Altering Non-verbal Cues to Implicitly Direct Attention in Social VR

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ABSTRACT

In this work we explore a concept system that alters the virtual eye movements without the user's awareness, and whether this can affect social attention among others. Our concept augments the real movements with subtle redirected gazes to people, that occur in intervals to remain unnoticed. We present a user study with groups of people conversing on a topic, and measure the level of visual attention among users. Compared to a baseline of natural eye movements, we find that the method has indeed affected the overall attention in the group, but in unexpected ways. Our work points to a new way to exploit the inherent role of eyes in social virtual reality.

KEYWORDS

User Attention; Virtual Reality; Collaboration; Eye-tracking

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1 INTRODUCTION

Eye gaze is related to our attention, and communicates a variety of social constructs such as turn-taking in conversations [2, 7]. With advances in head mounted display technology, social interactions will become possible in virtual reality (VR), ranging from face-to-face collaboration [4] to virtual meetings and conferencing applications [1]. Eye-tracking technology is increasingly supported by such devices, and is poised to provide new interactive capabilities beyond what is naturally possible [3]. In social VR, most works showed the advantages of using natural eye movements to support mutual eye contact and more natural conversation [6, 7]. However, recent work pointed to a new way to consider multisensory information: artificially augmenting collaborative virtual interactions beyond what is possible in real life [5].

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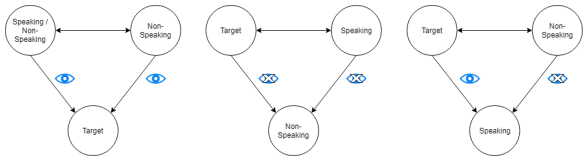

Figure 1: Concept of the virtual gaze alteration method.

In this regard, we explore a concept of implicitly altering the user's natural eye movements as a mean to affect the attention between people. In particular, whether eye gaze as a non-verbal cue can potentially attract attention to particular users, and with it have an effect on the conversation. The principle is a social constellation where one user is the target to receive enhanced attention. The other collaborators' gazes are more frequently directed toward the target user. As well, the other collaborators themselves are being gazed at less frequently.

Such a method can potentially work without a user's awareness, which can raise many new questions from a social as well as ethical perspective. A use case could be to provide a more balanced discussion between people. But in other cases, it could potentially be exploited to steer social activities such as decision-making to a particular direction – where users need to be made aware of potential effects in that regard. However, before we further this discussion, it is important to first understand if it is at all feasible to utilise such a method. And indeed, our study with groups of 3 indicated that this method can affect the group attention between people.

2 GAZE ALTERATION METHOD

In a collaborative system that supports eye-tracking, natural eye movements are displayed for each user. In addition, the system performs *virtual gaze shifts*, i.e., periodic changes of the real to different virtual eye movements as an indirect way to potentially direct attention between the people. Every 2-4 seconds (randomly selected), a gaze is redirected toward another person and holds for 0.5-1.5 seconds (randomly selected). How gazes are redirected is done in two ways as illustrated in Figure 1. Hereby we call a person a *target* when they are the one who should receive more attention by the method.

First, from a target's perspective, the virtual eyes of the other users will be shifted toward them to encourage activity. Second, from the other users' perspective, the system checks if they are speaking by a microphone. When not speaking, the likelihood of speaking is decreased by activating virtual gaze shifts to the room, away from users. When speaking, the goal is to increase likelihood

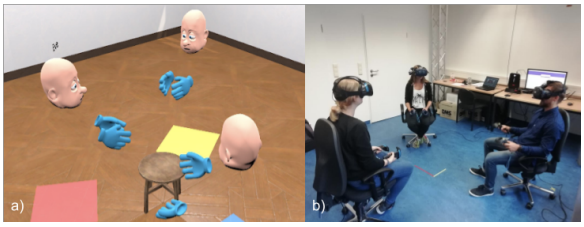

Figure 2: a)VR View b) Real View

that the target takes the next turn. Here the system 1) alters the target user's gaze to look at the speaking user, and 2) other non-speaking users are less frequently gazing at the speaker (i.e., gaze shifts toward the room away from the user).

