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Extended Abstract

Thinking outside of the box or enjoying your 2 seconds of frame?

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The emergence of low cost eye tracking devices will make QS quantified self monitoring of eye movements feasible on next generation mobile devices. Potentially allowing us to continuously infer reactions related to fatigue or emotional responses when interacting with the screens of smartphones and tablets [1] [2]. Despite the reduced spatio-temporal resolution of low cost consumer grade eye trackers [3], our hypothesis is that we may be able to capture clusters of fixations as well as frequencies of saccades and blinks, that may define our default states and reflect our overall level of engagement .

Experiment

Being amongst the first eye-self-trackers, this experiment explores whether we can identify individual signatures reflecting levels of attention in eye tracking data, typically collected twice a day over a week, each consisting of 24 trials where 8 colored squares are sequentially presented on the screen (~3 degrees wide, alternating between the colors blue, yellow, green, yellow, white and black) appearing for 2 seconds against their complementary color as background (trial), followed by 4 seconds of solid complementary color (baseline), thus constituting 480 secs of visual stimuli for each of 11 experiments performed over a week). After an initial calibration at the beginning of each experiment, stimuli was presented on a conventional MacBook Pro 13” in an ordinary office environment, running PsychoPy software [4], connected via USB to The Eye Tribe mobile eye tracking device, retrieving the eye tracking data through the associated API [5] using PeyeTribe [6], and subsequently applying a density based clustering approach to define fixations. Two right-handed subjects (males, average age 55) participated in the experiments and were not instructed to follow any specific viewing patterns.

Results

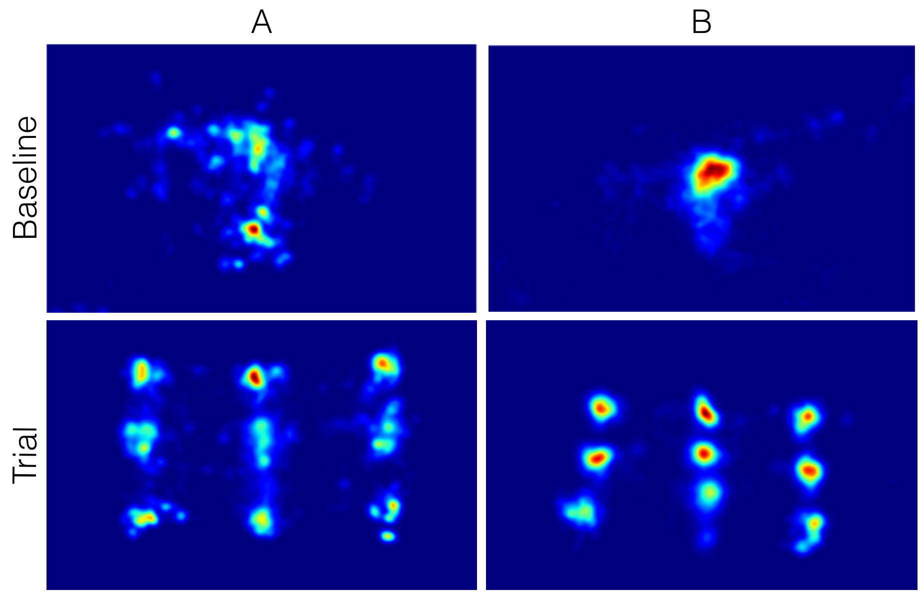

Figure 1: Typical Heatmaps in Baseline/Trial for A and B

Figure 1: Heatmaps, for A (left column) and B (right column). of fixations in the top examples when observing solid colors only, and at the bottom when the colored squares are presented against the complementary color background.

The trial heatmaps (lower row) reflect the position of the visual stimuli, but there are clear differences between the test persons; B has a higher tendency to maintain focus within the frame of the squares. A appears less focused on the frame and rather thinking outside the box, while overall fixations appear less dense in the middle horizontal versus the lower and upper horizontal rows. Likewise for B the central square in the lowest horizontal row shows a larger spread and overall this row reflects a less dense focus, although we cannot rule out it might be due to a calibration error for the eye tracker in the lower screen area.

The baseline heatmaps (top) depict a higher degree of difference between the subjects. Again, B has a higher tendency to maintain focus towards the center of the screen whereas person A shows a tendency to focus at the middle vertical, with fixations skewed towards the left side of the screen. We speculate that this consistent offset for A rather than being an artifact could potentially be related to gaze direction rooted in right hemisphere dominance when retrieving spatial information [7].

