Smartphone Pupilometry for Identifying Aphantasia and Hyperphantasia

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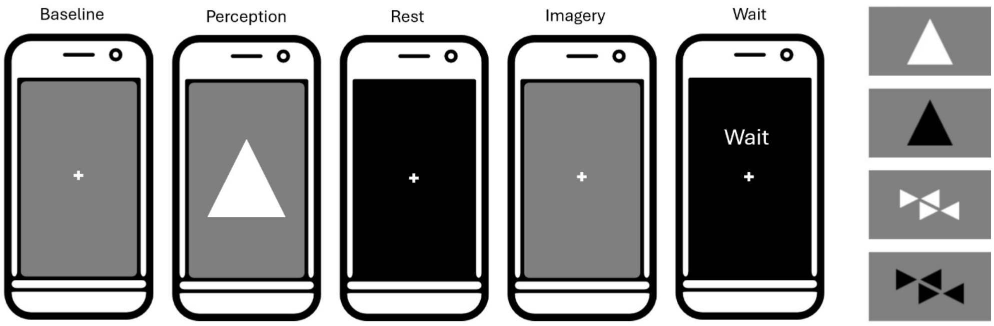

Fig. 1. Left: We used an Android application to capture and analyse near-infrared (NIR) images of the pupil (based on an approach from [1]), and to present a series of visual cues, rest cues, and visualisation cues (using a protocol adapted from [3]). Right: A set of two light, and two dark stimuli were seen, and subsequently visualised, by each participant.

I. Introduction

For many, the ability to create visual images that exist only in the mind is an inherent part of their daily experience – contributing to activities including autobiographical memory, planning, and navigation. However, this ability is not universal. Up to ~ 5% of the population report an absence of visual imagery [2], a condition known as *aphantasia*), while others report imagery whose vividness is akin to vision itself (*i.e. hyperphantasia*).

Until recently, measures of mental visual imagery were constrained to the subjective. Tools such as the Vividness of Visual Imagery Questionnaire (VVIQ) [4] ask individuals to report on a scale, their experience of generating visual imagery, in response to a set of defined scenarios. However, research has shown that difference in mental sensory experiences may also be indicated through biological measures. Pupilometry, the measurement of changes in pupil diameter, has been used to identify visual aphantasia [3].

In this project, we explore the potential for smartphone-based pupilometry to be used in the detection of aphantasia/hyperphantasia.

II. Prototype and User Study

Modern smartphones typically contain both traditional (RGB) cameras (front/rear facing) and a near infrared (NIR) camera. This NIR camera enables face recognition.

We developed a smartphone (Android) application to capture and analyse pupil responses using the NIR camera (Figure 1). Use of the NIR overcomes two challenges previously seen in previous attempts to measure pupils with a camera or camera phone [1]. Firstly, NIR is able to capture images in low-light conditions, meaning that the camera flash (which would itself trigger a pupil response) is not needed. Secondly there is a greater difference in the amount of NIR reflected back by the pupil and the iris, when compared to visible light. This means that the approach is robust to dark iris colors.

We conducted a two-part user study. An online survey collected demographic data and questionnaire-based measures of visual imagery including the VVIQ, whose scores range from $16-80$. Participants with low $(16-32)$, or mid-to-high VVIQ scores $(48-80)$ were invited to attend an in-person session in which they used the Android application to view and imagine four stimuli (two light, two dark). Images captured by the NIR camera were then analysed [5] to identify if differences in pupil response were observed for the real and/or imagined stimuli.

III. Preliminary Results

132 participants responded to the survey, and 32 of those attended for the smartphone pupilometry session $(9$ from the low VVIQ group, and 23 from the mid-to-high group). One-way ANOVAs show a difference in pupillary light response between seen light and dark stimuli in both VVIQ groups (low: $F(1{,}30)$=54.24, p= 0.00; mid-to-high: $F(1{,}30)$=3607.20, p<= 0.00). Differences in pupillary light response were also seen for imagined light/dark stimuli (low: $F(1{,}30)$=72.93, p=0.00; mid-to-high: $F(1{,}30)$=629.48, p=0.00), but in opposing directions; that is, the low VVIQ group did not show a difference in pupil response for imagined light and dark stimuli that was consistent with a pupillary light reflex. Our results indicate that variations in visual imagery may be identifiable with smartphone pupilometry, but this is not yet conclusive.

References

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