GazeAway: Designing for Gaze Aversion Experiences

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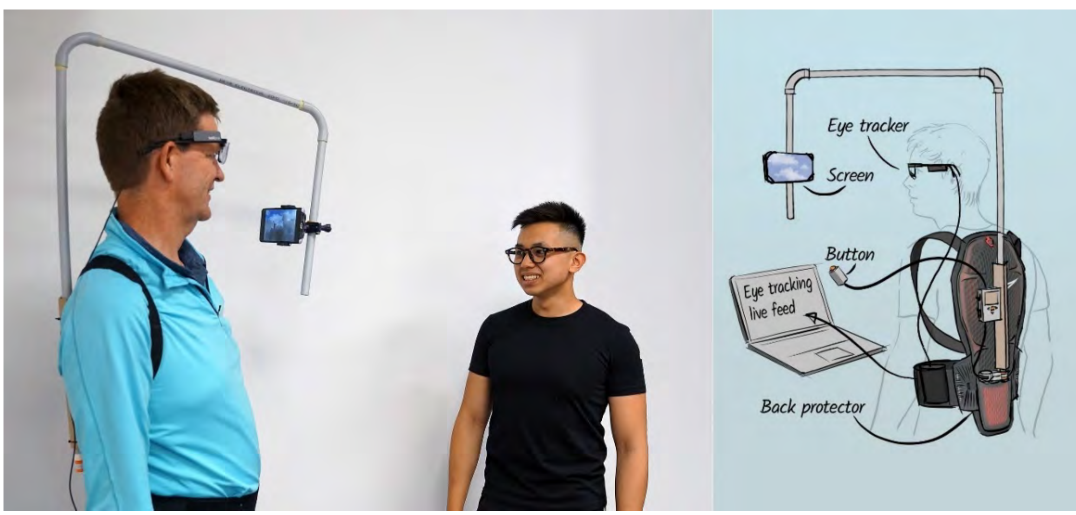

Figure 1: Left shows two people using GazeAway, one of our six augmented gaze aversion design explorations. Right shows an annotated sketch of the prototype as used in the preliminary evaluation, showing the individual components.

ABSTRACT

Gaze aversion is embedded in our behaviour: we look at a blank area to support remembering and creative thinking, and as a social cue that we are thinking. We hypothesise that a person's gaze aversion experience can be mediated through technology, in turn supporting embodied cognition. In this design exploration we present six ideas for interactive technologies that mediate the gaze aversion experience. One of these ideas we developed into "GazeAway": a prototype that swings a screen into the wearer's

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field of vision when they perform gaze aversion. Six participants experienced the prototype and based on their interviews, we found that GazeAway changed their gaze aversion experience threefold: increased awareness of gaze aversion behaviour, novel cross-modal perception of gaze aversion behaviour, and changing gaze aversion behaviour to suit social interaction. We hope that ultimately, our design exploration offers a starting point for the design of gaze aversion experiences.

CCS CONCEPTS

• **Human-centered computing**; • **Human computer interaction (HCI);**;

KEYWORDS

Embodied interaction, gaze aversion

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1 INTRODUCTION

Gaze aversion is a form of embodied cognition: it is a way in which we use our bodies to make sense in the world [6]. As part of this embodied sensemaking, we commonly perform gaze aversion: we direct our gaze away from what we are focussing on, usually looking at a visually less stimulating area in the environment [1, 15, 23, 26]. Gaze aversion can support cognitive processes in multiple ways: to help manage visual clutter [8, 23] or cognitive load [1, 18], to help with visualising an object [23], and to help with remembering by copying the remembered gaze [23]. We use gaze aversion when we are alone [1, 23, 26], but also in social interaction, for instance, to indicate to the interaction partner that we are thinking [1].

