Don’t Look at Me, I’m Wearing an Eyetracker!

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Abstract
Looking is a two-way process: we use our eyes to perceive the world around us, but we also use our eyes to signal to others. Eye contact in particular reveals much about our social interactions, and as such can be a rich source of information for context-aware wearable applications. But when designing these applications, it is useful to understand the effects that the head-worn eye-trackers might have on our looking behavior. Previous studies have shown that we moderate our gaze when we know our eyes are being tracked, but what happens to our gaze when we see others wearing eye trackers? Using gaze recordings from 30 dyads, we investigate what happens to a person’s looking behavior when the person with whom they are speaking is also wearing an eye-tracker. In the preliminary findings reported here, we show that people tend to look less to the eyes of people who are wearing a tracker, than they do to the eyes of those who are not. We discuss possible reasons for this and suggest future directions of study.

Author Keywords
Eye tracking; interaction; gaze contingency; social behavior; eye-based computing; wearables

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H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous

Introduction

Traditionally, wearables were designed to gather and use context information from a single person (the wearer), but increasingly wearables are starting to use information from the interactions of the wearer with others. Wearables that monitor social interaction can be used to provide context-dependent information to the people involved in an interaction, for example, using wearable displays to help autistic children interpret social signals [10], or to provide cues to actors on what to say next [9].

Eye gaze is a particularly informative cue for social interaction. Our eyes, uniquely among the senses, both send and receive social signals; in conversation, we use our eyes to continually monitor and signal information to one another – signalling, for example, when we are ready to stop speaking (turn-taking), or to indicate that we are attending to what is being said [4].

Wearable eye trackers are a valuable tool in the psychological and cognitive sciences, and are used to study the looking behaviour of people in a range of situations, and as a way of revealing something about the underlying cognitive processes (e.g., [2, 6]).

To study the cognitive and behavioural processes that go on during social interaction, it is useful to be able to record the gaze of two or more participants. Unlike earlier desk-based eye-trackers where a single participant would sit, immobile, in front of a screen, wearable trackers can track multiple interacting participants in a much freer way [8]. This allows researchers to use more ecologically valid paradigms when testing their hypotheses [3].

But does an eye-tracker, worn on the face of a participant, affect the way in which others interact with them? Studies show that when a person knows their gaze is being tracked, they change their looking behaviour. For instance, when participants believe their eye-tracker is turned off they look more at a sexy swimsuit calendar than if they believe the eye tracker is on [7]. Importantly, it has also been shown that this effect is transient: it disappears after approximately 10 minutes, unless participants are reminded about the eye-tracker [6]. Yet, the effect of reciprocal eye-tracking – where the person being looked at also has her gaze tracked – may influence these findings. Since all interacting participants are wearing eye-trackers throughout the interaction, the visibility of the devices could act as a constant reminder that they are being monitored, consequently affecting behaviour.

This work presents a first attempt to measure the influence of a target wearing an eye tracker on the gaze behaviour of the person looking at them.

Methods

During a structured interview, a confederate asks a question, and a participant responds. Each question and answer trial had a duration of 40 s (22 s for the question and 18 s for the answer, approximately). This is repeated 12 times for each condition (overall duration of each condition is 8 min), over a total of 30 confederate-participant dyads. Participant and confederate sat on opposite sides of a table, facing each other at a distance of 1 m. A cardboard structure occluded the space around the confederate, so participants could only see the confederate’s upper half of the body in front of a neutral plain background (see Figure 1). With the test participant wearing an eye tracker throughout, we evaluate two conditions: confederate wearing eye tracker (with Glasses), versus confederate not wearing eye tracker (No-glasses). Participants always completed the Glasses condition first, followed by the Non-glasses condition. Wearable eye-trackers, from Pupil Labs, were worn by the participant throughout, and by the confederate in the Glasses condition [5]. Before starting the interview, each went through a 9-point calibration routine; they completed the calibration twice, once before each of the two conditions. Gaze fixations were calculated for each frame of the participant's world-view video, with an output at approximately 30 Hz.

Using the open source face-tracking algorithm, OpenFace [1], we extracted face coordinates of the confederate from each frame in the participant's world-view video. Using these face coordinates, we fitted an ellipse centered on the nose of the participant, which controls for changes in size and inclination of the face across the frames. Our two regions of interest (ROIs) corresponded to the upper half of the ellipse (eye region) and to the lower half of the ellipse (mouth region) (see Figure 1).

