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An eye-tracking study of website complexity from cognitive load perspective

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ABSTRACT

Online shopping is becoming one of the most popular applications on the Internet. Websites are the important interfaces in HCI (Human–Computer Interaction). Website design significantly affects online shopping behavior. This research used eye-tracker to track the eye-movement process for 42 college students when they were surfing websites with different levels of complexity and completing simple and complex tasks respectively. The study examines how website complexity and task complexity jointly affect users' visual attention and behavior due to different cognitive loads. The study fills a research gap by examining this phenomenon from the cognitive load perspective and taking the moderate effect of task complexity into consideration. The results show that task complexity can moderate the effect of website complexity on users' visual attention and behavior. Specifically, when users conducted a simple task, fixation count and task completion time were at the highest level on the website with high complexity, while fixation duration was not significantly different on the websites with different complexity. However, when users conducted a complex task on a website with medium complexity, task completion time, fixation count, and fixation duration were all at their highest level. The load theory of attention was used to provide the explanation for the results. The findings provide guidelines for website managers and designers to maximize users' visual attention.

1. Introduction

With the rapid development of Internet technology, online shopping has become more and more popular. According to data from iResearch (http://ec.iresearch.cn/shopping/20130128/192198.shtml), the e-commerce market in China reached $1330 billion in 2012. The economic benefits of e-commerce are self-evident. Thus, how to improve users' web experience has become a major theme in research labs. Website design is considered to be an important factor that influences users' attitudes and behavior when shopping online [24].

The effect of website complexity on users' attitudes and behavior has gained attention from researchers in recent years [1,6,10–13,29,37,39]. However, there have been different findings about website complexity. It is still unclear about the relationship between website complexity and user experience. Some researchers believe that simple websites are more effective [1,38] while others think that complex websites increase the richness of information presentation and thereby enhance user satisfaction [32] and positively impact approach behavior for experiential users [6]. Furthermore, some studies show an "inverted U relationship" between website complexity and communication effectiveness [11], and between website complexity and user satisfaction for experiential users [29].

While more and more people choose online shopping, online sellers are eager to find out which kinds of website attract users most. However, what bothers many website designers is that an individual can leave a website very easily. The lack of understanding of the major impediments to users' longer website browsing and deeper exploration presents a substantial problem for designers. Exploring the cognitive process of users during web browsing is critical for website designers to understand user behavior. Although previous studies have proposed an implicit link between website/webpage visual complexity and cognitive complexity or cognitive load, normally the cognitive load can only be defined in concert with the user and task at hand [14]. However, little prior research on website complexity has taken task complexity into consideration, which could cause some of the conflicting findings mentioned above. Task complexity is a function of the amount of task-related information an individual has to process when performing a task [40]. The more information to be processed, the more complex

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the task is. Complex tasks require more cognitive work, such as psychological comparison [19]. So we raised our research question: Are there differences in the effects of website complexity on users' behavior under different levels of task complexity? This study fills a research gap by taking the moderate effect of task complexity into consideration while examining the effects of website complexity and provides a new perspective, cognitive load, to better understand the influence of website complexity and task complexity on users' visual attention and behavior.

To better understand users' attention (eye fixations) and how it relates to their cognitive load, we adopt an eye-tracking technique to conduct this study. Among human physiological parameters, eye movement has the most frequent period of update; as a result, eye-tracking can provide a stream of information about the user's mental state in real time [18,26]. At the same time, eye-tracking is an objective method which can reflect cognitive processing through eye-movement metrics [7]. This study reflects objectively the effect of website complexity on the user's visual attention and behavior under different levels of task complexity by using the eye-tracking data to understand the mechanism of website complexity. The findings of this study are of interest to website managers and designers because they provide guidelines for website design to enhance user experience and retain consumers as long as possible on their websites.

The structure of this paper is as follows. In Section 2, we review relevant literature about website complexity and task complexity, eye-tracking and its application to website design, and cognitive load theory. In Section 3, we propose the theoretical hypotheses. The research methodology including measurement and experimental procedure is described in Section 4. Data analysis and results are presented in Section 5. Finally, we conclude with a summary of the results, contributions and limitations, and directions for future research.

