An Eye-Tracking Approach to Evaluating Decision-Makers' Cognitive Load and Need-for-Cognition in Response with Rational and Emotional Advertising Stimuli

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Abstract. This study is concerned with using rational and emotional stimuli and analyzing changes of our visual attention responses with the aid of eye-tracking method. Those rational and emotional stimuli were designed in a form of advertising copies and images. To add rigor to our study, we organized heterogeneous stimuli and homogeneous stimuli to make appropriate stimuli, where heterogeneous stimuli consist of either emotional copies and rational images, or rational copies and emotional images. Homogeneous stimuli are designed to consist of either emotional copies and emotional images, or rational copies and rational images. By using those stimuli, we measured respondent's cognitive load and need-for-cognition by taking advantage of the eye-tracking technique. 80 respondents were invited to our experiments, and their physiological responses were measured in a form of cognitive load and need-for-cognition. We analyzed fixation length data from the participants' eye-movement with the stimuli. Participant's cognitive load increased more when they were exposed to heterogeneous stimuli, while participant's fixation length changed significantly only when there exists interaction effect between cognitive load and need-for-cognition in response to the stimuli.

Keywords: Eye-tracking · Cognitive load · Need-for-cognition · Rational copy · Emotional copy · Fixation length

1 Introduction

It is customary that we are exposed to a lot of advertising copies and images everyday. In our daily lives, we are forced to make some decisions on products and services which are advertised in various types of advertising copies and images. It is true that

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advertising copies and images affect our decision-making to some extents. Besides, we know that some of our cognitive efforts are needed to process those advertising copies and images before making decisions.

However, there are no studies investigating how much our cognitive load (CL) and need-for-cognition (NFC) are needed to understand many types of information from a physiological view. Understanding advertising copies and images is working as tasks on our brain. Processing such tasks require our mental resources which are interpreted as CL and NFL. In literature, CL was investigated from the eye-tracking approach [12]. In creativity literature, those people with high NFC are known to exhibit higher performance on recall and recognition tasks [9]. They tend to also actively seek new information to accomplish their goals.

It is well known in neuroscience that working memory is critically required when we work on tasks [2]. The size of individual working memory is closely related with CL (Cognitive Load). In our physiological responses, CL can be measured pupil expansion [3, 10].

Meanwhile, NFC is related to reflecting individual differences in cognitive motivation to enjoy effortful cognitive endeavours [5]. Therefore, it is no surprise that NFC affects cognitive elaboration and recall of various advertising stimuli [16]. Besides, NFC has influence on formation and changes in attitude [7] and problem solving [14].

In this study, we adopt an eye-tracking approach to measuring CL and NFC. Physiological approach like eye-tracking has many advantages compared to perceived approach such as survey method. It can reduce people's psychological, minimizing distortion of discretionary evaluation of participants' results. The physiological data is very hard to modify intentionally [19]. Especially, among the physiological metrics, eye movement data have a long tradition. A human's eye gathers the largest amount of information of all the sensory systems. People obtain more than 70 % of external information through visual processing. Also, in working memory, more than 90 % of information used for cognitive activity is obtained from visual information [19]. Eye movements triggered by visual stimuli indicate that an individual perceives selectively and actively [1]. Therefore, eye movement is considered an important measurement for understanding cognitive activity triggered by visual stimuli [6].

Literature review tells us that there is no study attempting to measure the effects of CL and NFC on decision-maker's visual attention responses when they are exposed to advertising copies and images which are designed as rational stimuli and emotional stimuli. Main objectives of this study are as follows. Firstly, this study aims to introduce the need of understanding CL and NFC in order to improve the quality of decision-making by using rational stimuli and emotional stimuli which are used to trigger CL and NFC. Secondly, this study tackles aims to investigate the effects of CL and NFC on our physiological system. Eye-tracking method is adopted to handle CL and NFC in response to rational and emotional stimuli.

2 Experiments with Eye-Tracking Method

2.1 Eye-Tracking Method

Eye-tracking methods were used for various applications. Noh et al. [14] used eye-tracking method to measure the effects of multimedia elements on learning achievements in digital contents. Buchmann et al. [4] also applied eye-tracking method to analyze semantic processing. Krishnasree et al. [10] developed a driver fatigue monitoring system based on eye-tracking mechanism. Eye-tracking enables automatic chasing and exploration of information without interrupting the automatic process of eye movement. It also provides a measure of fixation duration through which we can achieve a better grasp of cognitive processing [20]. Eye-tracking has proven to be a strong approach to measure performance in the interaction between products, services and customer, and its use is expanding to help better understand the reception of visual stimuli in information handling processes [13].

2.2 Stimuli

We used advertising messages and images as stimuli to check the level of NFC and CL. We set up experimental stimuli that were expected to have different levels of CL and NFC. Experiment participants were exposed to the stimuli. By using an eye-tracker device, we obtained eye movement tracking data and then conducted a survey to assess participants' self-reports about the level of CL and NFC that they perceived through the stimuli. To secure rigorous validity of our experiment results, the experiment stimuli were composed of rational and emotional copies and images. Those stimuli consist of advertising copies and images.

Advertising Copies. We prepared 20 examples of advertising copies (10 "emotional copies", and 10 "rational copies") to carry out the eye-tracking experiment. To secure validity of the stimuli, a professional market research company was recruited to produce those advertising copies. To obtain qualified advertising copies, two filtering sessions were carried out. At first, 474 copies (227 for iPhone and 247 for Galaxy) provided by the company were submitted to 1 professor, 6 doctoral students for the sake of further proof-reading and double-check. They assess the copies to check whether they possess adequate messages from the perspective of being rational and emotional. Here, a rational copy indicates that it appeals to facts and reasoning, and an emotional copy means that it appeals to our feeling.

