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Tanguy Dargent
Tech Lab, HEC Montreal, tanguy.dargent@hec.ca

Alexander Karran
Tech Lab, HEC Montreal, alexander-john.karran@hec.ca

Pierre-Majorique Leger
Tech Lab, HEC Montreal, Montreal, QC, Canada., pml@hec.ca

Constantinos K. Coursaris
Tech Lab, HEC Montreal, coursaris@hec.ca

Sylvain Senecal
Tech Lab, HEC Montreal, ss@hec.ca

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Tanguy Dargent
Tech[3]Lab,
HEC Montréal
tanguy.dargent@hec.ca

Alexander Karran
Tech[3]Lab,
HEC Montréal
alexander-john.karran@hec.ca

Pierre-Majorique Léger
Tech[3]Lab,
HEC Montréal
pml@hec.ca

Constantinos K. Coursaris
Tech[3]Lab,
HEC Montréal
coursaris@hec.ca

Sylvain Sénécal
Tech[3]Lab,
HEC Montréal
ss@hec.ca

ABSTRACT

Using cognitive script and cognitive lock-in theories, this paper presents the results of a user experience experiment that tested the user's emotional and cognitive states when presented with a major redesign of a service provider's website. A within-subject design involved 57 participants, who engaged in both informational and transactional tasks during four consecutive visits to a financial institution's website, generating a total of 772 observations. Psychophysiological data were collected as measures of cognitive load, emotional valence, and emotional arousal during users' website visits. Results suggest that repeat visits to an updated website lead to decreased cognitive load and increased arousal. They also offered support for the moderating role of task type on the relationship between task repetition and the users' emotional and cognitive responses. Specifically, transactional tasks were associated with a greater cognitive cost and lower emotional valence than informational tasks during the initial visits to an updated site.

Keywords

Cognitive load; Emotion; Website design; Human-computer interaction; User experience; NeuroIS.

INTRODUCTION

In order to provide a positive experience to their clients, companies are renewing, improving, and upgrading their interface designs and online processes. The change, however, from a habitual-use website to a rediscovered one implies a cognitive cost for users. In that, repeated use of the website helps users develop automated cognitive processes to facilitate their use of this web interface. More specifically, the automation of cognitive processes underlying interactions with the interface makes decision-making easier for users. Automation allows people to make quick decisions with less effort [1]. In other words, users develop cognitive shortcuts by following cognitive scripts, which are "a structured representation describing a stereotyped sequence of events in a particular context" [2].

Therefore, any website redesign could make the user experience temporarily worse during initial visits to the new interface by causing an increase in both visit duration and usage. However, research suggests that repeated visits to this new interface could enable the creation of new cognitive scripts that would reduce the cognitive cost associated with task completion [3].

This study aims to verify if there is an improvement in the user experience of a financial institution's client during his/her initial visits to the newly updated website specifically by considering the user's cognitive and emotional states. Moreover, this study aims to verify if the task type influences the re-adaptation process of the user during their initial visits to the newly updated interface.

LITERATURE REVIEW & RESEARCH HYPOTHESES

Online Cognitive Script Theory

Cognitive scripts are studied in the field of marketing to explain consumer habits while interacting online or offline with organizations. A cognitive script is defined as a structure describing an appropriate sequence of events in a particular context [2]. In the case of website users, they would follow pre-established cognitive patterns to carry out their actions. From a cognitive standpoint, the function of scripts is to enable humans to perform everyday tasks without having to be cognitively involved in the task. For example, a user who wishes to check her email will automatically and almost unconsciously follow the same path for each connection. Thus, she will be able to check her emails quickly and with reduced mental effort.

Furthermore, humans tend to involve scripts in anticipating situations [8] and making predictions based on past situations [7] to reduce the cognitive cost and make a decision faster [1]. Cognitive scripts facilitate the cognitive processing of tasks by enabling humans to automate their performance [10] and in turn develop habits. The scripts associated with these habits enable an individual to adopt more automatic behavior patterns in known situations [11]. Results from Sénécal et al. [3] suggest that scripts can be applied in the context of online commerce.