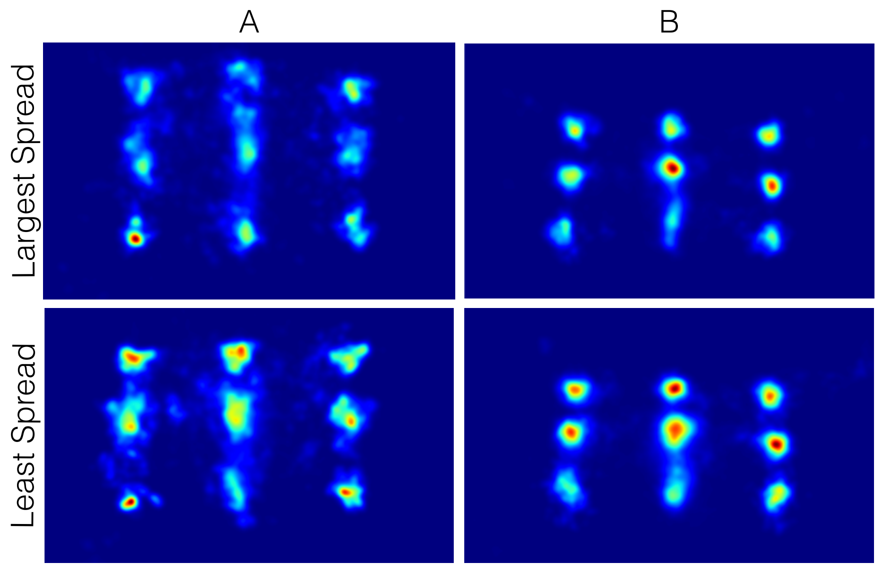

Figure 2: Variations in heatmaps (Baseline/Trial combined

Figur 2: Although there are variations in power within the heatmaps for A and B over the week, individual differences are discernible, where the upper row shows the largest spread of fixations while the lower row represents more narrowly focused fixations.

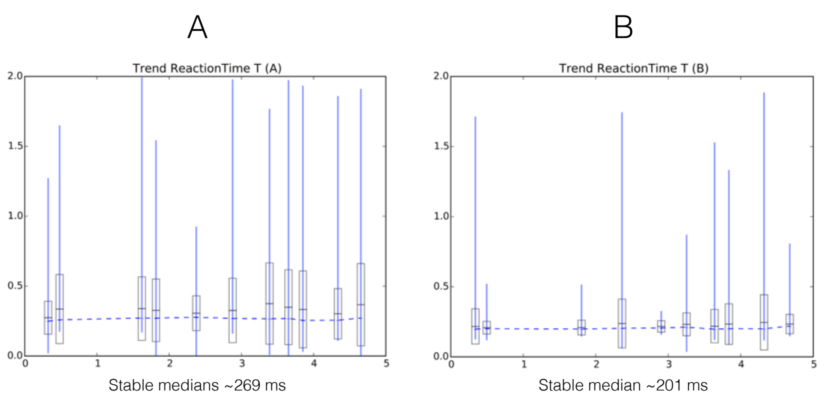

Figure 3: Different Reaction Times between A and B

Figure 3: Differences in time to target reaction time when fixating on the presented visual stimuli throughout the week for A and B; minimum, mean standard deviation, mean, mean + standard deviation, and maximum (line indicates the median). The reaction time to focus on a visual target is measured from presentation of stimuli to the first fixation starts at or close to the presented square, including the saccade between points. The saccade time cannot be accurately determined due to the 60 Hz sampling frequency of Eye Tribe tracker, but is estimated to be 30-50 ms. Fixations typically jump to adjacent positions in space, so the variation in distance is not large, as can be seen. The reaction time median, which best filters out any noise and accidental mis-calibrations, remains remarkably consistent throughout the entire week, and clearly differs between the test persons at around 269 ms vs 201 ms.

