1. INTRODUCTION

Although the dichotomy between privacy attitude and behavior is a well-known problem [1, 11], it is not clear how users make privacy decisions online. We believe that cognitive psychology provides the foundations to better understand privacy decision-making via three established areas: the dual-process model, cognitive effort and mental models theory.

The dual-process model explains cognitive processing via two approaches: System 1 associated with effortless and intuitive thinking; and System 2 linked with effortful and analytical thinking that only intervenes at times to endorse, correct and reject decisions [6].

System 2 taps into individuals’ limited cognitive effort capacity and changes in pupil dilation act as indication of cognitive effort spent [5].

Mental models are used within HCI to model designs that closely match users’ models. Mental models therefore enhance predictability of systems [10]. It has also been linked to dual-process modes of thinking [4].

As discussed in [2], we posit that investigation of the cognitive processes in privacy decision-making will contribute towards explaining the un-usability of online privacy designs. We present a preliminary study investigating users’ cognitive effort in privacy decision-making.

2. METHOD

The research hypothesis was $H_1$: The effort involved in making a set of privacy decisions online is different from that required for a set of representative System 1 tasks. The dependent variable cognitive effort was measured via pupil dilation. The independent variable included different tasks consisting of privacy tasks and tasks known to involve System 1 only.  

6 participants from our school took part in a within-subject pilot study. 2 participants are PhD students and the rest post-doctoral research associates. Eye-tracking data was collected using Tobii X2-30 mounted on a 27” monitor. Verbal responses were recorded via Tobii Studio 3.2.2.

Following established eye-tracking protocol [9], each question was presented for 45 seconds. Q1 involved multiplication of 2 single digits and Q2 a visual comparison which is thought to involve System 1 [6]. Q3 was inspired by Spiekermann et al.’s study on requesting profiling type privacy information when buying a camera [11] while Q4 referred to sharing a birthday picture versus identifying information (e.g. date of birth). Q5 was the Stroop test [13] which is known to cause the Stroop effects requiring intentional cognitive effort due to color incongruency [8]. Q6 was Wason’s selection task [14], a widely investigated reasoning problem that is cognitively effortful in its abstract version [3, 12].

2.1 RESULTS

2.1.1 Exploratory Analysis

We plot % pupil dilation against the eye-trackers’ recording time as shown in Figure 1. A loading phase leading to a peak period followed by release slope can be observed for each participant. This corresponds to previous research in problem-solving [7]. However, although % pupil dilation dropped quickly for the two simple tasks, it increased into the rest phase.

2.1.2 Regression Analysis

The data did not pass Levene’s test for homogeneity of variance, therefore we only use linear regression analysis as an approximation of whether the type of task predicted participants’ pupil dilation. The test was conducted on the data for 1 of the participants who produced 90% valid gaze points. The results of the regression model for the left eye are summarised in Table 1 and 2. The model with task as independent variable explained 16.7% of the variance of pupil dilation with $R^2 = .167, F(1, 6987) = 1396.366, p<.01$. We reject the null hypothesis that there is no significant difference in pupil dilation between a specific set of privacy decisions and representative System 1 tasks. However we cannot make conclusive inferences. The large unexplained % variance could be caused by noise in the data or other arousal factors which were not controlled (e.g., visual processing, luminance, anxiety and stress).

2.1.3 Fourier Analysis

We used FFT in Matlab to conduct a frequency-domain decomposition and plotted a waterfall graph. From Figure 2 we observe that our data lie at the low frequency part of the graph with noise potentially contributing the high frequency part of the signal (i.e. higher than 1.5Hz).

3. DISCUSSION

It appears that the 2 privacy tasks might not call for similar cognitive effort as intuitive and effortless System 1 tasks. However we believe the following enhancements are key to more controlled experiment design and pointed explanations: 1. start the experiment with a rest period to avoid anticipation effect for Q1; 2. measure loading and release rate and duration of peaks; 3. control task complex-
4. CONCLUSION

We present a pilot study measuring cognitive effort via pupil dilation. The results point to possible difference in pupil dilation between System 1 tasks and the privacy decision tasks. This would indicate that these specific privacy decisions are not effortless or intuitive. However due to the sensitivity of eye-tracking data, confounds and noise, further investigations are required.

5. ACKNOWLEDGMENTS

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6. REFERENCES