Investigation of the relationship between visual website complexity and users' mental workload: A NeuroIS perspective

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Abstract. We report promising research-in-progress results from an ongoing experiment on the relationship between visual website complexity and users' mental workload. Applying pupillary based workload assessment as a NeuroIS methodology we found indications that navigation complexity, i.e., the number of (sub)menus, is more problematic than information complexity.

Keywords: NeuroIS, eye-tracking, mental workload, pupillary diameter, IS complexity, website complexity, navigation complexity, information complexity

1 Introduction

Website/webpage complexity affects a user's mental workload [1]. Huang [2] identified the amount of information and the number of links as important attributes of website complexity. The problem from a website design perspective is how to balance between the dilemma of a complex menu structure (a lot of menu links and submenus) but non-complex pieces of information or a non-complex menu structure (with fewer links/submenus) with a high amount of information (more complex). To evaluate this problem researchers need a convenient way to assess a user's mental workload. Determining a user's mental workload is often mentioned as a fundamental problem in IS research (e.g. [3,4]) from various theoretical perspectives (e.g. cognitive load, task technology fit, job demands-resources), particularly in NeuroIS (e.g. [5-10]).

In recent years very interesting results have emerged from a new field called NeuroIS in which efforts have been made to determine a user's mental workload based on objective psychophysiological measurements [8-10]. IS scholars have used pupillary based mental workload assessment already using realistic experimental setups, e.g., route planning [11,12], E-mail classification [11], decision support systems [13], and social networks [6,14].

To the best of our knowledge there is no study investigating the relationship between visual website complexity and users' mental workload using psychophysiological measures – with one exception: The work of Wang et al. [1] investigated website complexity from a cognitive load perspective via eye-tracking technology. Using

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fixation count and fixation duration they found increased fixation counts, fixation durations and task completion times when performing simple tasks. Interestingly they did not analyze pupillary measures in order to evaluate mental workload.

That is why we study the usage of three website variants with systematic manipulations of navigation and information complexity using eye-tracking based pupillary diameter responses. With our work we contribute to IS complexity research. In addition, we addressed a very practical problem for website designers.

2 Methodology

2.1 Applying the NeuroIS guidelines

In order to clearly contribute to NeuroIS research and show strong methodological rigor we strictly followed the NeuroIS guidelines of vom Brocke et al. [15]. In particular, to assess prior research in the field of measuring mental workload as an important IS construct a comprehensive literature review was conducted (cf. [16]). To base our experimental design adequately on solid research in related fields of neuroscience [15] we reviewed the fundamental anatomic mechanism of the pupillary dilation controlled by the vegetative nervous system and the key role of the Edinger-Westphal nucleus that is inhibited by mental workload and directly leads to a pupillary dilation. Our methodology uses eye-tracking-based pupillometry as a well-established approach in physiology and psychology “widening the 'window' of data collection" [17, p. 93]. With our method bio-data (i.e. pupil diameter) can be used to better understand mental workload as an IS construct (cf. guideline 4 of [15]). In comparison to other neuroscience tools eye-tracking-based pupillometry is the contact-free and efficient method of choice [18]. We applied the guidelines and standards from Duchowski [19] and the Eyegaze Edge^{TM} manual.

2.2 Measurements

To capture the pupillary diameter as the measure of interest in this research, eye-tracking was performed using the binocular double Eyegaze EdgeTM System eye-tracker paired with a 19" LCD monitor (86 dpi) set at a resolution of 1280x1024, whereby the eye-tracker samples the pupillary diameter at a rate of 60 Hz for each eye separately.

2.3 Stimuli

Following [20] we manipulated website visual complexity via the number of links in our menu structure (resp. submenus). According to [1] we choose three contrary but balanced levels for navigation and information complexity. Navigation complexity was manipulated by the (sub)menu structure (low: 3 menus; average: 3×3 (sub)menus; high: $3 \times 3 \times 3$ (sub)menus). Information complexity was manipulated by content/text partitioning. All three variants (system A,B,C; see Figure 1) contained the same content/information in summary but we divided this content into (sub)menu-specific pieces of information. Luminescence levels of the three systems variants were checked.

