility, and dominance" [16].

We propose to adapt this channel for nonverbal communication for HCI and particularly as a game mechanic for interaction with virtual characters. By bringing implicit social interactions such as gaze into the virtual world, we add a layer of nonverbal communication with the computer with which we aim to enhance user interaction. Figure 1 shows a game character a player is talking to; as the conversation goes on, the player is distracted and looks around while she talks. The character realises this, interrupts herself and turns to identify what caught the player's attention. With social gaze interaction, characters become aware and sensitive in a social way to the player's gaze. We believe this holds great potential in terms of immersion, as it enables players to embody their character and interact with virtual characters on a deeper level, closer to what they might do with humans.

In order to study the various possibilities to integrate social gaze in a game, we developed a first-person game from the ground-up. We identified a variety of social gaze effects; for each of them, we designed a character that exhibits this behaviour. The game, entitled *The Royal Corgi*, requires players to interact with game characters to gain their trust in a quest to become the next Royal Corgi Instructor. During the game, players need to make dialogue choices to attain their goal -

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however, as they gradually discover, their eyes also influence the dialogue depending on the characters' personalities.

This new mode of interaction leads us to study both how possible it is for users to apply gaze mechanisms usually found in human-human conversations to game characters, but also what effects interacting with gaze-aware characters have on a player. As such, we identify three main research themes. First, can players make sense of gaze mechanisms which are generally implicit in face-to-face conversations? It is usually desirable to render a game interface as natural and intuitive as possible. With game controllers such as the WiiMote and the Microsoft Kinect, players can now reproduce real-life movements for gameplay; we wish to investigate whether interacting with the eyes in games can be made natural as well. Second, does using natural gaze patterns to interact with virtual characters have an effect on the player's sense of immersion and presence? In a quest to make gameplay as immersive as possible, researchers have studied what increases enjoyment in games [27] and gaze as an input modality has previously been found to increase immersion in games [15, 24]. Gaze-aware game characters thus may have the potential to impact player's immersion. Finally, we are interested in whether this process has an effect on the player's internal state, including awareness of their own eye movements. Gaze-aware agents have been reported to create positive feelings of rapport [2]. In addition, Grynszpan et al. reports that although we use gaze socially, we are generally not aware of doing so [10]. Gaze mechanisms in gameplay could have an impact on the way people think about their eyes beyond the game and the way it makes them feel.

This paper presents the following contributions. (1) We propose social gaze interaction as a concept for human-computer interaction and explore its consequences on user interaction. (2) We do so through a new game, *The Royal Corgi*, which we designed with social gaze as a gameplay mechanism from the start and is the first of its kind. (3) Finally, our study provides insights on how social gaze interaction holds great potential for immersive and natural experiences and has an impact on the self-awareness of the users.

RELATED WORK

As an important means of nonverbal communication, gaze has naturally been a topic of focus for interaction with virtual agents and robots. We also explore the ways the eyes have been used to interact with interfaces and more particularly with games.

Interaction with virtual agents and robots

In a human-robot interaction (HRI) context, social gaze can be considered in two directions. First, it can be reproduced by the robot or agent to elicit an emotional response from the human. A vast body of work has shown that providing robots and agents with human-like eye behaviour improves communication and positive feelings of connection with the artificial personality (for an extensive review on the topic, see [23]). In video games, the character's eyes are occasionally leveraged for communication: in *The Wind Waker*, Link looks to the side to signal to the player when an interesting object is

nearby, while *L.A. Noire* takes full advantage of the nonverbal behaviour of the eyes by challenging the player to determine whether a character is lying depending on his extremely realistic eye movements. However, the player's gaze is not taken into account.

Second, social gaze can be inferred from the human to inform the virtual personality. For example, Eichner et al. presented a showroom where agents adapt their presentation depending on the user's gaze attention [6]. In museum settings, robotic tour guides have been designed to wait to start giving explanations until a visitor presents visual interest in a scene [4], and have been made to detect when a visitor avoids meeting the robot's gaze during a quiz session [17]. Bee et al. have also studied the effects of establishing eye contact with a virtual agent and found that it created positive feelings of rapport [2]. Finally, Ishii et al. studied users' attention while conversing with an agent; when users seemed distraught, the agent would prompt the user with questions. They found that doing so increased perceived agent intelligence and conversation awareness [12].

These works are examples of the potential that social gaze interaction holds and explore single aspects of it. Here we formally introduce social gaze interaction and explore its feasibility and consequences on a players' perceived immersion.

Eye-tracking for interaction and games

By being responsive to the user's gaze, social gaze interaction is in itself an eye-based interaction technique. While there has been extensive research on eye-based interfaces, the majority have been focused on target selection [18] and positioning [28], text entry (see an overview in [20]) or steering [25] panning and zooming [26]. Only few works on using eye tracking to correct the eyes position for videoconferencing [29, 31] and the body of work on virtual agents mentioned above present applications that makes use of the naturally social behaviour of the eyes for interaction.

The lack of eye-based interaction techniques that harvest the natural behaviour of the eyes is particularly acute in games that use the eyes as input. The idea of using the eyes for interaction with games has been explored in a variety of ways, especially to investigate the difference between using the eyes versus the controller a game was originally designed for. Examples include *Half Life* and *Sacrifice* [15], a Paddle game [5], *Quake2*, *Neverwinter Nights* and *Lunar Command* [24], *World of Warcraft* [14] or *Mario* [21]. Results alternate between reporting increased performance over mouse [5], increasing perceived immersion and fun [15, 24], but also report that the way the eye tracks moving objects results in latency when using the eyes as ways to aim fire in FPS [15, 24]. Finally, Wetzel et al. recently demonstrated how a player's gaze behaviour can be used in real-time to adapt the parameters of a game and provide sufficient challenge while reducing frustration [30].