Within HCI, designers have been increasingly developing technologies that enable embodied interactions (e.g. [5, 6, 14]) to support and alter sensemaking practices. However, sensemaking is not always consciously done [14], as is the case with gaze aversion. Due to this subconscious nature, we believe that technology has the potential to alter a person's gaze aversion experience, with the potential of supporting embodied cognition, as has been demonstrated with, for example, subtle gaze direction techniques that supports later recall [2, 10, 20], and using gaze aversion as a game mechanic [19].

In this work, we present six design ideas for gaze aversion, of which we developed one, GazeAway (Figure 1), into a Wizard-of-Oz prototype that was used by six participants. The ideas along with the participant interviews resulted in a preliminary understanding of ways in which interactive technologies can change our experience of gaze aversion, which are translated into preliminary design strategies that designers can use as starting point when aiming to design novel gaze aversion experiences. Ultimately, we hope that our work can serve as a starting point towards understanding how to design interactive technologies aimed at mediating our gaze aversion experience and aid designers in creating novel gaze aversion experiences.

2 RELATED WORK

Gaze in general has been of interest in the HCI community, as demonstrated in work on "subtle gaze direction" [2, 10, 20], a technique that uses either a computer screen [2], AR [20], or VR [10], to show subtle changes in saturation in a small area of an image to catch the attention of the viewer [2]. This technique makes use of human peripheral vision and its sensitivity to changes in saturation and movement, while the foveal vision is specialised in viewing colour [3]. The viewer will notice the cue, but the cue will be gone as soon as the viewer turns their gaze to that area [2]. "GazeRecall" shows that subtle gaze direction can be used in support of future recall: Rothe et al. [20] applied this technique to direct the gaze of the person experiencing this cinematic piece, and support the user in paying attention to aspects of the experience that required recall at a later stage. Though the work on subtle gaze direction looks at gazing and not gaze aversion specifically, it shows that interactive technology can mediate gazing experiences and that this mediation can support a cognitive process like recall.

Art has also shown interest in gaze. Hölling et al. [11] applied subtle gaze direction in audio-visual art installations, guiding the onlooker's gaze through the artwork. The art piece shows that gaze can be the topic of the work, or gaze can be used as a tool to guide the user's experience of the work. Work by Dikker et al. [27] visualised mutual gaze in the form of visually represented synchronised brainwaves: artist Marina Abramović [16] looks into the eyes of the gallery visitors that sit across her, with the addition of brain wave measurements using EEG being visualised next to the seated pair. This performance art piece made the implicit effects of gaze explicit by means of visualising the EEG signals, therefore changing the gaze experience of the gallery visitors. From these art pieces we see that gaze can be directed and explicitly visualised in order to change the visitor's experience of the art piece.

Apart from using vision to guide gaze, we can use the "moving body" [17], as, for example, in Tanaka et al.'s [28] work: the authors used electrical muscle stimulation (EMS) to rotate the neck and thus the gaze of the wearer towards a fire extinguisher [28]. Suggesting bodily movements has also been done in context of everyday activities, as demonstrated by "SomaFlatables" [22], a system that suggests embodied behaviours like pushing an ear forward when the user indicates they can not hear their interaction partner. EMS and inflatable wearables, are two examples of how we can create suggestions of bodily movement that mediate the gaze aversion experience.

In videogames we found an example of how gaze aversion can be used to facilitate a new experience. The game "SuperVision" [19] is entirely played through gaze: the player can only successfully play the game by not looking directly at the items they are trying to control on the screen. Instead, the interactions rely on the player's peripheral vision. It juxtaposes itself with "subtle gaze direction": where "subtle gaze direction" encourages a person to look at a specific area, "SuperVision" tries to achieve the opposite – not looking at a specific area. The game is an example where a person is made aware of their gaze aversion behaviour through a game, resulting in a new playful gaze aversion experience.

Taken together, we find that prior work has engaged with gaze aversion, but mainly as an input for different interaction technologies, rather than explored as a technologically-mediated experience, which we believe deserves investigation because prior work has shown that technologies have the ability to mediate gazing experiences, even offering embodied support for cognitive processes like recall. This leaves us with a gap in knowledge on how to design the gaze aversion experience. In order to begin filling this gap, we aim to start answering the RQ: How should we design interactive technology that mediates gaze aversion experiences?