After the first session, a survey was carried out to divide the qualified copies into rational copy and emotional copy. 50 raters were asked to rate, on a scale from 1 to 9, how appealing a copy was, with 1 being "emotional very much" and 9 being "rational very much". These measures were adapted from Rosselli et al. [17]. The raters received no more than 40 copies, considering their capability to rate without mental fatigue. Finally, 376 advertising copies (179 for iPhone and 197 for Galaxy) were rated as qualified to be either rational or emotional. If copies have a rating score less than median, they were classified as emotional ones. If rating score is greater than median, the copies were categorized as rational ones. As stated previously, we selected 10 rational copies and 10 emotional copies to conduct the eye-tracking experiments.

Advertising Images. 10 advertising images were organized with the professional support of graphic designers. Also, 40 raters were invited- 24 male (60 %) and 16 female (40 %) to determine validity of the images. They were categorized into two groups of 20 each. One group was shown only emotional images, while the other group was exposed to only rational images. We asked them to rate each image on a seven-point Likert scale, with one being "emotional very much" and seven being "rational very much". There exists significant difference ($p < 0.05$) between the two groups. Therefore, we were convinced that those advertising images are qualified to be used as proper stimuli for our experiments.

Stimuli Group. For the sake of rigorous experiment design, we organized stimuli into four groups- "emotional image × emotional copy", "rational image × rational copy", "emotional image × rational copy", "rational image × emotional copy." Then the two groups such as "emotional image × emotional copy" and "rational image × rational copy" are classified as homogeneous stimuli, and the two groups "emotional image × rational copy", "rational image × emotional copy" are termed as heterogeneous stimuli.

2.3 Results

From Fig. 1, we found that the level of CL was lower in the group exposed to homogeneous stimuli compared to the group exposed to heterogeneous stimuli. This means that if two heterogeneous stimuli ("emotional image × rational copy", "rational image × emotional copy") are presented, the participant's CL to process that information increases. Such mental workload may be understood in terms of the relationship between demand for mental resources required for the task and the capability of individuals to supply such resources [13]. This indicates that, because there are limits on cognitive processing, the amount of information that can be activated or processed and the degree of cognitive processing that can be handled is also limited. However, there was no interaction effect with NFC in terms of CL. Regardless of the level of NFC, the heterogeneous stimuli increase CL.

From Fig. 2, when participants have high NFC, the fixation length increases as CL increases. However, neither the main effect of NFC nor that of CL on fixation length was statistically significant. In the end, we could demonstrate that fixation length changes only when interaction effect between NFC and CL exists. Therefore, we reject hypotheses 1 and 2, but accept hypothesis 3. Human gaze is related to obtaining information and cognitive processing [8]. When individuals find it difficult to extract information or are interested in an object, the length of eye fixation increases (Just and Carpenter 1976). People with high NFC have the tendency to accept cognitively effortful situations naturally, and therefore, when they are presented with heterogeneous stimuli, as in this experiment, they will process that information willingly, accepting the CL. As a result, their fixation length increases as they try to deal with the CL derived from NFC. On the other hand, if homogeneous stimuli are presented

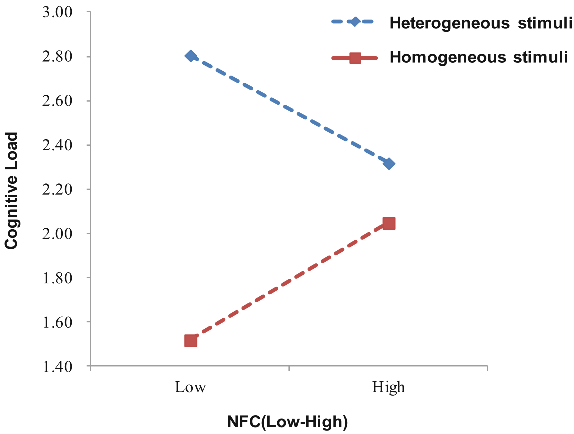

Fig. 1. Cognitive Load in line with NFC (Color figure online)

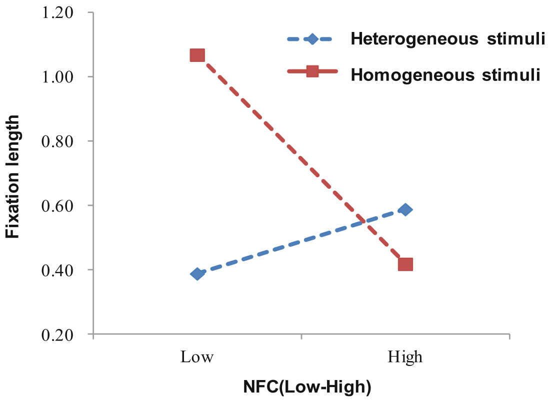

Fig. 2. Fixation length (Color figure online)

(low CL condition), there is no need to handle the problem caused by discord among stimuli. This results in straightforward decrease of fixation length as a result.

3 Concluding Remarks

Decision-makers may show different metrics of CL according to the characteristics of situation. We found that heterogeneous stimuli increase participant's CL. One of interesting results was that there is no significant change in participant's fixation length even when there are changes in either CL or NFC level. However, participant's fixation length changes significantly under 90 % confidence level only when there exists interaction effect between CL and NFC. Another result worthy of being mentioned was that when participants with high NFC were exposed to heterogeneous stimuli, fixation length increased. This result is similar to Henderson [8] in which eye fixation is related to information acquisition and cognitive processing. Future study issues include the following topics. First topic is that EEG and ECG analyses are necessary to investigate more serious research topics by using rational and emotional stimuli. Second topic is that fMRI test results can be used to strengthen our view towards how decision makers will react to rational and emotional stimuli.

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