Isokoski et al. provide an impressive survey of the different ways the eyes have been used for gaming, and highlight that very few have been built from the ground-up specifically to integrate the eyes as inputs [13]. Hillaire et al. adapted

Concept (effect)	Player's action	Effect on character	Example potential for gameplay
Desire for interaction	Looks at character	Looks back at player, awareness of being looked	Possibility to trigger interaction with reluctant character
Avoidance of interaction	When not in a conversation, avoids meeting the eyes of the character	Inability to start interaction, potential frustration	Possibility to avoid a character
Apparent distraction	While in a conversation, looks around repeatedly	Annoyance, potential perceived lack of respect	Penalising the player for inattention
Cultural disrespect	Sustained eye contact	Annoyance, potential perceived lack of respect	Introducing cultural understanding in gameplay
Dominance test	Stares at the character's eyes	Submission to aggression, or aggression back and pride	Confidence training
Gaze following trigger	Insistently or repeatedly looks at something else than the character	Movement of the eyes to follow the player's gaze direction	Distracting the character
Signs of intent	While in an interaction, looks away at specific object or location	Hypothesis and prediction on intent	Bluffing the character
Joint attention	While in an interaction, looks away at specific object or location	Knowledge of the player's object of attention	Influencing game story depending on interest in objects

Table 1: Summary of the social gaze concepts used in the game.

the game's blur and focus to mimic the eyes' reproduction of depth of field, which reportedly increased the sense of realism experienced by the players [11]. Nacke et al. also showed how the eyes could be used as a metaphor from cultural references, such as the Medusa's gaze, which freezes a person on eye contact [22]. In the study, players reported the eyes as their favourite biofeedback interaction method. The study also stressed the importance of establishing an intuitive mapping between direct biofeedback (such as gaze) and its effects.

In this work, we create a game from the ground-up in which characters react socially to the player's gaze. Building such a game enables us to study the feasibility of implementing intuitive eye interactions that users may not have to learn to use because they can compare it to social situations with humans.

SOCIAL GAZE INTERACTIONS

Psychology informs us about the wide range of reactions to gaze depending on the perception of the gazing person's competitiveness and status [16], for example. Based on these findings, we identified prominent social gaze interaction concepts that we wished to implement. These are summarised in Table 1 where the concepts are named and which provides details on what the player does, what effect this can have on the game character, and an example of the concept's potential for gameplay in general.

Desire for interaction. Humans have an accurate ability to determine whether they are being looked at [8]. Looking at someone can indicate the desire to enter an interaction, which starts when both parties establish eye contact. This can be seen as ways for the user to influence the game: players may force a character to attend to them if they insistently look at them, forcing the character's awareness of the player's presence.

Avoidance of interaction. In contrast, gaze aversion - avoiding to meet someone's eyes - prevents that person from starting an interaction [16]. This is for example the case at traffic crossings. Here again, players can take advantage of this concept to control the game: if characters are actively seeking eye contact to start a conversation, players can choose to ignore them and divert their gaze.

Apparent distraction. While in a conversation, frequent eye movements directed at something else than the person talking

can be interpreted as lack of interest and attention in the interaction. This can potentially trigger annoyance and anger from the person talking [1]. This concept can be used in games as ways to penalise the player for lack of inattention.

Cultural disrespect. Certain cultures may inversely interpret eye contact as a lack of respect [1, 8]. Prolonged eye contact may annoy a person who expects specific displays of respect. This difference can be used for interaction as means to introduce cultural understanding in gameplay.

Dominance test. By extension, staring can be interpreted as aggression. Depending on the character's perception of the staring player and their own personality, he or she may exhibit a submissive behaviour, or excessive pride if the player looks away first. This can potentially be turned into a way to encourage players to exhibit confidence through their eye behaviour.

Gaze following trigger. Gaze following seems to be a behaviour that is "hard-wired" in the brain [7]. When a person looks insistently at a specific location, other people tend to physically follow their gaze to identify what caught their attention. This concept has the potential to allow for playful interactions with a character, for example to voluntarily distract them.

Signs of intent. While engaged in an interaction, people may also infer knowledge from monitoring the other person's gaze and predict what they are interested in or about to do [3]. Purposefully showing signs of intent can be a way for the player to bluff the game characters so that they wrongly predict the player's next action.

Joint attention. When two persons have a conversation and one of them keeps looking at a third object, this can trigger joint attention, where the other person will also look at the object to potentially clarify the topic being discussed. This can be used to influence the game's storyline depending on what the player seems more interested in.

This list of concepts is not exhaustive: social gaze is a broad topic and effects can vary culturally. We have chosen this subset in order to explore a large range of reactions and gameplay possibilities for the players. As Table 1 shows, some concepts share the same action from the player or effect on the character. The ambiguity surrounding the interpretation of social gaze and its effects can be taken as a playful mechanism [9]:

due to context and the high variability of player personalities, the integration of social gaze interactions into gameplay can lead to potentially desirable ambiguous interpretations of the game mechanics and of the virtual personalities. Social gaze is an input mechanism that game designers can play with, and it can be embraced in a wide variety of ways, from the socially accepted to the perhaps playfully anti-social.