2. Theoretical background

2.1. Website complexity and task complexity in online research

Complexity is a function of the amount of variety in a stimulus pattern [2]. Based on this definition, Geissler et al. [10] argued that the complexity of a stimulus depends on three factors: number of elements, the level of dissimilarity between elements, and the level of unity between elements. The definition of website complexity is mainly derived from the definition of stimulus complexity. Huang [16] identified complexity, novelty, and interactivity as important website attributes and mentioned that complexity refers to the amount of information that a site is offering, including elements such as text, hyperlinks, pictures, animations, and video, and the variation in these elements: picture size, arrangement of these attributes, and so on. Consistent with webpage design elements suggested by Geissler et al. [10], Deng and Poole [6] defined webpage visual complexity as composed of two dimensions: (1) visual diversity, which refers to the varieties of design elements, like graphics, text, and links, and (2) visual richness, which refers to the detail of information present in a webpage as measured by the amount complexity of the web content, including the number of design elements, the content of text, number of graphics, and links and layout of a page. Lavie and Tractinsky [23] found that users' perceptions of websites consisted of two main dimensions, classical aesthetics and expressive aesthetics. The classical aesthetics dimension emphasized orderly design and clear design, and the expressive aesthetics emphasized the creativity of designers. In addition, the classical aesthetic perception of websites is similar to the visual complexity of websites.

Extant studies have paid much attention to the determinant factors that influence website complexity. Through manipulating five variables (the length of the homepage, the number of hyperlinks, the number of pictures, the amount of text, and the presence or absence of animation), Geissler et al. [10] found that homepage length, the number of hyperlinks, and the number of pictures have a significant influence on the perceived homepage complexity. Tuch et al. [37] proposed that compressed file size can be utilized as a reliable, valid, and objective measure for visual complexity. Michailidou et al. [27] verified through experiment a positive, significant, and robust relationship between visual complexity of the page and the number of images, visible links, words, and TLCs(Top Left Corners). In fact, among these potential measures of website complexity, that used in Geissler et al.'s [10] study has been most widely adopted [6,11]. In our study, we use Geissler et al.'s findings for reference.

Extant studies implied that website/webpage complexity affects many user outcomes, such as communication effectiveness [10], usability [37], flow [16], arousal, and pleasantness [6]. Which are better, simple websites or complex websites? Previous studies offered different answers to this question. Agarwal and Venkatesh [1] implied that simple websites are easy to use and effective. However, complex websites can communicate richer information and intrigue consumers [12] and thereby positively impact consumers' arousal [6]. In addition, Geissler et al. [11] put forward an "inverted U relationship" between website homepage complexity and communication effectiveness. For experiential users, Deng and Poole [6] found that webpage complexity positively impacts users' approach behavior, whereas Nadkarni and Gupta [29] suggested an "inverted U relationship" between website complexity and user satisfaction. There is still much to explore about the relationship between website complexity and users' behavior.

In this study, we argue that task complexity can play an important role in determining how website complexity affects users' visual attention and behavior. Based on Wood's [40] frame, task complexity should be the function of three types of complexity: component complexity, coordinative complexity, and dynamic complexity. Task complexity is also linked with the "increase in information load, information diversity, or rate of information change" [4]. A task is more complex, e.g., if there are multiple paths of achieving it or if different paths for desired outcomes conflict with each other [4]. Campbell [4] identified 16 types of tasks and characterized them as simple tasks, decision tasks, judgment tasks, problem tasks, and fuzzy tasks according to the level of task complexity. To simplify the manipulation, we classify online shopping tasks into simple tasks and complex tasks. This classification was adopted by previous studies [15,25]. Compared to a simple task, a complex task requires more cognitive resources, such as psychological comparison [25].

Various studies in the existing literature showed how to manipulate task complexity when conducting an experimental study. According to Miller [28], individuals can hold 7 ± 2 chunks of information in their working memory concurrently. Jiang et al. [17] chose a PDA (personal digital assistant) to represent a condition with a high level of task complexity because a PDA had 17 experiential features, such as address book, note pad, and mail. Accordingly, browsing a watch was considered to be a relatively simple task because a watch only had six experiential features. Leuthold et al. [25] referred to tasks conducted to meet goals with one criterion as simple tasks and tasks conducted to meet goals with several criteria as complex tasks. Both methods were found to be reliable. We apply the method used by Leuthold et al. [25] in this study.

2.2. Eye-tracking research on website design

During recent years, the affective and cognitive aspects of user interface design have received increasing attention [7,34]. Eye-tracking is widely used in HCI (Human–Computer Interaction) studies since eye movement can reflect the visual search mode, which is important in revealing the cognitive processing mechanism.

There are several advantages to using eye-tracking to examine website design. First, eye-tracking removes the subjectivity of self-reporting data [33]. Second, eye-tracking allows us to track users' reactions to webpage elements without affecting the ecological validity and/or "wholeness" of the stimuli and can show which parts of the page captured participants' attention most [3].