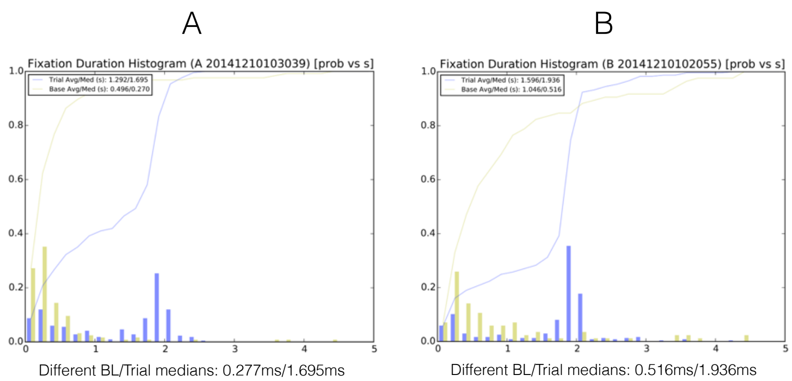

Figure 4: Stimuli Dependent Fixation Duration for A and B

Figure 4: Fixation duration histograms (bars) and cummulative histograms (lines), for both A and B during an experiment. Fixation duration appears to be stimuli dependent with, in this case, a median time of 1.695 s vs 0.270 s for person A in trials vs baseline and 1.936 s vs 0.516 s for person B. This indicates consistent differences in A & B's fixation durations. This stimuli-dependent difference when attending to the presented squares versus the solid color backgrounds is not only observed in fixation durations, but also to some extent in e.g. saccade frequencies and fixation patterns. No dependency on color of the presented squares were observed, despite the large self reported perceived differences related to the extreme

complementary color contrasts such as green squares on top of a red background or yellow squares presented against a blue background.

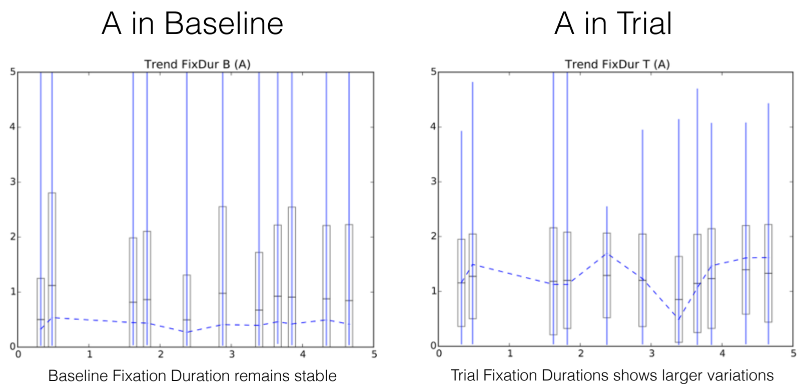

Figure 5: Variation in Fixation Duration over experiments might point to condition dependent reactions/signatures

Figure 5: Variations of the fixation duration for A across all experiments in the entire week. The baseline fixation length when observing solid background colors shows less variation than when attending to the presented complementary colored squares.

Conclusion

While the time to target reaction time to focus on the presented visual stimuli differentiates subject A from B, this eye tracking measure appears constant across the two subjects during the whole week, and thus seems to reflect a personal signature neither affected by training nor the differing complementary color contrasts of the presented stimuli in the experiments, whereas the spread and length of fixations in response to the presented colored squares varies within subjects A and B during the experiments over the week. We initially hypothesized that the fixations on the presented visual targets would likely be more focused in the morning, compared to experiments performed in the afternoon where the subjects might presumably be feeling more tired, but this seems not to be the case. During some of the morning experiments which resulted in less focused fixations the subjects actually reported that they felt more fresh and alert. However, some of the most dense fixations on targets were actually recorded late in the afternoon for both subjects, raising an intriguing question as to whether the length and spread of fixations to the presented visual stimuli is correlated with the level of engagement of the subjects, or merely reflects a less agile focus that might be inversely related to the perceived fatigue as reported by the subjects in some of the experiments. Recent eye tracking studies indicate extended fixation duration time in subjects reporting feeling fatigued at non-optimal periods during the day related to their circadian rhythm [1]. Whereas shorter gaze duration have been found in eye tracking experiments when subjects read emotionally positive versus neutral words [2]. Although the present study is clearly limited by the number of participants and the duration of the experiments, we find that these questions merit that we explore to a much larger extent how we based on continuous eye tracking data might build QS quantified self data capturing aspects of perceived fatigue versus alert engagement throughout the day.

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