THE ROYAL CORGI GAME

We built a game with the intent of implementing these concepts. In order to seamlessly integrate social gaze interaction as part of the gameplay, we made several early design choices. We decided on a first person-style game, where the player sees the viewpoint of their character. Furthermore, we designed it to be a social game, where players have to talk to a lot of characters and interact with them in order to progress in the game. To study whether they could make sense of each gaze concept, we decided to assign each of them to a different character and present players with a wide range of personalities and behaviours.

Because the game is focused on using the eyes as natural controllers, the interface had to be designed so that players could use their eyes as they would in real-life conversations. For this purpose, we recorded voices for the characters instead of displaying dialogues on the screen, which would have required players to read and thus not use their eyes for face-to-face interaction. We also designed the dialogues so that each character would finish their lines by a question to which players could only answer by 'yes' or 'no', again to avoid players having to read potential answers. For example, a character would ask "Do you like dogs?" and wait for the player's answer.

For increased realism, we chose to design the game so that players had to walk up close to a character in order to start a conversation with them. This means that during a conversation, characters were facing the player in a way that resembles a face-to-face conversation. Finally, the player's head-up display (part of the screen informing players of time left, status, etc) was designed so that the player's status was matched by a colour code evolving progressively between red (bad) to green (good). This is so that players could be aware of their status changing using peripheral vision only and not diverting their eyes from the main scene.

Game synopsis

Our game, named The Royal Corgi, takes place in medieval England. The king has just acquired a new Corgi (a breed of dog) which he is fond of, and is looking for an instructor dedicated to his beloved dog. The player impersonates a greedy young lord whose goal it is to gain influence at the court and views the new position as the perfect way to get closer to the king. He needs to gain the trust of the king's counsellors, which will advise the king on who to appoint as instructor. The game can thus be viewed as a networking game.

Characters (see Figure 3) have different levels of influence, which they will grant to the player if they answer correctly to their questions but also if they exhibit certain social gaze behaviours that they are sensitive to. While a player is not



Figure 2: Screenshot of the start of the game. The HUD is visible in the bottom left corner: the yellow colour indicates the influence of the player is average. The player is looking at the Budget Advisor, which is thus turned towards her.

interacting with a character and just walking around the room, characters also turn towards the player if the player is looking at him/her (*Desire for interaction*), then turn back to his/her initial position when they player looks elsewhere.

The game takes place only four minutes before the meeting in which the king will decide who will be the Corgi instructor. The player will only be appointed as Corgi instructor if their influence level is higher than a certain threshold. The player is thus pressed by time to talk to (and please) as many influential people as possible during this time. Players do not know in advance the characters personalities and levels of influence and can only discover it by talking to them.

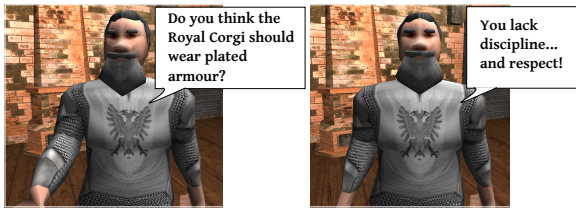
Characters

The *Military Advisor* is a stern character, whose only concern is to make sure the player is devoted to training the Corgi to be a defensive dog for the king (Figure 3a). He is very influential, but will be offended and dismiss the player if they look away for too long or too many times while they are in a conversation (*Apparent distraction*).

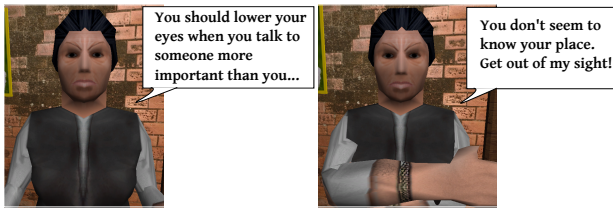
The *Horse Instructor* is also serious, and very proud (Figure 3b). She is influential because she is the instructor of the royal horse, which she considers to be of higher importance than the royal Corgi. The player needs to be humble in front of her, and lower their eyes often while talking to her, otherwise she will take it as a lack of respect (*Cultural disrespect*).

The *Archivist* is a character with ambition but low self-esteem (Figure 3c). The player can make him advocate in their favour to the king if they dominate him and stare him down when he tries to challenge them in a staring contest. If players are not dominant with this character, he will turn against them by gaining confidence and will try to get the position for himself (*Dominance test*).

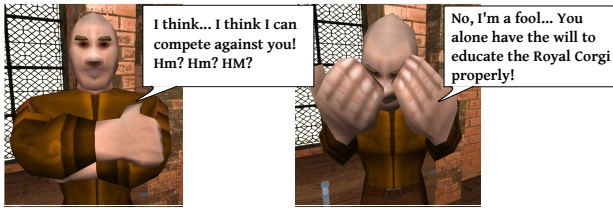
The *Budget Advisor* is also quite influential (Figure 3d). He just came back from a honeymoon with his new wife, which is next to him. The Budget Advisor is accommodating about the player's answers on how they plan to manage the finances of the royal Corgi if they were to be appointed. However, he is a jealous man and he will monitor whether the player



(a) The Military Advisor gets offended if the player looks around too often.



(b) The Horse Instructor first warns the player about the display of respect she expects, then gets annoyed when the user does not comply.



(c) The Archivist challenges the player in a staring contest, then exhibits submissive behaviour if the player did not look away.



(d) The Budget advisor get annoyed if the player spent too long looking at his wife during the conversation.



(e) The Painter exhibits friendly behaviour if the player spent more time looking at the "artistic" painting.

Figure 3: Examples of the effects of the player's gaze on different characters.

glances at his wife while they are talking. He will get angry if this is the case. His dialogue mentions his wife, in order to trigger a glance by the player (*Signs of intent*).