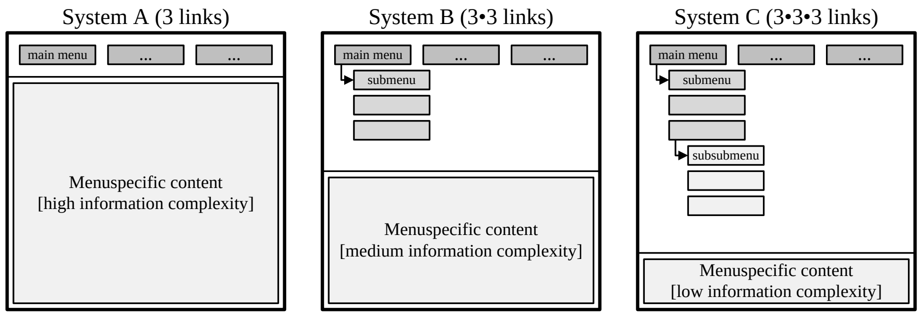

Fig. 1. Conceptualized website complexity (System A: low menu complexity – high information complexity; System B: average menu complexity – average information complexity; System C: high menu complexity – low information complexity)

Please note that we directly tested objective website complexity since perceived website complexity correlated only medially with objective website complexity (r = .3 according to [21, p. 515], cf. [22]).
The participants in our experiment had to perform nine distinctive search tasks – three for each system. In order to counter-balance our design, the test order of the systems (A, B, C) was randomized. In addition, for every test system (A, B, C) three of the nine search tasks were randomly assigned.

2.4 Description of the test procedure

Prior to all data collection, each test participant is welcomed by the experimenter (supervisor of the experiment). After that the participant has to fill out a consent form and also a questionnaire with demographics (stage 1). In stage 2, we take the necessary precautions for the experiment, for which we make use of the eye-tracker. Hence, the eye-tracker is calibrated. In stage 3, the experiment starts with the first search task the participant has to accomplish.

2.5 Data cleansing

Only naturally determined artifacts, e.g. by eye-blinks, were deleted.

3 Results

3.1 Sample Characteristics

Our 13 participants are aged from 23 to 35 years (M=28.1, S.D.=3.9). 6 persons are female, 7 male.

3.2 Relationship between visual website complexity and users' mental workload

We found clear pupil diameter differences between the three system variants (table 1) which were partly significant already at this state of research (n = 13, A/B: $p_{left\ eye} < .05$, $p_{right\ eye} < .05$; B/C: $p_{left\ eye} < .1$, $p_{right\ eye}$ n.s.; A/C: $p_{left\ eye} < .01$, $p_{right\ eye} < .01$):

Table 1: Mean of pupillary diameters in relation to system variant

System	PD [mm]	
	left eye	**right eye**
System A	3.220	3.249
System B	3.246	3.278
System C	3.279	3.290

4 Discussion, limitations and future research

From a mental workload perspective the system A is the model of choice since the pupillary based mental workload indicator is lowest for this system variant.
That means for the practical website design perspective that complex menu structures with a lot of menu links and submenus should be avoided. Instead of that, the designers should use less submenus (lower navigation complexity) but more text (more information complexity) – contingently with scroll bars.
From a theoretical point of view we contribute with our work to IS complexity research. Our results indicate that navigation complexity (i.e., the number of (sub)menus) is more problematic than information complexity from a mental workload perspective.
At this state of research our main limitation is rooted in the small sample size (n=13). In the future we will test more participants (n~70). In addition, in an extended version of this paper we will report on triangulated NASA TLX evaluations and results from electrodermal activity assessments for the whole sample.

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