Affective and Cognitive Responses to a New Interface

Cognitive load relates to cognitive resources allocated by the individual to perform a task [15] but also in the process of acquiring skills to perform a task [15, 17]. Cognitive effort in creating cognitive scripts can lead to reduced effort in performing the task [3, 18]. Repeat visits to an interface allow users to identify predefined sequences, create scripts, and reduce cognitive load [3]. Hence:

H1: Repeat visits to a new interface reduce cognitive load

User experience is also characterized by emotional valence and emotional arousal [19]. Valence is the directionality of the emotional response, i.e., the unpleasant or pleasant character of emotion [20]. Arousal represents physiological activation ranging from non-aroused to aroused [21], commonly measured by electrodermal (EDA) activity [14]. Both these emotional response measures may be observed together to assess emotional response according to its direction (valence) and its intensity (arousal). Moreover, literature suggests that difficulty of use trends towards a negative effect on valence and a positive effect on arousal [22]. Considering that cognitive scripts allow automated cognitive processing and help reduce the difficulty of using an interface [9], we posit that repeated visits to a new web interface give rise to a more positive valence and a decrease in arousal; hence:

H2: Repeat visits to a new interface reduce emotional arousal

H3: Repeat visits to a new interface increase emotional valence

Influence of the Task Type

A user may perform numerous tasks when interacting with an interface (e.g., login, search information, perform a transaction). Each of these tasks may induce different psychophysiological states, particularly in terms of the cognitive effort required to perform the task [4, 24]. To categorize various tasks, Dumont et al. [4] outlined a framework that defines categories of tasks according to the type of cognitive effort required. This categorization is relevant in the case of a study on cognitive scripts since the extrinsic cognitive load level depends on the task itself [16] and could thus influence the creation of cognitive scripts because a task might be harder to learn than another. In this framework, tasks are defined in a three-step process: Reception, thinking, and response. The reception and response components are then further sub-categorized according to the reception or response vehicle mode (visual, motor, audio, etc.) or according to its content.

When interacting with a website, the main difference between tasks lies in the response mode to a task, i.e. the action taken by the user to perform the task. These actions include searching for information or performing a transaction such as logging in or paying an invoice. When searching for information, the response is visual, whereas when performing a transaction, the response is motor, e.g. when the user enters information via a [6]. Therefore, in the context of this study, we distinguish tasks as either "transactional" or "informational".

In addition, since a transactional task involves typing on a keyboard, the user will have to interact simultaneously with more than one object, compared to a visual search task [27]. Note that the mouse is excluded from tools dedicated to transactional tasks because the user can use the mouse to guide his gaze [28]. In contrast, when a user's attention is divided between the keyboard and the screen, his gaze would keep alternating between the two objects, which increases effort, as compared to a task not involving any motor action [29]. Thus, keyboard usage would imply an increase in the cognitive load of transactional tasks.

Furthermore, prior research suggests that for users, the assessment of electronic service quality varies according to the type of task being performed on the website [30]. During informational tasks, users attach more importance to site usability; during transactional tasks, they focus on the information presented, both textual and visual, and the security of the transaction. This suggests a difference in the user's perception of the interface, based on the task type.

Finally, as mentioned, the complexity of using an interface would lead to an increase in cognitive load [15, 16, 31]. Given the complexity involved in a transactional task, we posit that transactional tasks have a more negative impact than informational tasks on a user's cognitive load when adapting to a new interface. Thus, we hypothesize that:

H4: Task type moderates the relationship between task repetition on the new interface and cognitive load, where repeated visits will have less of an impact on reducing cognitive workload with an informational task than with a transactional task

Moreover, the literature suggests that the ease with which a user interacts with an object will positively influence her pleasure in using the object [32, 33]. Ochsner [23] suggests that there is a positive relationship between the complexity of an image and emotional arousal. In other words, the greater the complexity of an image, the greater the arousal. He also suggests that complexity has a negative influence on a user's valence. Thus, an increase in the difficulty of use generates negative valence and greater arousal [22]. Conversely, if the difficulty of using a product decreases, the emotional valence will tend to become more positive [34]. We posit that a lower difficulty of use, characterized by reduced cognitive load, would induce a more positive valence and lower arousal for the user. Thus, we propose that adaptation to informational tasks would be done with a more positive emotional valence; hence:

H5: Task type moderates the relationship between task repetition on the new interface and emotional valence, where the increase in valence will be greater during the initial website visits for an informational task than for a transactional task.