The *Painter* is a jaded character (Figure 3e). He is paid by the king to paint countless paintings of the Corgi (visible in the room) but wishes to paint more challenging and inspiring art. He is placed in between two paintings, one of a Corgi and one of classical art. If the player glances more at the Corgi painting while they talk, he will dismiss them, but if they look more at the other one he will acknowledge them as someone who shares his taste and will give them a small amount of influence (*Joint attention*).

The *French Ambassador* is a character designed to waste the player's time (Figure 1). Instead of waiting for the player to engage a conversation with her, she will come to them as soon as they look at her more than a few seconds. She will then start a lengthy conversation about dogs and cheese, which will never change the player's influence level and can not be interrupted. The only way to escape her is to look away while she talks. She will then turn around, asking whether there is something important happening behind her (*Gaze following trigger*). Only at that moment, the player can interrupt the conversation and walk away. Once they have learnt about her personality, players can also avoid her by not looking at her (*Avoidance of interaction*).

In order to encourage players to talk to many different characters and to create an even wider variety of personalities, we also placed characters that are not influenced by the player's eyes. We were interested in discovering whether players would start imagining effects that their eyes had on the game, once they learnt that certain characters reacted to them. The *Archbishop* is half-mad and concerned that the Corgi is possessed; he wants the player to swear they will try to exorcise it. The *Fool* does not make sense when he talks but will bring a positive amount of influence if the player takes the time to talk to him. Finally, five competitors are also placed around the room and only dismiss the player when they talk to them.

Implementation

Once the time is up, the game displays the player's score and offers to play again. During a game, players can only talk once to a character; the game is designed to be short in order to give players the opportunity play again and speak several times to the same character to figure out how to win their trust. This short gameplay also provides us with the opportunity to prompt users at several stages of their discovery of the game and its social gaze concepts, and ensure they talk to every character at least once.

Players can move in the environment using the mouse to move their head and the WASD keys to walk; start a conversation with a character by getting close to them and pressing the spacebar; interrupt a conversation by pressing the spacebar again (except the French Ambassador); answer 'yes' or 'no' by using the Q and E keys; and finally, they can hear their character's inner voice by looking at a character and pressing the V key, which will give them insights on who they are and hints on their personalities. For example: "This is the royal

Horse Instructor. She's very proud - better make her think I respect her". The player's gaze is not visible during the game.

The Royal Corgi was developed using Unity3D, custom voices and dialogues, and commercially available 3D models and graphics. The graphics were not detailed enough to allow us to make the character's eyes or face move, but still allow for body animations. While it would have been desirable, the fact that characters can not move their eyes does not impact our goal, which is to implement social gaze interaction from the user's point of view.

The implementation of the gaze concepts is straightforward and very modular. By defining regions of interest (ROIs), characters are made aware whether the player's gaze is located on their faces, on their bodies, or somewhere else. The size of the ROIs varied depending on the object but were generally in the order of 350*350px when viewed while in a conversation. At a viewing distance of about 60cm, this ensures eye tracking accuracy was sufficient for robust selection of ROIs. The amount of time the gaze is located on one ROI was also monitored, and the concepts are implemented depending on the length of the gaze or the frequency it switches to another ROI. Characters can thus be made sensitive to eye contact (and its absence) and the supposed attention or intention of the player. Finally, the eye tracking data was smoothed in real time using a median filter.

USER STUDY

We conducted a qualitative user study with twelve participants (6M, 6F, age $M = 26.8$, $SD = 5.4$). Their background ranged from computer science and design to psychology and occupational therapy. All participants reported playing video games at least monthly, except P1 and P10 who reported having never played; When prompted to rate how used to First-Person shooters they were on a scale of 1 (not at all) to 5 (very used to them), the average was 3.86 ($SD = 1.38$).

Participants were first introduced to the game and its controls. They were placed around 60cm from the screen and underwent a short 9-point calibration procedure for the eye-tracker, a Tobii TX300 collecting data at 60Hz on a 23" screen with a 1920*1080 resolution. They were also encouraged to explore the game and talk to all the characters, and to voice their thoughts while playing the game. The screen was placed so that players would face characters at eye-level to increase conversation realism (see setup in Figure 4).

Participants were only told how to use the different keys to interact with the game, and that their eyes would also have an effect on the game. They did not know in advance how their eyes would affect the characters. When the game started, players found themselves at the corner of a room and could see several characters in front of them (see Figure 2). They also saw the time ticking down and their influence status on the HUD. They were then free to walk around and choose who they wanted to interact with: each time they played, they interacted with different characters. On average, users interacted with 4.2 ($SD = 1.3$) characters per game. Excluding competitors and the French Ambassador, interactions lasted for 52 seconds on average ($SD = 20.7$). The Ambassador's

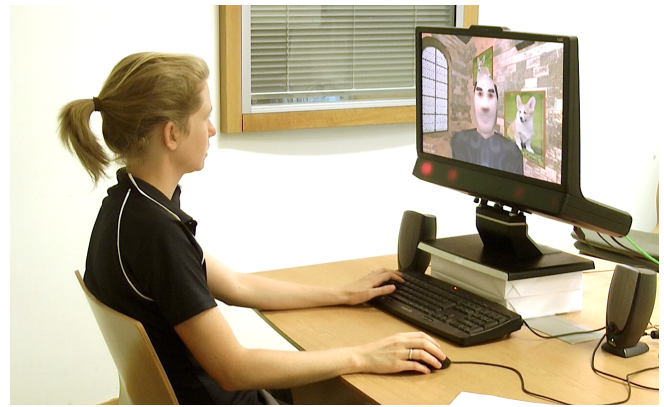


Figure 4: A participant playing the game on the Tobii TX300.

dialogue looped and players could only interrupt interaction by figuring out how to distract her, which is why on average interaction with her lasted for 85.5 seconds ($SD = 51.7$).