3 USER STUDY

The goal of the within subject study was to observe if attention in a VR conversations can be altered with the method. We designed a deception study where participants were informed about the alterations after the study. This was validated with our ethics committee, and user consent was given at the end. Users discuss a decision-makingtopic in 5 minutes for each condition, e.g., what to do at the next weekend. A setup for three VR users was created, where they can talk to each other as avatars. The software was written in C# and Unity. We used an HTC Vive Pro Eye and two Tobii Pro VR Integration headsets. Avatars could blink and move their eyes according to real eye movements.

The study follows a within-subjects design comparing the proposed method to a baseline condition where no manipulation was performed. We focus on a single user as the *target user* for each instance. Target users changed throughout the study, so that every participant was the target user once (random order). We measured visual attention and user awareness in this study.

Task goal for users was to agree to the same end result, which is asked afterwards to ensure participants are involved actively and seriously in the discussion. The topic is displayed on the participant's screen. A 5 second countdown started to indicate the start of the conversation. Techniques are activated after a threshold of 30 seconds of the conversation, to assess its effect in the main part of the conversation without a potential bias from initial chatting.

36 participants (20 female) aged between 22 to 30 (mean=25, SD= 2.59) took part in the study, grouped to 12 groups of 3 persons. Group participants were introduced to the task and filled out a demographic questionnaire. Then everyone put on the VR headset and the eye trackers were calibrated. Users then conducted the discussions with the different conditions (counterbalanced by a Latin square). After the purpose of the study and the techniques were revealed, they were asked about their consent.

The main dependent variable is visual attention, defined as the user's eye gaze ray hitting another user's virtual head collider at each frame. From this data, we derive *Target Attention*, as the ratio of users looking at the target versus users looking elsewhere (environment, third user). We also derive *Group Attention*, as the ratio of users looking at the other two users, versus looking at the environment as an approximation of overall attention to the peers.

4 RESULTS

In a questionnaire after each condition, we asked about the impression of the technical quality of our VR environment to see whether participants noticed something about the techniques. A Friedman test showed that there was no significant difference between the techniques. As well, the interview revealed no indication that users were aware of such a method during the study.

A Friedman test was used to analyse for statistical differences among conditions for *Target Attention*. Baseline (M = .31, SD = .28) compared to gaze (M = .26, S.E. = .26) showed no significant differences considering attention toward the target user ($\tilde{\chi}^2$ = 1.059, p = .303). However, the Friedman test revealed a statistical difference between the two conditions for factor *Group Attention* ($\tilde{\chi}^2$ = 5.765, p = .16). This indicates that the gaze method (M = .3511, S.E. =.1563) has led to higher attention to the people in the group than the baseline of no alteration (M = .328, S.E. = 1.161).

5 DISCUSSION AND CONCLUSION

We explored a concept that subtly alters eye movements, in a way that it can remain unnoticed but ideally can play a role in the attention allocation between users. Our study showed that the overall attention was significantly affected and the method remained unnoticed across users. An open question is how this has affected the group attention. While this is at odds with the goal of the effect (we aimed for more attention toward the target), it yet confirms that the principle concept has the power to actually affect attention. This can become impactful considering future VR based meetings and collaborations and the potential to improve the attention.

We consider our work as the first to consider altering the relation between eye-gaze and attention for the benefit of a user. Altering eye movements is complex, as every person's gaze behaviour may be different and the addition of simple gaze shifts perceived by the group members can steer the attention in both ways. It is possible that users look more to a target person, because the person looks at you; but at the same time it may be possible that this is perceived as a dominant act and you may avert your gaze. In the future, it is of interest to look into the alterations in more detail, for example, to distinguish the power of the effect from directing gaze to a target versus averting gaze to other users.

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