Since informational tasks would involve less complexity, they would lead to less frustration [22]. We posit that performing informational tasks during the initial visits would induce less arousal. Hence:

H6: Task type moderates the relationship between task repetition on the new interface and emotional arousal, where the decrease in arousal will be smaller during the initial visits for an informational task than for a transactional task

METHODOLOGY

Using an experimental within-subject design, users first used the old (and familiar) interface once and then the new interface three consecutive times. They performed both transactional and informational tasks each time; the order of tasks performed was randomized for each visit. The experimental stimuli consisted of a 13-year-old banking website and the redesigned version of the same website that participants had never seen before. Both transactional and informational tasks were completed during the experiment. The four transactional tasks were: (i) Log-in, (ii) Pay bill after adding a payee, (iii) Transfer funds between accounts, and (iv) Transfer funds to a friend. The four informational tasks were: (i) Find the account balance, (ii) Consultation of a transaction, (iii) Find the salary amount in the transaction list, and (iv) Find an upcoming transaction.

Participants were recruited through an external recruitment agency and via the panel of our institution. Participants, screened on the basis of having used the old website for at least one year, were compensated with a $30 gift card. The total sample included 57 participants (average age: 33, 26 women). Repeated measures and repeat visits to the new website yielded 193 observations (114 for transactional and 79 for informational tasks) per website visit and 772 observations in total. This multi-method study used three quantitative psychophysiological data collection methods to measure each of the three dependent variables, i.e., emotional valence, emotional arousal, and cognitive load, respectively: Facial emotion recognition, electrodermal activity (EDA), and pupillometry respectively.

Emotional valence was recorded and modelled as either positive or negative using a facial expression recognition software, *Noldus Facereader* (Wageningen, Netherlands). This tool allows the measurement of valence by measuring emotions on the basis of automatic facial emotion recognition based on micro-movements of facial muscles, such as wrinkling of the nose or frowning [35, 36]. This emotion is then modelled by *Facereader* with an emotional valence score ranging from -1 to +1 for negative and positive emotions respectively [37, 38].

Emotional arousal ranges from calm to excited [20]. Arousal is assessed in this study with EDA, which was measured with BIOPAC MP150 sensors (Goleta, USA) sampled at 500Hz. This arousal measure is standardized with the EDA score average for each task [14].

Cognitive load corresponds to the cognitive resources an individual allocates to a task. To assess cognitive load, pupillometry, i.e., the measurement of pupil diameter, was used. In a controlled environment, pupil diameter is a proxy for cognitive load [39]. Cognitive load increases when the pupil dilates while controlling for distance and lighting conditions. To measure pupil diameter, a Tobii eye-tracker (Danderyd, Sweden) was used, and eye-tracking calibration was based on Etco et al. [40].

RESULTS

As posited in H1, there is a descending trend for cognitive load when repeated visits to the new interface. Also, there is also a major decrease in cognitive load between the old and the new interface ($Mean_{Old}$=.366, $Mean_{New1}$=.191, p=.006; $Mean_{New2}$=.118, p=.026; $Mean_{New3}$=.059, p=0.072; one-sided p-values). **Thus, H1 is supported**.

Participants experienced a slight, but non-significant, decrease in arousal between their visit to the old interface ($Mean_{Old}$ = .266) and their first ($Mean_{New1}$= .258) and second ($Mean_{New2}$ = .255) visits to the new interface (all one-sided p-values>0.1). However, they experienced a surge in arousal between the 2nd and 3rd visits to the new interface ($Mean_{New2}$=.255, $Mean_{New3}$=.379, p=0.072). Given the surge in arousal between the 2nd and 3rd visits to the new interface, **H2 is therefore not supported, as it suggests a decrease**.