After each four-minutes game, the researcher asked them whether they had noticed any effects from their eyes on the game, and if so, to describe them. Participants played on average 5.3 games ($SD = 0.8$). The number of games played per participant varies, because we asked them to stop playing only when they had interacted with all the characters at least once and some participants were quicker than others. Participants were then invited to discuss their gameplay experience in a semi-structured interview, always with the same researcher. During the interview, the researcher asked questions such as "When did the game react to your eyes?" "How did it make you feel that the characters responded to your eyes?" and "Did you adapt your behaviour?". Finally, they were asked to complete a questionnaire for demographics. The entire study (which lasted for about an hour) was filmed, then transcribed for analysis.

The analysis of the interview transcripts provided us with a great amount of valuable insights and findings, which we re-group here by theme.

Ease of interaction and naturalness

No participant reported strain on their eyes, despite playing for 20 minutes on average. All participants reported that they had to adapt their behaviour to use the game, and that they had to make conscious efforts to perform the way they were expected for each character, but described it as having to be more focused ("It was a bit alien 'cause it was a higher level of concentration than if you would just play" (P6)). In general, they expressed that maintaining control of their eyes was difficult: "It was difficult, 'cause you're not normally constrained, you can normally look wherever you want" (P8).

However, this difficulty is contrasted by the fact that all the participants expressed that the interactions were "real" (P1, P6, P9) - specifically, that the way they could interact with their eyes was natural but also that the way the characters reacted to their eyes was natural. "It was the easiest kind of roleplaying. [...] It was very simple to show respect, show

disinterest... [...] That's quite easy to do with your eyes" (P8). Most concepts felt "obvious" (P4), especially the ones implemented in the Budget Advisor, the Military Advisor and the Painter, which were often discovered first. "It's like you're talking to people in real life. That's how people would react in real life" (P6). "It made complete sense, that's how I was able to work out the patterns." (P8).

Participants that were used to video games discovered most gaze concepts after playing three times. On the contrary, the two participants that reported having no prior experience with video games did not discover the concepts after four games until being explicitly prompted about it. We hypothesise that this may be because experienced players may be more used to different types of controllers and thus to the idea that a new part of their body could be having an effect on the game, whereas the two novice players may have been overly focused on using the keyboard and mouse and did not remember that their eyes also had an effect. The Archivist's staring contest was discovered only once, by chance.

Immersion

Social gaze interactions seem to have drawn people into the game. When prompted about how the game made them feel, all participants reported strong feelings of immersion, in that they chose to qualify the game as more "immersive" (P1, P5), "personal" (P1, P6, P9), "engaging" (P7), "involved" (P9, P12) than what they are used to and feelings of being "in the room/game" (P3, P8, P10). P10 elaborates: "I really felt like I was having a conversation with these people". Several participants never realised that characters turned when they were being looked at. However, it was appreciated when it was noticed: "It feels like they know your presence there" (P5) "It felt like they knew I was there" (P1).

Some participants also reported wanting to physically nod and mimic characters (P4, P7, P8). Further, several participants reported feeling like they "acted" (P5, P11) like their character and described experiences of embodiment: "I felt like I really was the character. [...] I started to think as myself as yeah, I'm the Corgi instructor. [...] I heard my thoughts, and then I embodied the thoughts." (P8). P4 said that he occasionally had to remember his "physiological role".

Strong feelings towards the game and the characters

Various participants expressed strong feelings triggered by the fact that they felt the game "knew" what their eyes were doing. We believe this is caused by the strong feelings of immersion reported above. One participant in particular, whose background is psychology, described the experience as being "on show": "It makes you think like the character is at the will of others [...] It's almost like there's judgement coming from the game. You're on show yourself, you're the one performing for them. [...] It feels like a dangerous environment in some ways" (P3).

A participant further detailed that he was uncomfortable with having to embody such a greedy character. "I forgot my character of the greedy young lord [...] It made me more uncomfortable because I didn't like that character, but it made me

feel like I had to be that person, I couldn't just press the buttons and press through it, I had to make myself do that, and it was weird, but I liked it. Because I didn't experience it before [...] It is weird... how powerful that is" (P4).

In addition, we found that participants reacted strongly to particularly polarising characters. The Horse Instructor demanded that players lower their gaze, to which participants generally complied in order to earn more influence. But certain participants decided that they would not, because they felt like they were as good as her - even at the loss of influence. "She thinks she's better than me, but of course not, I won't do that" (P11) "I thought 'I'm as important as you!' I'm not going to lower my eyes for you" (P12). P1, which complied when prompted to look down, particularly elaborated on her experience with the Horse Instructor: "It sort of reminded me, all of a sudden I'm in primary school or something. Quite a deep feeling actually [...] It reminded me what it was to feel small, properly small, and a bit inferior."

The Ambassador was designed to be annoying by wasting the player's time. However, we found that she sometimes triggered unexpected behaviours. Participants either expressed strong feelings of dislike towards her, trying to escape her as soon as possible, or on the contrary thought of her as a "friend" (P10). One participant added "I felt like she was my favourite [...] I feel like I can go and talk to her. You don't get the aggression if you get it wrong" (P5). It seems that, in an environment where they felt on show and judged for their physiological actions, participants were seeking a figure of reassurance - especially in a challenging game where they had to prove themselves worthy and convince people, such as a networking event. Thus, despite the Ambassador not having an effect on the player's performance, some still enjoyed talking to her. When prompted about trying to interrupt her, they also mentioned trying to do it in a soft way, seeking "the polite thing to do" (P3) "without offending her" (P10).

