

Optimization of Cognitive Load in Conceptually Rich Hypertext: Effect of Leads

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Theoretical Foundations

The hyperlinking feature of hypertext, which in the cognitive flexibility perspective encourages advanced learning (Spiro & Jehng, 1990), frequently overloads working memory according to the cognitive load theory (Sweller, 1988). One of such negative effects of hyperlinks is split attention. When two or more sources of information are separated in space (e.g., text located on different hypertext pages), information integration is compounded by intensive search-and-match processes, which are involved in cross-referencing mental representations, and, thus, it may place an unnecessary strain on limited working memory resources. One tool that seems to have the potential to reduce split attention and physically integrate different pages in hypertext systems is the lead. Leads are link comments that appear as a popup balloon when the mouse is over the hyperlink providing a one-sentence summary of the content of the linked page. The purpose of the present research study was to assess the effect of leads on cognitive load associated with split attention in the context of conceptually rich instructional hypertext.

Methodology

One of the measures that seems especially promising in terms of dynamic assessment of cognitive load is Electroencephalography (EEG). Whereas some recording tools such as functional Magnetic Resonance Imaging capture a “snapshot” of the brain activity, EEG is useful for tracking changes in cognitive processing over a period of time. EEG signal has been shown to consist of identifiable frequencies or rhythms and empirical research demonstrates that these rhythms can be considered an “alphabet for brain functions.” (Basar, 1999) Three of these rhythms have been linked to cognitive load. The basic conclusion that EEG researchers make is that the power of alpha and beta rhythms decreases and the power of theta increases with increased cognitive load (as described in Basar, 1999).

20 education majors enrolled in the teacher education program at a large Midwestern university volunteered to participate in this study. Since brain waves tend to vary with age, gender, race, and handedness, all subjects were to be 18 to 23 years old, female, Caucasian, and right-handed. All subjects were native speakers of the English language.

Materials for this study were 4 hypertext systems (2 with leads and 2 without leads) on 4 learning theories. Each system consisted of one main text of about 500 words, and 7

embedded hyperlinks to subordinate texts of about 90 words. All texts were measured and corrected to have equivalent Flesch reading difficulty score. Text difficulty and consistency were also determined through independent subjective assessment by 4 experts. Leads contained a summary of the linked page (4±2 meaningful units of information).

Data on subjects’ metacognition, reading ability, and prior knowledge was collected during a pre-test session. Each subject was asked to browse and read the 4 hypertexts in the following order: lead-nolead-lead-nolead or nolead-lead-nolead-lead. While the participants were reading these hypertexts, their brain activity was recorded with EEG (P3 and F3). Each subject rated their mental effort after browsing each hypertext on a perceived mental effort scale (Paas, 1992). Reading time for each hypertext was the behavioral measure of cognitive load.

Results and Conclusions

Results of a repeated measures (RM) MANCOVA indicated a strong main effect of leads ($F_{12}=3.27$, $p<.05$) as well as significant effect of one of the covariates: metacognition ($F_{12}=6.83$, $p<.05$). As expected, leads significantly decreased cognitive load in the context of conceptually rich instructional hypertext, and thus, there’s sense in integrating this tool in web-based learning. While univariate RM ANCOVAs on alpha, beta, and theta rhythms showed a strong effect of leads, neither self-reports of mental effort, nor reading time demonstrated variations in cognitive load in the lead and nolead hypertext conditions. It appears that these measures are not suitable in situations when a dynamic assessment of instantaneous cognitive load (as in the case with hyperlinks) is required. On the other hand, power of alpha, beta, and theta rhythms proved to be a useful measure of dynamics of cognitive load in a task that involves continuous reading.

References

- Basar, E., (1999). Brain Function and Oscillations. Springer, Berlin Heidelberg.
- Pass, G. W. C. (1992). Training strategies for attaining transfer of problem-solving skill in statistics. *Journal of Educational Psychology*, 84 (4), 429-434.
- Spiro, R.J., & Jehng, J. (1993). Cognitive flexibility and hypertext. D. Nix & R. Spiro (eds.), *Cognition, Education, and Multimedia*. Hillsdale, NJ: Erlbaum.
- Sweller, J. (1988). Cognitive load during problem solving: Effects on learning. *Cognitive Science*, 12, 257-285.