The repetition of visits to the new website has no significant effect on the valence of participants ($Mean_{Old}$=-.228, $Mean_{New1}$=-.241; $Mean_{New1}$=-.241, $Mean_{New2}$=.241; $Mean_{New2}$=-.241, $Mean_{New3}$=-.231; all one-sided p-values>0.1). **Thus, H3 is not supported.**

Results suggest that the cognitive load for a motor response task (transactional) was significantly higher than for a visual response task (informational) for each visit ($Mean_{New1Inform}$=-.093, $Mean_{New1Transac}$=.272, p<.001; $Mean_{New2Inform}$=-.113, $Mean_{New2Transac}$=.154; p<.001; $Mean_{New3Inform}$=-.149, $Mean_{New3Transac}$=.075, p=.003; all one-sided p-values). **Thus, H4 is supported.**

Valence is more positive for informational tasks than for transactional tasks during initial visits to the new interface, while there were no statistically significant differences at baseline, i.e., visits to the old and familiar interface ($Mean_{OldInform}$=-.182, $Mean_{OldTransac}$=-.214, p>0.1; $Mean_{New1Inform}$=-.164, $Mean_{New1Transac}$=-.254; $Mean_{New2Inform}$=-.160, $Mean_{New2Transac}$=-.258; $Mean_{New3Inform}$=-.149, $Mean_{New3Transac}$ =-.247; all one-sided p-values<.01, level of unilateral significance). In fact, when comparing responses between the old and the new interface, there is no significant change in informational tasks, whereas for transactional tasks valence decreased significantly ($Mean_{OldTransac}$=-.214, $Mean_{New1Transac}$=-.254, p=0.03). **Thus, H5 is supported.**

Arousal was significantly greater for informational tasks than transactional tasks during the second and third visits; however, there was no difference in the initial visit to the new interface ($Mean_{New1Inform}$=.318, $Mean_{New1Transac}$=.246, p=.132; $Mean_{New2Inform}$=.346, $Mean_{New2Transac}$=.214; p=.019; $Mean_{New3Inform}$=.518, $Mean_{New3Transac}$=.300, p=.027; all one-sided p-values) **Thus, H6 is not supported.**

DISCUSSION AND CONCLUSION

This study aimed to gain further insight into the influence of cognitive scripts and cognitive lock-in during the redesign of a website. Results suggest that repeat visits on a new interface lead to a decrease in cognitive load. Results also suggest a significant increase in emotional arousal during the third visit; this was contrary to what was expected as repeated visits were hypothesized to result in decreased arousal. Moreover, no significant change in emotional valence exists between the three visits to the new interface. Results also show that task type (in this case, informational vs. transactional tasks) plays a moderating role in the relationship between task repetition and cognitive load and valence. Indeed, informational tasks generated less cognitive load with a gap that narrowed throughout the repetitions. Thus, task type influences the relationship between the repetition of visits to the new interface and user experience. These results suggest that informational tasks would be less complex to master during the first three visits. Also, the user's cognitive load tends to decrease during transactional tasks, but no significant change was found during informational tasks. This suggests that the creation of scripts is faster for informational tasks (first visit) than for transactional tasks, which require more than one visit.

In addition, informational tasks were associated with a more positive emotional valence and higher emotional arousal during the first three visits to the new website. Thus, a greater valence differential during the first visits, with greater valence for informational tasks, was found as expected. Also, informational tasks did not evoke less emotional arousal during the initial visits as expected. Hence, these results can be interpreted as follows: Informational tasks are less complex than transactional tasks to master during the first three visits to a new website interface design and yield more pleasure (high arousal and more positive valence).

This study's findings extend the literature on cognitive scripts by showing how scripts influence user experience following an interface update. Results suggest that the creation of cognitive scripts could be influenced by factors – here, task type - other than the repeated use of an interface. Results suggest that the relationship between the repeat visits to a new interface and cognitive load will be moderated by the task type. This deepens cognitive script theory [2, 3] with the knowledge that higher cognitive load is experienced for transactional tasks than informational tasks during initial interactions with the new website.

Our study also contributes to practice by aiding managers and interface designers aiming to foster an optimal user experience via an interface redesign. Since cognitive load decreases with repeat, managers should take steps to encourage clients to make multiple visits to the website in order to obtain a cognitive lock-in of the latter.

Two limitations should be noted. First, the repetition of tasks on the new interface took place during the same test session which is not a typical use setting in the real world. Also, each user visited the new interface three times, which gives an insight into the experience during initial use but not its evolution over time. Future studies should assess UX through more visits over longer time intervals.

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