COGAIN Symposium
Wuppertal, August 21st 2017.

Implicit Events in Virtual Reality: A New Concept for Eye-Based Interaction?

Teresa Hirzle
Ulm University,
Germany

Jan Ehlers
Ulm University,
Germany

Anke Huckauf
Ulm University,
Germany

Enrico Rukzio
Ulm University,
Germany

Pupil size is a sensitive physiological information channel that reveals internal states of a person. Furthermore, pupil responses are caused by implicit events, which occur usually without noticing it. The current study makes use of these events by presenting an eye-based interaction technique based on attention shifting. As the pupil especially reacts to changes of illumination and environmental noise, the study is conducted using a virtual reality head-set with integrated eye tracking. Results show that focusing attention on a target correlates with increased pupil diameters, whereas the simple observation of neutral objects does not provoke a pupil reaction. Therefore, we conclude that using implicit events as interaction technique in eye-based Human-Computer Interaction scenarios is a promising approach.

Keywords: eye tracking, attention, usability, new media, pupil dilation, pupillometry, intent prediction

Introduction

Eye-based Human-Computer Interaction applications are mainly based on gaze interaction. The pupil, however, provides valuable information on internal states of a person and can therefore be applied to determine cognitive and affective processes. Particularly, pupil responses reveal information on implicit events, such as decision making (Einhäuser et al. 2010) or interaction intent (Jadue et al. 2015). The presented study aims to investigate the potential of using implicit pupillary information to determine intent and attentional selection in human-computer interaction.

Decision-related pupil responses are reported in Jadue (2015), where larger pupil sizes are observed while clicking on objects in contrast to simply observing non-chosen objects. Correspondingly, De Gee (2014) reports strong pupil enlargement correlated with "yes"- compared to "no"-answers. In both cases pupil responses are obtained during passive observation or by selecting objects based on their semantic content ("yes" or "no" items). In the present study, however, pupil responses are induced by focusing attention on abstract objects that bear no meaning and actively need to be enriched with personal significance. To control environmental influences, the current study is conducted using a virtual reality headset with integrated eye tracking (Geiselhart et al. 2016).

Interaction intent is operationalized by shifting overt attention towards various (abstract) objects, which do not carry any semantic information. We aim to differentiate between pupil responses based on predefined attention behavior (instructions from the experimenter) compared to purely internal generated control. Pupil diameter is expected to be larger during target fixation compared to passively observing (abstract) objects.

Methods

The study was conducted using a monocular eye tracking system based on the Samsung GearVR. The system provides a frame rate of ~ 35 fps and a spatial resolution of 400x300. Calibration, gaze mapping and study application were implemented with Unity 3D running on a Samsung Galaxy S6 Edge+ smart phone. We applied a within-subject design with randomized conditions and object order; pupil diameter served as the dependent

The 2017 COGAIN Symposium: Communication by Gaze Interaction Wuppertal, Germany. August 19th and 21st, 2017

variable. Attention behavior (instructed allocation vs. self-chosen allocation vs. passive observation) constitutes the independent variable.

Participants

Pupil and gaze values were obtained from 19 subjects (13 female; mean age 23 years; SD 5). Tracking errors in approx. 50% of the trials resulted in varying sample sizes among conditions (control condition: 14, "internal condition": 15; "external condition": 8). Subjects were students of computer science or psychology and participated voluntarily (CS) or received course credits (PSY). Informed consent was obtained from all participants.

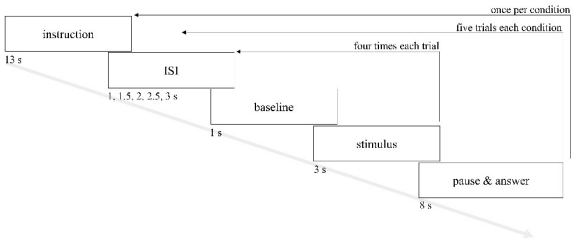
Materials

Four abstract, rather unambiguous objects of the same brightness were applied on a constantly gray background. Objects were thin black outlines of simple, geometric forms. Thereby, stimuli by itself should not provoke any affective associations or induce considerable cognitive load and should even not cause a pupil dilation due to their brightness. Furthermore, visual feedback was not applied.

Procedure

Participants underwent three conditions, each consisting of five trials. In any case, objects were presented consecutively in the middle of the screen and once per trial. Besides the control condition, in which all items had solely to be observed passively, subjects were asked to freely focus attention on one arbitrary object per trial ("internal condition") or to pay particular attention to one predefined object ("external condition"). Remaining objects during the respective trials had simply to be looked at. Attention was operationalized as "a concentrative orientation towards the respective stimulus". After each trial participants had to name the position of the target to make sure they payed attention to it. The procedure is depicted in figure 1.

. Fig. 1 Study procedure.

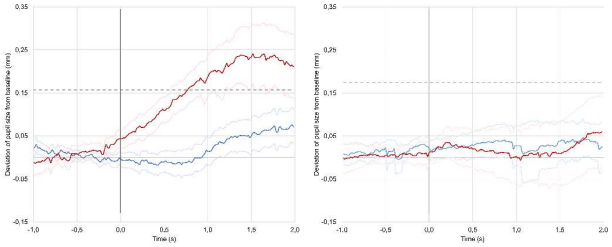


Results

To standardize participant's pupil diameter near zero baseline mean was subtracted from each single value during measurement. Missing values (e.g. blink) are replaced by interpolation.

Figure 2 depicts the course of pupil size averaged over all trials of focusing attention on target (red) and passively observing the remaining objects (blue). Left figure depicts signal dynamics within the "internal" condition, indicating strong pupil enlargement during internally generated attention behavior. Determination of differences followed the non-parametric Wilcoxon test and revealed a significant difference ($Z=-3.07$, $p<.01$). Within the "external" condition, these differences could not be obtained.

Fig. 2 Course of pupil diameter during "internal" (left) and "external" condition (right).



Discussion

Focusing attention on a target results in bigger pupil sizes than simply observing a neutral object. The use of implicit events (here: pupil dilations) as an indicator of intention in HCI is promising. The current study shows that attentional shifts towards abstract objects are reliably detectable. Thereby, internally generated attention selection provokes strongest responses.

Using the VR eye tracking headset provides an excellent opportunity of controlling environmental influences. However, to further develop the presented approach into a versatile interface for human-computer interaction, the associated mechanisms have to be evaluated in more complex settings and on the basis of increased cognitive noise.

To sum up, the presented results support the approach of using implicit events induced by attention shifting to recognize interaction intent. However, long-term studies should be conducted to investigate the effect of this strategy over time.

References

De Gee, J. W., Knapen, T., & Donner, T. H. (2014). Decision-related pupil dilation reflects upcoming choice and individual bias. In *Proceedings of the National Academy of Sciences, 111(5),* E618-E625.

Einhäuser, W., Koch, C., & Carter, O. (2010). Pupil dilation betrays the timing of decisions. *Frontiers in human neuroscience*, 4-18.

Geiselhart, F., Rietzler, M., & Rukzio, E. (2016). Eyevr: low-cost vr eye-based interaction. In *Proceedings of the 2016 ACM International Joint Conference on Pervasive and Ubiquitous Computing: Adjunct,* 277-280.

Jadue, J., Slanzi, G., Salas L., & Velásquez, J. D. (2015). Web user click intention prediction by using pupil dilation analysis. In *2015IEEE/WIC/ACM International Conference on Web Intelligence and Intelligent Agent Technology (WI-IAT), volume 1,* 433-436.