3 IDEATION

In order to ideate gaze aversion mediating technologies, three members of the research team used the 6-3-5 method for brainwriting to generate 24 ideas [24]. Three questions guided us through the brainwriting session: 1) "How can we guide the user to look at something 'boring'?", 2) "How can we detect when a person would benefit from looking up?"; and 3) "How can we guide the user to look away?" This resulted in 33 ideas, of which we present six. Each idea represents a different way in which interactive technologies can mediate the gaze aversion experience, based on where the technology is in relation to the user's body, and how the technology interacts with the user.

- **Nudging the head:** (Figure 2a). The user wears a device around their neck, resting on their shoulder. The device's microphone detects when the user is using filled pauses like "uhm", which can be used to support recall [7]. When detected, the device inflates pockets that push the head upward into a gaze aversion position, for example looking up and to the side. This work takes on Saini et al.'s [22] approach, providing a gentle nudge for the head movement, allowing the user to override it. This idea creates the embodied nudge to perform gaze aversion as a result of the user performing other forms of embodied cognition.
- **Crawling critters:** (Figure 2b). The user fits a regularly used item in their environment with a "critter extension" (inspired by [13]), which gives any object little legs to move around on. A camera is used to detect fidgeting behaviour in the person. Fidgeting behaviour is used for self-regulation [12]. Once fidgeting is detected, the object with the "critter extension" starts to move away from the user. This motion is designed to gently grabs the user's attention and direct gaze aversion through subtle gaze direction. When the person looks at the "critter", the object stops moving, offering a spot for gaze aversion. The "critters" are a physical representation of subtle gaze direction cues, and suggest gaze aversion when a person is fidgeting.
- **Augmented view:** (Figure 2c). Inspired by "GazeRecall" [20], the user wears an AR headset and a skin conductivity sensor. When the device notices that the user is in a demanding cognitive process such as remembering or creative thinking, expressed through a higher skin conductivity [4, 25], a white area starts to appear in the peripheral field of vision. This spot stops growing when the gaze is directed towards the white area. This augmented view changes the gaze aversion experience, as it emphasises an area in the field of view to be specifically used for gaze aversion.
- **Gaze aversion hot-spots:** (Figure 2d). Once again inspiration came from subtle gaze direction [2], though this version opts to provide a stimulus in the physical environment, rather than on the screen the user is already engaged with. The digital picture frame is placed in the peripheral view of the user and shows a familiar picture. When the device's built-in eye tracker detects eye movements (e.g., blinking more quickly or starting gaze aversion [8, 23]), it initiates a gentle, progressive blurring of the picture in the frame. When the user fixes their gaze on the device, the blurring animation stops, offering a spot to gaze at. Similar to the crawling critters, this idea aims to change the gaze aversion experience by offering subtle gaze direction and, subsequently, a place to avert the gaze to.
- **Fishing for thoughts:** (Figure 2e). The user wears a rig on their back with a small screen that shows a slow animation. When not in use, it is positioned to the side. When the camera detects gaze aversion, a motor rotates the rig into view, giving the user a dedicated spot to avert their gaze to. The gaze aversion experience changes here through moving a screen with limited visual information into the line of sight of the user whenever they engage in gaze aversion. Like Idea 1, "Nudging the head", this idea uses the detection of another embodied cognition behaviour as a means of encouraging gaze aversion.
- **The turn-around:** (Figure 2f). This body-based gaze direction system involves a revolving chair with a servo motor and touch sensors on the arm pads. The chair rotates slowly when it detects fidgeting behaviour on the arm pads, encouraging the user to avert their gaze by rotating the chair. This idea differs from the others because it moves the entire body, but it does not suggest where to direct the gaze at, like Ideas 2, 4 and 5.