We hypothesise these counter-productive behaviours for the game stem from participants getting the impression of being "in" the game and physically identifying with their character. They report to have felt judged, and as a result exhibited various behaviours apparent to coping mechanisms: they fought back and defended themselves or they sought a friendly supporter.

Personal differences

As expected, participants had different expectations about what respect meant in terms of eye behaviour. Some participants found it obvious that the Horse Instructor would require lowering the eyes ("It's natural, like when you have to look down to respect someone" (P11)) while others thought it would never happen in real life ("It was weird looking down, I wouldn't actually expect anyone to say that to me" (P7)). In a similar fashion, while some participants were at ease with maintaining eye contact with the Military Advisor or the Budget Advisor ("I knew intuitively that to show respect I had to maintain eye contact" (P8)), others thought it odd to be always looking at his eyes ("That's the way people interact, you don't always look at their eyes" (P3)).

Similarly, some participants found it obvious to look away to distract the French Ambassador (*"If i had someone who enjoyed talking quite a lot that's what I would do. I would try to make a distraction"* (P6)) while others felt it was unnatural (*"I would never normally try to escape someone by looking around at the ceiling while they spoke to me"* (P7)).

Participants also voiced different ideas about how much they think people are aware of their eye movements - and showed different levels of awareness themselves. Some (P3,P5,P8) mentioned that they think people aren't generally aware of it (*"It's something you don't think about when interacting with someone"* (P5)), while others (P6,P7,P10) mentioned being very conscious of it: *"I was consciously making sure my eyes were where they were meant to be, which I always do in real life situations"* (P6).

As a result, participants also had different strategic approaches to how much eye contact is acceptable during face-to-face conversation, which showed in the strategies they chose to adopt. Those who are aware of their eye movements were at ease maintaining eye contact with the Military Advisor and the Budget Advisor, for example, while others found it difficult to keep their attention focused on one character and kept looking away. *"You're just supposed to keep eye contact - It's too awkward, I don't know, I get distracted"* (P2).

Enjoyment

Despite these strong differences in opinion, all participants reported the game as enjoyable, fun and frequently laughed out loud when discovering patterns, such as being caught looking at the Corgi painting or the Budget Advisor's wife. They reported appreciating the wide variety of interactions possible with their eyes - from looking at something to looking away on purpose. *"[about the Ambassador] it's a bit different and it's more playful than just having characters where you have to look in a certain direction to influence them. I really liked it"* (P5).

Participants seemed to enjoy the new modality, which is often the case in eye tracking studies, and the embodiment effect. For example, they mentioned that *"It's more rewarding 'cause I'm not just using my fingers and clicking things"* (P5) and *"It made the game more fun, because it gave an extra dimension to the game"* (P12). The extra dimension highlights the potential of eye tracking to augment existing modalities without replacing them, and provide players with an additional layer of control.

Potential for other games

Participants often expressed how they could envision the eyes being used in the same way for other games, specifically role-playing games such as Assassin's creed, Oblivion, or Fable. Several participants mentioned L.A. Noire as a comparison. *"I could definitely see the eyes taking that button pressing bit out of it and I just think it would be so much fun to play around with it"* (P8). One participant also mentioned how it could be used for pointing at things to be picked up (P12), which has been explored by Smith et al. [24]. Another mentioned that the eyes could also be used to make the screen focus on a particular area (P9), which Hillaire et al. studied [11].

Interestingly, three participants (P2, P3, P4) mentioned that they could envision this kind of technology being used for social therapy training, such as game tailored for persons with autistic symptoms. They thought that, if being played regularly, this kind of game could influence the way people behave socially - and potentially improve their social interactions by learning how people can react to different attitudes without risking real-life repercussions. *"This would actually be a really interesting game for people who don't communicate very well, the concept of that game could be used in order to almost socially train people, train people how to interact in a social setting."* (P3). In a similar way, P1 also mentioned that such technology could be used for social skills such as job interview training, in order to *"convey [personality] traits and be in the best possible light"*.

Game implementation insights

Several participants (P1, P2, P4) reported that the way the Painter was presented helped understanding what was needed of them. It seemed to have been subtle but clear enough for their expectations from games: *"The Painter was pretty obvious, [...] just by the way the camera positioned itself. It's good to get some visual guidance"* (P2). Participants were on the lookout to discover what actions would be triggered by their eyes, *"I really like the fact that the controls weren't so explicit"* (P4). They could not see their gaze on the display, and this occasionally led them to imagine that the game was more reactive than it actually is. For example, one participant thought that all the Corgi paintings scattered around the room could register their gaze, when actually only the painting next to the Painter mattered for interaction. Another one thought that the Archbishop followed his gaze up and down whenever he was next to him, which was simply a coincidence due to the animation.

In general, participants did not notice the Archivist's staring contest - only one person discovered it by chance. When explained later the Archivist's concept, participants suggested using more body language - coming closer, raising eyebrows, to hint players on that fact that something specific is happening. While this was not possible with our 3D models, where the face is static, it is a great insight as to how slightly more obvious body language could allow even more powerful and playful social gaze concepts in future games: *"[the graphics are] intentionally not real, so the cues have to be more pronounced in order to make sense"* (P4).

