Investigating the Effect of Light on EOG data

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Project brief

Aims & objectives

Electrooculography (EOG) is a cost-effective and non-invasive technique for measuring eye movements, widely used in clinical diagnostics and for eye-gaze estimation used to develop eye movement-based human-computer interface (HCI) systems. Based on the electrical activity that is generated by the human eyes, EOG is recorded using electrodes attached around the eyes. Although EOG signals are often considered insensitive to illumination changes in the EOG-based HCI system domain, a standard clinical ophthalmic test indicates that the EOG signal amplitude for the same ocular displacement can oscillate with sudden light or dark onset. Following light onset, the signal typically peaks after 7–12 minutes (Light Peak), declines to a dip at ~20 minutes (Light Through), and reaches a steady state after 90 minutes. Given the inconsistencies, this study investigates the EOG signal in different light conditions with the aim of clarifying its effect in HCI applications.

Methodology

A recording protocol was designed to capture the behaviour of EOG signals under two typical indoor lighting conditions: 150 lx (dim) and 500 lx (bright). Participants were first set up using the standard electrode configuration as shown in Figure 1, and instructed to follow a visual target displayed on a monitor. Recordings were made in 64-second epochs, each separated by a 116-second interval, forming 3 minute cycles. After two pre-adaptation cycles (300 lx), participants underwent 22 cycles (66 minutes) in darkness (dark adaptation), followed by 30 cycles (90 minutes) under white light (light adaptation). The experiment duration was chosen to ensure that the light- and dark- induced oscillations in EOG amplitude had sufficient time to reach a steady state. The full protocol was then repeated under both lighting conditions.