We decided to go with Idea 5, "Fishing for thoughts", because of the way that it can encourage gaze aversion when performing another embodied cognition behaviour, as well as promote awareness when performing gaze aversion behaviour. Additionally, this idea addresses both the visual (offering a screen with low visual stimulation) and the physical aspects (placing the screen in the peripheral view) of gaze direction. Ideas 1, "Nudging the head", and 6, "The turn-around", address only the physical aspect of gaze aversion by creating or suggesting bodily movement, while Ideas 2 and 4, "Crawling critters" and "Gaze aversion hotspots" respectively, solely address the visual aspect by using subtle gaze direction and creating a place to avert the gaze to. Though Idea 3, "Augmented view", is worn on the body and provides visual cues, we did not select this idea as we were most interested in a physical prototype to support sense-making in the physical world, rather than an actuation that exists merely in the digital world.

4 PROTOTYPING GAZEAWAY

We created a prototype where we simulate the mediation of gaze aversion (Figure 1) in order to perform an early evaluation of the developed concept with the help of participants (Figure 1). We

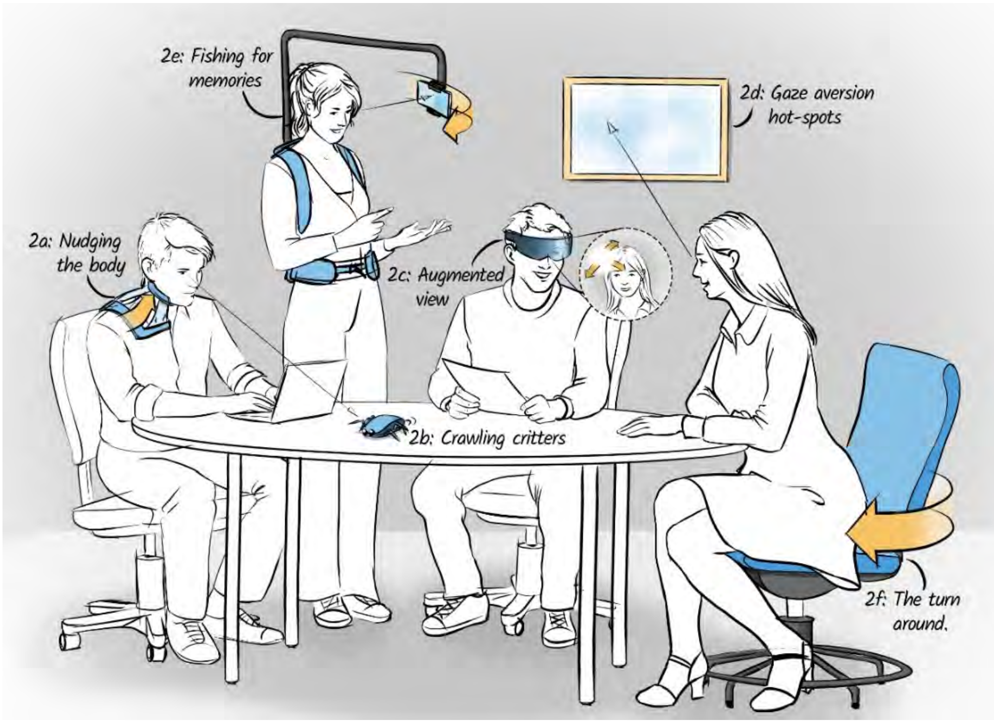

Figure 2: The six ideas. 2a: Nudging the body; 2b: Crawling critters; 2c: Augmented view; 2d: Gaze aversion hot-spots; 2e: Fishing for memories. 2f: The turn-around.