The limitations from our graphics also came into light with other suggestions from participants, such as making the Ambassador turn only in the direction where the player was looking (P2) (the animation made her turn left and right regardless of the gaze direction), making characters turn only their head instead of their whole body when being looked at (P9), or making more expressive faces.

Despite the care we took in the game design, we omitted to isolate the part of the screen that presented the score as a special region of interest (ROI) to be ignored when the gaze falls onto it. This led to characters such as the Military Advisor misinterpreting the player as inattentive, and players feeling unfairly scowled for their behaviour. In hindsight, we should

have isolated this part of the screen to be ignored. This shows that for social gaze interaction, game designers need to keep in mind the different levels of attention their players will experience in the game and the different layers of information available to them - and what this means in terms of gaze behaviour. Players appreciated when the ROIs were carefully divided - such as the distinction between head and body for the Horse Instructor: *“I really liked [...] the details, the Horse Instructor knew about your eye level”* (P5).

Although the interactions were reported as natural, several participants felt that their eyes were restraining them in their interactions: Instead of adding something for the player, they would penalise them if they did the wrong thing. This highlights that social gaze interaction can be made to control the player and penalise them, which might be desirable in certain games, but which is something one should be aware of and conscious of when applying social gaze interaction in games.

Finally, one participant mentioned that although the game was using the eyes in an active way, it was not tiring, hinting that it may be because the parts where the eyes are “observed” are divided into units of time - the dialogues. While the player is not talking to anyone, they are free to look around the room in a natural way, which he said allowed the eyes to rest. This is again a useful insight into designing more games that use the eyes in natural ways: *“It was a little bit tiring but it was only for short interactions, because the characters offer a way to chunk up the interactions and you can let your eyes loosen everywhere else”* (P4).

DISCUSSION

These game implementation insights are to be balanced with the hardware we used. In our study, we chose an eye tracker designed for lab studies, whose accuracy and compensation of head movements ensured the data we gathered from players was largely accurate for the size of ROIs we used. Even though our techniques operate with wide ROIs, in future work we plan to test how small the ROIs can afford to be and how precise interactions can be with eye trackers targeted for the general public, such as the Tobii EyeX which is specifically designed to integrate gaze in games. It would be also interesting to experiment with multi-user eye tracking, or devices that have a larger range of tracking capability, in order to integrate social gaze interactions beyond desktop-bound games - games that are played in the living room, for example.

An obvious limitation to our study is that our characters were not able to move their own eyes. In order to fully study the potential and repercussions of social gaze interaction, it is necessary to evaluate the impact on interaction when both the virtual character and the player can exhibit social gaze behaviour. Nonetheless, this exploratory work provided us with numerous findings and insights on the potential of social gaze interaction as a game mechanic.

One promising field of application are games that train specific behaviour in players, as has been suggested by several participants. Eye-contingent games and virtual agents are already used in clinical situations, for example for autism [19, 10]. We can envision social gaze interaction being a suc-

cessful candidate to further develop social therapy or cultural training and learn the consequences of one’s gaze behaviour in different situations.

In more conventional games, social gaze interaction could be integrated seamlessly along the storyline to allow players to embody their characters. In a spy game, players could consciously have to not look at a particular piece of evidence. We can also imagine a Poker game, where virtual players would be aware of the player’s eyes: Poker is a game where the eyes are crucial and can reveal a lot to a seasoned player. It could thus be used to train oneself to bluff or hide giveaway clues.

An important aspect to consider for design with social gaze interaction is the strong feeling of embodiment reported, and what this implies for the players. Having their eyes monitored by other characters made some participants feel on show and judged. By adding social gaze interactions in a game, we also brought in the consequences of the weight of a peer’s gaze. In addition, some participants expressed negative feelings about the character they had to impersonate. While they may have felt this way even without gaze interaction, we believe that the fact that they physically embodied the game’s greedy character emphasised this feeling. We suggest game designers should be particularly attentive to the role they offer their players and what they want to make them feel.

Finally, the game audience is also an important consideration: social gaze expectations vary depending on culture and personality. A specific angle of approach in terms of audience is that of female players. While we noticed strategies and trends between genders, our participants sample size was not large enough to report specific findings. However, several female participants expressed that they had to remember that their character was a man, which they expressed to be difficult since the interaction style was so embodied. We would like to further our players’ gaming experience by creating another version of the Royal Corgi where the main character is female.

CONCLUSION

We introduced social gaze interaction as a game mechanic, and implemented a range of social gaze concepts into a game we built specifically for this purpose. Our study showed that the social gaze concepts were found natural and participants did not have to be taught how to interact. Participants reported experiences of immersion and presence and described strong feelings of embodiment. Finally, they mentioned modifying their physiological behaviour in order to adapt to the game as they discovered different concepts and played with them purposefully. This highlights the potential of social gaze interaction for games as a way to enhance user experiences with virtual characters, and gathers insights for future games wishing to integrate social gaze interaction.

