The Augmented Narrative – Toward Estimating Reader Engagement

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ABSTRACT
We present the concept of bio-feedback driven computing to design a responsive narrative, which acts according to the readers experience. We explore on how to detect engagement and give our evaluation on the usefulness of different sensor modalities. We find temperature and blink frequency are best to estimate engagement and can classify engaging and non-engaging user-independent without error for a small user sample size (5 users).

Author Keywords
Eye tracking, reading, skin temperature, blink frequency, engagement.

ACM Classification Keywords
H.5 Information interfaces and presentation (e.g., HCI): H.5.2 User Interfaces, Interaction Style .

INTRODUCTION
Reading has beneficial implications beyond the acquisition of knowledge. To read, the brain connects neural regions designed for other tasks. In fact white matter, that coordinates communications between these brain regions increases in skilled readers. Moreover, higher intelligence is supported by brain networks and efficient information processing. The more people read, the higher their critical thinking skills. However, recent studies suggest that people reading digital have a harder time to focus and finish a book compared with people using printed media. The advanced interactivity tends to distract more than help focus and engagement. Thus the contributions of this small study is to introduce the concept of a literary bio-feedback for storytelling to keep engagement.

CONCEPT: AUGMENTED NARRATIVE
We call literary works that transform themselves into interactive narrators Augmented Narratives. We understand interaction as spontaneous stimulations of the narrator to maintain engagement during the storytelling. For literature to stimulate the reader when needed, the text must first be able to tell if its reader is engaged or not. By knowing when to deliver stimuli, the text can helpfully intervene. We envision these interventions as multimedia aids that give the reader extra-textual information, such as sound effects, that do not compete with the visual sense, but support mental imagery.

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APPROACH
As a first step to implement Augmented Narrative, we try to better detect engagement, concentration and attention by tackling engagement and boredom while reading. Based on literature review on reading experience our hypothesis are 1) boredom can be detected by high blink-frequencies and other eyegaze features [5] ; 2) engagement -a higher mental workload-can be detected in the drop of the nose temperature [4] ; 3) heart rate can distinguish between both [2].

Ground truth: Engaging versus Boring Text Selection
Extracts from three victorian novels were selected to induce boredom. We assume the victorian moral and theological doctrine in their plot have become a meaningless lesson to most present-day readers. Thus, the texts will create frustration and ultimately result in boredom. Based on the same assumption, the three engaging novels are contemporary literary texts, more approachable for todays readers.

Ground truth: Immersion Questionnaire
An engaging experience has immersion, cognitive absorption and flow.[3] We looked into engagement and boredom with a questionnaire based on immersion, [6] where readers rated the level of empathy, frustration, boredom and enjoyment on a scale from 1 to 5.

EXPERIMENTS
The study asked 5 English speakers (3 female, avg. age 28.7 std. 3) to read the 3x3 novel excerpt.Participant were fitted with temperature sensors mounted on nose and ear. Before each run, we checked placement and calibration of the tobii EyeX eye-tracker (Fig. 1) and set the camera for blink activity recording. Participant read on a convertible PC tablet in approximately 6 to 10 minutes each text (mean 8, std 1.2) - in latin square design. After each reading, participants filled in the immersion questionnaire according to their subjective engagement.

RESULTS
Temperature change on nose seems a good indication of increased workload. Using linear regression we calculated the temperature slop curve, which turned out to be a significant

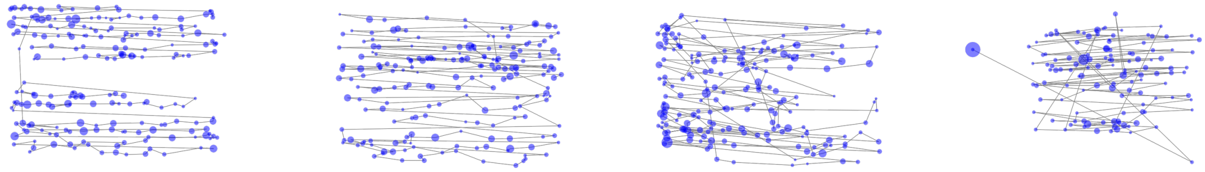

Figure 1: Sample filtered eye gaze data (about 1 minute) from one user reading engaged (first two) and not engaged (last two). The engagement rating for the documents decreases from a-d.