decided to use eye-tracking glasses, Tobii Pro Glasses 2 [29], over other detection methods mentioned in the ideas, since eye-tracking appears to be one of the more effective ways to detect when a person is in a cognitively demanding thinking process [8, 23, 30, 31]. Though the detection of gaze aversion can be done automatically, we opted for a Wizard-of-Oz setup as we wanted to perform a preliminary evaluation without the investment in these automatic detection methods to test our concept at an early stage of the design process. The prototype consists of a PVC-pipe rig attached to a motorcycle back protector, with a Lego MINDSTORMS [32] microprocessor and servo motor rotating the rig. A smartphone mounted on the end of the rig displays a video of slowly moving clouds, chosen to support low cognitive load, inspired by prior work using the same scenery [1, 3, 9]. The height of the screen could be adjusted by placing it higher or lower on the rig to account for the participant's height. The rotation is activated in a Wizard-of-Oz way [21] through a button connected to the microprocessor held by the researcher positioned behind the user, who wears the prototype and eye tracker. The researcher viewed the real-time eye tracking data and pushes the button when the user looks away from their focus of action, that being their interaction partner, or the paper they are writing on. Pushing the button actuates the servo motor to swing the rig into a "gaze aversion position" slightly to the side of the user. The button is pushed again when the user returns their gaze, returning the rig to the starting position.

5 PRELIMINARY EVALUATION

We performed a preliminary evaluation to gain an initial understanding of how users might respond to GazeAway. Six participants (three males and three females) were recruited and formed three duos: one male/male, one male/female, and one female/female duo. All participants were affiliated with the researcher's institution as a student (n=1), researcher (n=3) or PhD candidate (n=2). Two duos were colleagues, one set (male/female duo) consisted of intimate partners. Each participant took part in all mentioned roles (solo, as the user in the duo scenario, and as the interviewer in the solo scenario), in order to investigate the changes in gaze aversion experiences in solo and social settings. Participants were counterbalanced in the order in which they experienced the different roles in the scenarios.

In the solo scenario, the participant was seated at a table. The researcher was seated behind the participant and watched the eye tracker data. The user had three minutes to write down an answer to the prompt: "Describe what you did during the last Christmas break". The researcher pressed the button when the user appeared to be in a remembering process, which made GazeAway swing into closer view for the participant. Once the participant was refocusing on their task, the researcher pushed the button once more to let the GazeAway return to its original position.

In the duo scenario, one participant (the user) wore the prototype and the eye tracker. The other participant (the interaction partner) interviewed the user. Both participants were standing, facing each other. The researcher stood behind the user, holding the actuation button and looking at the eye tracking data. The interaction partner received a prompt card to interview the user for three minutes, asking to "Describe your last vacation" or "Describe a project you are proud of". For our data collection, we video-recorded the participants and recorded their eye-tracking data.

After completing both scenarios, the participants completed a semi-structured interview about their experience, which included questions like "How did GazeAway change your interactions?" and "How did GazeAway change your remembering process?"

6 PRELIMINARY FINDINGS

In this section, we present our preliminary findings:

- **Wearing GazeAway increased the user's awareness of their gaze aversion behaviour through proprioception:** The participants noticed the weight of the GazeAway prototype, which added a new layer to the interactions. When the rig moved, several participants mention that they felt the weight shift on their backs and shoulders. These reports suggest that proprioception (sensing the location of the weight of the prototype) influenced the participant's experience of gaze aversion through creating more embodied awareness.
- **Users altered their behaviour in order to integrate the GazeAway into social interactions:** One participant explained that they tried to not look directly at the screen for too long, because they *"did not want to appear distracted"* while talking with their interaction partner, thus making their gaze aversion intervals shorter. GazeAway also appeared to influence where the participants looked, since several participants appeared to prefer to look to the side where the screen was, but they rarely looked directly at the screen. Additionally, one participant who reported to often shift weight while standing and talking with someone, noticed that they moved less while wearing the GazeAway out of concern of accidentally hitting the prototype against a wall or a person.
- **Personalisation to body and gaze aversion behaviour supports the use of GazeAway:** Since we created only one prototype, we had to rely on a single back protector with limited adjustability for the evaluations. In the evaluations, we observed that participants who fit the prototype better, were better able to control the movements of the rig due to improved stability of the structure. Additionally, the participants expressed personal preferences in the video shown on the screen, the height of the screen and distance of it to the face, as well as the location of the rig in each position. Such personalisations can be used as a way of allowing the user to tailor GazeAway to benefit their gaze aversion experience.