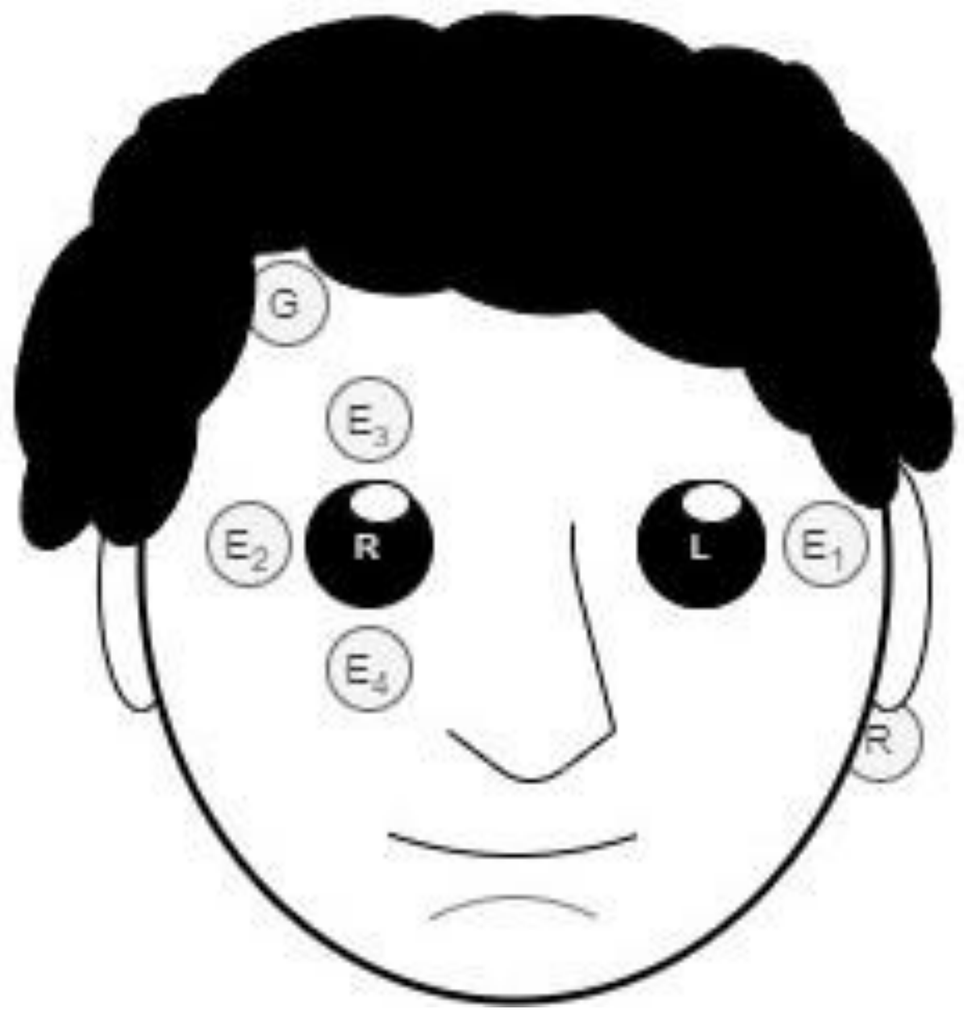

Figure 1: Electrode configuration used in this work

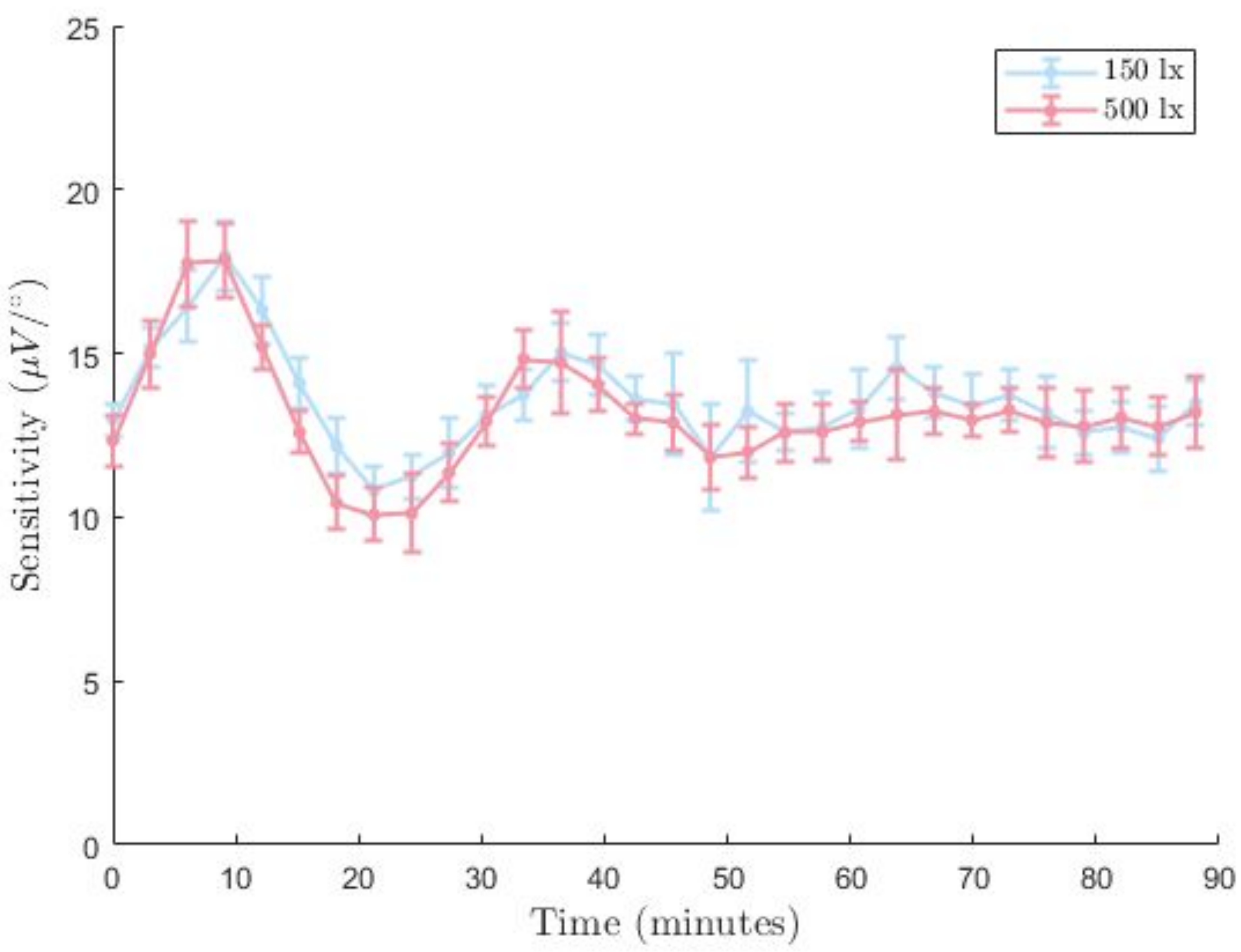

Figure 2: EOG sensitivity for one participant under two different lighting conditions. Points show mean sensitivity per epoch; error bars indicate standard deviation.

Results & conclusions

Figure 2 illustrates the EOG potential displacement per degree of gaze movement, termed the EOG sensitivity, for one participant. Similar trends were observed across all participants. Analysis of the recorded EOG data confirms that while steady-state sensitivity values are comparable between illumination levels, significant fluctuations after light onset may lead to over- or under-estimation of the user's gaze, adversely impacting the gaze estimation accuracy. These findings suggest that while EOG-based HCI systems are largely insensitive to illumination levels under steady-state conditions, lighting transitions necessitate frequent recalibration to maintain accuracy in real-world settings. Hence, this highlights the need to model the slow-oscillation. Such a model has the potential to enable real-time compensation, improving long-term reliability of EOG-based HCI systems.

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