We then evaluated the mean proportion of time participants spent looking at each ROI. Data for the two ROIs is not independent because participants can only look at one place at a time. Therefore, we analysed gaze to these two ROIs separately. A paired-samples t-test was conducted to compare the proportion of looking time to each ROI in the Glasses and No-glasses conditions.

Figure 1. Sample frame of a participant's Pupil Labs video in the Glasses condition, showing gaze of the participant (red dot) and ROIs (blue and red half-ellipses).

Results

For gaze directed to the eye region, there was a trend for a significant difference between Glasses and No-glasses conditions ($t(29) = -2.03$, $p = .052$) (see Figure 2). Participants gazed more to the eye region in the No-glasses condition ($M = .068$, $SD = .07$) than in the Glasses condition ($M = .044$, $SD = .049$).

For gaze directed to the mouth region, there was no difference between Glasses and No-glasses conditions ($t(29) = -.406$, $p = .688$) (see Figure 2). Participants gazed equally to the mouth region in the No-glasses condition ($M = .119$, $SD = .094$) than in the Glasses condition ($M = .111$, $SD = .099$).

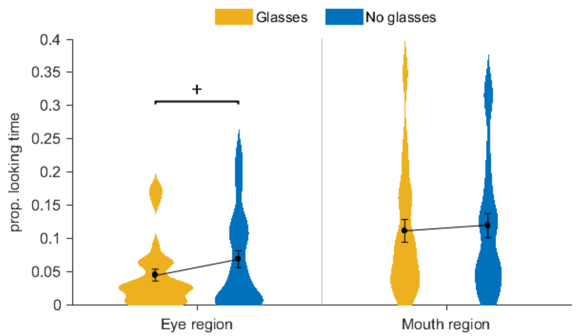

Figure 2 Proportion of looking time to each ROI and condition: mean (•), SE (error bars) and frequency of values (width of distribution). Plus symbol (+) signifies difference between conditions at $p < .1$.

Discussion and Future Work

We find that people will look more at the eyes of someone who is not wearing an eye tracker, compared to the same person wearing an eye tracker. No difference is found in looking behaviour towards the mouth region between the two conditions. This suggests that gaze directed specifically to the eye region is influenced by the presence of an eye-tracker on the person being looked at.

But why do people look less at the eyes of someone who is wearing an eye-tracker? There are limitations with the current study that prevent us from giving a concise answer, but below we explore possible explanations and suggestions for future work.

The other person's tracker provides a visible reminder that you too are being tracked. We moderate our gaze when we know our eyes are being monitored, but this effect reduces over time – we forget that we are wearing an eye-tracker [7]. It may be that conversing with someone who is also wearing a device prevents us from forgetting that we are being tracked, at least in the short term. Over the course of the 12 (Glasses) trials tested here, there is no obvious deviations from our main finding. However, a study over a longer timescale might evaluate this to see whether the effect eventually disappears (with the hypothesis that the wearer gets used to the confederate wearing a tracker).

Confederate behaviour. The confederate, however well-trained, might alter her gaze behaviour in some way when she knows that she is being tracked. These unconscious changes might in turn lead to the participants avoiding eye contact. Future studies could discount this possibility by, for example, recording confederate eye movements throughout using a discrete, desk based eye tracker, and comparing for differences between the two conditions.

Camera, tracker, or just an unusual object? The Pupil Labs tracker has a prominent world-facing camera worn next to the eye (during the induction and calibration process, all participants are made aware of this feature). In addition to the reminder that their eyes are being tracked, a camera looking directly at them could add to the feeling of being scrutinised. The camera might feel like an 'extra eye' on the participant, discouraging them from maintaining eye contact. One way of testing this might be to run a condition where the confederate wears only a head-worn camera, with the conditions being that the participant is told that it is switched off (or on).

Alternatively, the effect could just be a consequence of having an unusual object worn close to the eyes. This might be tested with a condition where other unusual head-gear, or facial markings such as tattoos, are worn by the confederate.

This last possibility has wider implications for wearables beyond eye-trackers. Does the presence of a head-worn wearable change the way in which we engage with the person who is wearing it? And if so, does the effect persist through longer use, and what are the social consequences of this, if any?

Conclusion

This work demonstrates that the gaze behaviour of the person looking is changed by whether the person being looked at is wearing an eye-tracker or not. The work is preliminary, however, and further study is needed to establish why this might be the case, and whether the effect will persist in long-term use of wearable eye trackers.

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