Towards Neuro–Information Science

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Our research questions are motivated by problems involved in interactive information retrieval. Current research tackles two fundamental problems i) measuring cognitive demands imposed on users engaged in information search, and ii) detecting relevance decisions. We employ three types of techniques: eye-tracking, functional magnetic resonance imaging (fMRI), electro-encephalography (EEG). Our work thus far has focused mainly on measuring cognitive effort using traditional methods from experimental psychology (e.g., dual-task: Gwizdka, 2010) and eye-tracking (Cole et al. 2011; 2010).

In the present projects we investigate the possibility of detecting relevance decisions. Information relevance judgment has been conceptualized mostly as an atomic judgment about the relation of an information object to a user's current information need. We hypothesize that there are fundamental neural processes associated relevance decisions and we propose that these processes can be detected by EEG or fMRI. Relevance decisions are important events during interaction with a search system. They can indicate user's interest, user's progress in a task, and reflect the search system's effectiveness. In experiments relevance is often measured in terms of cognitively-mediated explicit actions, such as saving a document, or through self-assessments of content relevance. Direct and non-intrusive detection of relevance decisions would provide an objective and deeper means to capture this important aspect of the user's mental state while in the 'flow' of search and so enable study of search behaviour in natural settings.

Cortical correlates of relevance decisions have received some attention. For example, Wakusawa et al. (2009) conducted an fMRI study comparing behaviours and objects that are relevant or irrelevant to a situation. Brain response regions were found to differ for behavioural and for object irrelevance, while relevant behaviours and objects activated the same regions. It is not clear if judgments of objects and behaviours are related to judgment of information relevance, but this work shows there is specific brain activation for both relevant and irrelevant judgments and so it is plausible that the brain activity in information relevance judgments is measurable. This hypothesis received partial support from EEG study conducted by Behneman et al. (2009), who showed that changes in the EEG (theta and alpha bands) can be used to distinguish relevant and irrelevant sentences to a given information need.

We explore the hypothesis that the brain activity in information relevance judgments is measurable and we are presently conducting experiments in two settings: EEG+eye-tracking and fMRI+eye-tracking. The experiments have the same design (Figure 1). Each subject performs two types of tasks: 1) word search, and 2) information search. The 1st task involves locating a given word in a short text displayed on screen and is expected to require low-level orthographic processing. The 2nd task involves finding relevant factual information in news stories and is expected to require high-level lexical/semantic processing. We hypothesize that the two tasks involve activity in different brain regions. To ensure that the subjects actually make relevance judgments, each information search task contains an additional review phase (Figure 1). Each session includes 30 pseudo-randomized trials of each task type, as well as a few training trials.

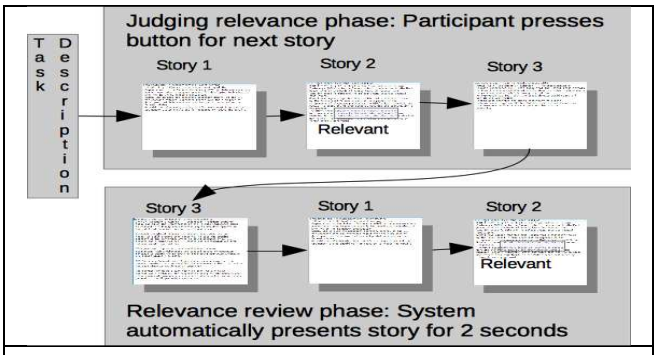

Figure 1. Experimental Design

We believe that establishing fundamental distinctions in brain activity related to information search should lead to a better understanding of the search process and, as a consequence, to the design of better search engines.

REFERENCES

- Behneman, A., Kintz, N., Johnson, R., Berka, C., Hale, K., Fuchs, S., Axelsson, P., et al. (2009). Enhancing Text-Based Analysis Using Neurophysiological Measures. In D. D. Schmorrow, I. V. Estabrooke, & M. Grootjen (Eds.), *Foundations of Augmented Cognition. Neuroergonomics and Operational Neuroscience*. Vol. 5638, 449-458. Berlin, Heidelberg: Springer.
- Cole, M., Gwizdka, J., Liu, C., Belkin, NJ. (2011). Dynamic Assessment of Information Acquisition Effort During Interactive Search. *Proceedings of ASIS&T 2011*.
- Cole, M. J., Gwizdka, J., Liu, C., Bierig, R, Belkin, N. J., Zhang, X. (2011). Task and User Effects on Reading Patterns in Information Search. *Interacting with Computers*, 23(4), 346-362.
- Gwizdka, J. (2010). Distribution of cognitive load in web search. *Journal of the American Society for Information Science and Technology*, 61(11), 2167–2187.
- Wakusawa ,K., Sugiura, M., Sassa, Y., Jeong, H., Horie, K., Sato, S., Kawashima, R. (2009). Neural correlates of processing situational relationships between a part and the whole: an fMRI study. *Neuroimage*, 48(2), 486-496.