REFERENCES

1. Argyle, M., and Cook, M. *Gaze and mutual gaze*. Cambridge University Press Cambridge, Eng. ; New York, 1976.
2. Bee, N., Wagner, J., André, E., Vogt, T., Charles, F., Pizzi, D., and Cavazza, M. Discovering eye gaze

- behavior during human-agent conversation in an interactive storytelling application. In *International Conference on Multimodal Interfaces and the Workshop on Machine Learning for Multimodal Interaction* (2010), 9:1–9:8.
3. Castiello, U. Understanding other people's actions: Intention and attention. *Journal of Experimental Psychology: Human Perception and Performance* 29 (2003), 416–430.
 4. Das, D., Rashed, M. G., Kobayashi, Y., and Kuno, Y. Recognizing gaze pattern for human robot interaction. In *Proc. of HRI* (2014), 142–143.
 5. Dorr, M., Böhme, M., Martinetz, T., and Barth, E. Gaze beats mouse: A case study. In *The 3rd Conference on Communication by Gaze Interaction (COGAIN 2007)* (2007), 16–19.
 6. Eichner, T., Prendinger, H., André, E., and Ishizuka, M. Attentive presentation agents. In *Proc. of the 7th International Conference on Intelligent Virtual Agents* (2007), 283–295.
 7. Emery, N. J. The eyes have it: the neuroethology, function and evolution of social gaze. *Neuroscience and Biobehavioural Reviews* 24 (2000), 581–604.
 8. Frischen, A., Bayliss, A. P., and Tipper, S. P. Gaze cueing of attention: visual attention, social cognition, and individual differences. *Psychological bulletin* 133 (2007).
 9. Gaver, W. W., Beaver, J., and Benford, S. Ambiguity as a resource for design. In *Proc. of CHI* (2003), 233–240.
 10. Grynszpan, O., Simonin, J., Martin, J.-C., and Nadel, J. Investigating social gaze as an action-perception online performance. *Frontiers in Human Neuroscience* 6, 94 (2012).
 11. Hillaire, S., Lécuyer, A., Cozot, R., and Casiez, G. Using an eye-tracking system to improve camera motions and depth-of-field blur effects in virtual environments. In *VR* (2008), 47–50.
 12. Ishii, R., Nakano, Y. I., and Nishida, T. Gaze awareness in conversational agents: Estimating a user's conversational engagement from eye gaze. *ACM Trans. Interact. Intell. Syst.* 3, 2 (Aug. 2013), 11:1–11:25.
 13. Isokoski, P., Joos, M., Spakov, O., and Martin, B. Gaze controlled games. *Universal Access in the Information Society* 8, 4 (Oct. 2009), 323–337.
 14. Istance, H., Hyrskykari, A., Vickers, S., and Chaves, T. For your eyes only: Controlling 3d online games by eye-gaze. In *Proc. of INTERACT* (2009), 314–327.
 15. Jönsson, E. If looks could kill - An Evaluation of Eye Tracking in Computer Games. Master's thesis, KTH Royal Institute of Technology, Sweden, 2005.
 16. Kleinke, C. L. Gaze and eye contact: a research review. *Psychological bulletin* (1986).
 17. Kobayashi, Y., Shibata, T., Hoshi, Y., Kuno, Y., Okada, M., and Yamazaki, K. Choosing answerers by observing gaze responses for museum guide robots. In *Proc. of HRI* (2010), 109–110.
 18. Kumar, M., Paepcke, A., and Winograd, T. Eyepoint: Practical pointing and selection using gaze and keyboard. In *Proc. of CHI* (2007), 421–430.
 19. Lahiri, U., Warren, Z., and Sarkar, N. Design of a gaze-sensitive virtual social interactive system for children with autism. *Neural Systems and Rehabilitation Engineering, IEEE Transactions on* 19, 4 (Aug 2011), 443–452.
 20. Mollenbach, E., Hansen, J., and Lillholm, M. Eye movements in gaze interaction. *Journal of Eye Movement Research* 6(2) (2013), 1–15.
 21. Muñoz, J., Yannakakis, G. N., Mulvey, F., Hansen, D. W., Gutierrez, G., and Sanchis, A. Towards Gaze-Controlled Platform Games. In *Proc. of IEEE Conference on Computational Intelligence and Games* (2011).
 22. Nacke, L. E., Kalyn, M., Lough, C., and Mandryk, R. L. Biofeedback game design: Using direct and indirect physiological control to enhance game interaction. In *Proc. of CHI* (2011), 103–112.
 23. Ruhland, K., Andrist, S., Badler, J. B., Peters, C. E., Badler, N. I., Gleicher, M., Mutlu, B., and McDonnell, R. Look me in the Eyes: A Survey of Eye and Gaze Animation for Virtual Agents and Artificial Systems. In *EG 2014 - STARs*, Eurographics Association (2014), 69–91.
 24. Smith, J. D., and Graham, T. C. N. Use of eye movements for video game control. In *Proc. of ACE* (2006).
 25. Stellmach, S., and Dachsel, R. Designing gaze-based user interfaces for steering in virtual environments. In *Proc. of ETRA* (2012), 131–138.
 26. Stellmach, S., and Dachsel, R. Investigating gaze-supported multimodal pan and zoom. In *Proc. of ETRA* (2012), 357–360.
 27. Sweetser, P., and Wyeth, P. Gameflow: A model for evaluating player enjoyment in games. *Computers in Entertainment* 3, 3 (July 2005), 3–3.
 28. Turner, J., Bulling, A., Alexander, J., and Gellersen, H. Cross-device gaze-supported point-to-point content transfer. In *Proc. of ETRA* (2014), 19–26.
 29. Vertegaal, R., Weevers, I., Sohn, C., and Cheung, C. Gaze-2: Conveying eye contact in group video conferencing using eye-controlled camera direction. In *Proc. of CHI* (2003), 521–528.
 30. Wetzel, S., Spiel, K., and Bertel, S. Dynamically adapting an ai game engine based on players' eye movements and strategies. In *Proc. of the 2014 ACM SIGCHI Symposium on Engineering Interactive Computing Systems* (2014), 3–12.
 31. Yang, R., and Zhang, Z. Eye gaze correction with stereovision for video-teleconferencing. In *Proc. of ECCV* (2002), 479–494.