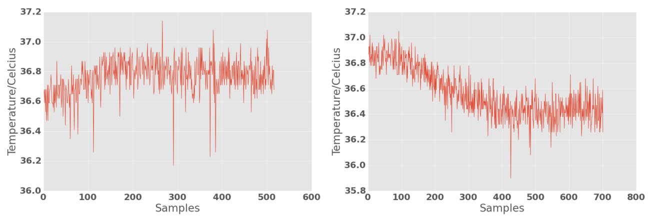

Figure 2: Sample measurement of nose temperature show a visible drop for engaged reading (right)

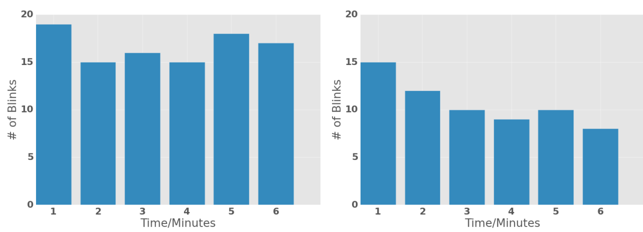

Figure 3: Sample blink frequency measurement. Left is unengaged, right engaged reading.

indicator of engaging vs. non-engaging over all participants (p=0.03) see Fig 2. Blinking frequency change (slope) was also a significant indicator (p= 0.05) over all users, see Fig.3. Visually, we identified some differences between classes. We calculated around 40 features, yet, none was significant. Features closest to significance (p values around 0.08 - 0.12) were fixation number, median fixation duration, variance fixation duration and number of saccades opposite to the reading direction (x-axis of the eye-tracker).

Classification

Linear regression was used to calculate the slope of number of blinks and relative temperature change (nose temperature - ear temperature value) over the reading period. For eye gaze, we apply Buscher et al[1] fixation summarization method; consecutive fixations of 5 pixels and closer, are summarized into one of longer duration. For each text we use the number of aggregated fixations, median and variance of the fixation duration. We also calculate the number of saccades opposite to the reading direction. If the angle between saccade and x-coordinate axis of the screen is larger than 45 degrees, is counted as not in the main reading axis. We train a support vector machine with a radial basis kernel using these features and leave-one-out user independent strategy (training 4 users, evaluating 1 until we asses all users) for the two class problem: engaging versus non-engaging. We also use these features to train a support vector regression assigning 1-6 for the engagement value (1 low) for one user applying the leave-one out strategy to the texts (training 5 texts and evaluating the 6th to see if its sorted according to the users preference rating).

DISCUSSION

For the two class svm problem we achieved 100% accuracy rating. The relative rating worked for 3 out of the 5 users. Both remaining users had most-boring and most-engaging ratings correctly classified, but the remaining text's ratings are switched. Yet, given the questionnaire, these texts have similar frustration ratings. Also, the temperature sensor was not optimally touching the nose of one user, making the recordings not conclusive. We counted the eye blinks manually from the recorded video.

CONCLUSION AND FUTURE WORK

We cannot claim to recognize engagement with this small sample, yet results are promising. Especially, as blinks and temperature can easily be integrated into smart glasses. Next steps include gathering more representative data and tracking mental imagery of sound and text to maintain attention.

REFERENCES

1. Buscher, G., Dengel, A., and van Elst, L. Eye movements as implicit relevance feedback. In *Ext. Abs. CHI 2008* (2008), 2991–2996.
2. Chang, Y.-C., and Huang, S.-L. The influence of attention levels on psychophysiological responses. *International Journal of Psychophysiology 86*, 1 (2012), 39–47.
3. Csikszentmihalyi, M., and Csikzentmihaly, M. *Flow: The psychology of optimal experience*, vol. 41. HarperPerennial New York, 1991.
4. Ioannou, S., Ebisch, S., Aureli, T., Bafunno, D., Ioannides, H. A., Cardone, D., Manini, B., Romani, G. L., Gallese, V., and Merla, A. The autonomic signature of guilt in children: A thermal infrared imaging study. *PloS one 8*, 11 (2013), e79440.
5. Irwin, D. E., and Thomas, L. E. Eyeblinks and cognition. *Tutorials in visual cognition* (2010), 121–141.
6. Jennett, C., Cox, A. L., Cairns, P., Dhoparee, S., Epps, A., Tijs, T., and Walton, A. Measuring and defining the experience of immersion in games. *International journal of human-computer studies 66*, 9 (2008), 641–661.