7 DISCUSSION

Our initial exploration suggests that interactive technology can mediate gaze aversion in both positive and negative ways. We described different ideas through which the gaze aversion experience could be altered, and used a prototype of one of these ideas to gather preliminary experiences from our participants. Based on this, we now suggest three different preliminary strategies for mediating gaze aversion experiences:

- **Consider using other senses to mediate gaze aversion experiences:** Our prototype altered the user's awareness of their gaze aversion behaviour not only through visually swinging to view, but also through proprioception. Therefore, we propose that by utilising other senses, such as proprioception, the experience of gaze aversion can be enriched.
- **Consider interactive technologies that mediate gaze aversion experiences in support of social interactions:** From the preliminary findings we learned that even though GazeAway was not seen as a distraction, wearers did put in an effort to integrate the technology into their social interactions. GazeAway increased the wearer's awareness of their gaze aversion behaviour through a less socially acceptable behaviour: looking at a screen during social interactions. The wearer limited this behaviour by making their gaze aversion interval shorter. Designers of interactive technologies for gaze aversion should therefore consider to support rather than distract from social interactions.
- **Consider using a prototype to investigate how a technology changes the perception of gaze aversion:** The findings from the ideation session suggest that the way the user perceives their own gaze aversion behaviour could be altered in four different ways: emphasising by moving the body (Ideas 1 and 6, also see [28]), obscuring gaze aversion from others (Idea 3, see also [1, 20]), emphasising by transforming the environment (Ideas 2, 3 and 4), and emphasising through user-related cues, e.g., GazeAway swinging into place (Idea 5). In the preliminary evaluation, these alterations in perception were reflected in the considerations that participants had in social interactions. Our prototype did make gaze aversion more apparent to the wearer and interaction partner, as expected, but we did not expect the consideration of altering the length of gaze aversion in a social interaction due to the use of the prototype. Interestingly, our participants did not find GazeAway's movements distracting during social interaction, but they did alter their behaviour in social interactions based on the GazeAway's actuations.

8 LIMITATIONS AND FUTURE WORK

The presented work is based on our preliminary findings with a small participant group, coming from similar backgrounds, who had short interactions with a Wizard of Oz prototype only exploring one of the mentioned ways in which perception of gaze aversion could be changed. This means that all other mentioned ways have not been investigated through prototypes. To add, we relied on Wizard of Oz actuation instead of automatic gaze aversion detection. Therefore, there might be differences in the detection of gaze aversion and latency in actuation of the rig. Hence, future work could explore the design for gaze aversion by creating more high-fidelity prototypes that are used in longer studies with a larger and more diverse participant group.

Secondly, GazeAway only makes use of eye tracking in order to detect a high cognitive load. We can make the measurement for cognitive load more robust by combining eye tracking with other methods, such as brain activity sensors to detect high cognitive load [1, 23, 26], or skin conductivity to measure stress, as used in AffectCam [25] and Prospero [4]. Our participants voiced different preferences for videos, while our prototype only showed slowly moving clouds. Future work could investigate the effect of different videos on the screen on gaze aversion experiences, showing, for example, a blank space [1, 23, 26], or an urban environment [3].

9 CONCLUSION

Through the presentation of six design ideas as well as the preliminary findings of participant experiences using our prototype GazeAway, we found that technology can create increased awareness of gaze aversion behaviour, facilitate novel cross-modal perception of gaze aversion behaviour, and change gaze aversion behaviour to suit social interaction. We formulated an initial set of findings along with preliminary strategies to mediate gaze aversion experiences. Ultimately, we hope that our work can serve as a starting point towards understanding how to design technology aimed at mediating our gaze aversion experience and aid designers in creating novel gaze aversion experiences.

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