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# METACOGNITION IN B2C E-COMMERCE: A COGNITIVE NEUROSCIENCE PERSPECTIVE

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## Abstract

*To bridge the research gap on the issue of metacognition in the IS research, this study examines consumer's metacognition in the context of B2C e-commerce. Especially, focusing on the e-commerce solution in terms of Electronic Product Catalogs (EPCs), this study attempts to investigate the effect of the IT artefact on consumer's metacognition in online shopping. From the perspective of cognitive neuroscience, the study combines neurophysiological methodology with psychometric measures to develop a deeper understanding of consumer's metacognition. The fMRI (functional Magnetic Resonance Imaging) is introduced to capture consumer's neural activities in the region of interest (ROI) related to metacognition across the conditions of e-commerce websites with and without EPCs in a manipulated online shopping scenario. Besides, consumer's evaluation of the e-commerce websites is further studied.*

*Keywords: Metacognition, E-commerce, Online shopping, Electronic Product Catalogs, EPCs, Product filter, Website design, Neurophysiological methodology, fMRI, NeuroIS.*

# 1 INTRODUCTION

The IS research has developed in-depth understanding of human cognitive processes in the context of e-commerce, whereas the research on metacognitive processes has not received enough attention. This research argues that it is important to study consumer's metacognitive process and the effect of the IT artefact on consumer's metacognition. By monitoring and control of cognitive processes, metacognition is crucial to consumer's shopping process and evaluation in the context of e-commerce. In terms of e-commerce solution, this study investigates Electronic Product Catalogs (EPCs) which is developed by implementing online product catalogs and filtering function. With the support of EPCs, consumers can filter products online both effectively and efficiently according to their preferred criteria such as category and features. In comparison, this study manipulates e-commerce website without product catalogs or filtering function to contrast with e-commerce website with EPCs in the experiments. Consumer's evaluation of e-commerce websites and its relationship with metacognition is further studied in the research.

From the perspective of cognitive neuroscience, we adopt a neurophysiological methodology to improve the IS research. Neurophysiological tools have received increased attention in the IS research because of their ability to capture data inside human body (Lieberman 2007). Meanwhile, the tools have been widely introduced in the IS research (Cyr et al. 2009; Dimoka et al. 2011; Dimoka & Davis 2008; Dimoka et al. 2007; Galletta et al. 2007; Randolph et al. 2006; Riedl et al. 2010a; Riedl et al. 2010b). Among the neurophysiological tools, fMRI (functional Magnetic Resonance Imaging) focuses on scanning brain's blood oxygenation level dependent (BOLD) signals on the basis of blood's magnetic properties with superb spatial resolution (Dimoka 2010). In this sense, IS researchers can utilize fMRI to capture subject's neural responses during decision making and information processing. Likewise, we use fMRI to scan the region of interest (ROI) related to consumer's metacognition in online shopping, and to contrast the neural activation of metacognition under the conditions of e-commerce website with and without EPCs in a manipulated online shopping scenario. Besides, the study adopts psychometric measures to investigate consumer's evaluation of e-commerce websites with the IT artefact.

This study aims to examine consumer's metacognition in online shopping and evaluation of e-commerce websites by providing neuroimaging evidence. In particular, this study concerns the following research questions:

- 1) Are consumer's brain activation levels in metacognition-related cortical regions evidently distinct when online shopping on e-commerce websites with and without EPCs?
- 2) Are consumer's brain activation levels in metacognition-related cortical regions during online shopping process significantly related to consumer's evaluation of e-commerce websites?

## 2 LITERATURE REVIEW

### 2.1 Electronic Product Catalogs

Nowadays, the booming in e-commerce fosters a need for Electronic Product Catalogs (EPCs). With the support of EPCs, e-commerce consumer's shopping experience could be improved. Especially, the filtering function enables consumer to match the needs and the available products on the e-commerce websites effectively and efficiently. For example, EPCs related to digital camera could facilitate consumer to filter out the preferred product from a huge number of choices according to filtering options such as megapixels, optical zoom, sensor type, and brands, etc. Well-organized EPCs can have a significant influence on consumer's shopping process, which in turn impacts sellers' profit. In this study, the Electronic Product Catalogs (EPCs) refer to online catalogs of products, provided by e-commerce websites or third-party websites, which provide filtering functions for consumers to advance their online shopping experience.

Previous studies on EPCs tend to transfer relevant research on marketing to the e-commerce studies, including study based on traditional shopping behavior research (Maes et al. 1999), consumers' ways of choosing a product by taking tasks and goals into account (Bettman & Kakkar 1977), the impact of the structure of tasks on the choice of process (Newell et al. 1972), the way the information is displayed (Bettman & Kakkar 1977), and the attribute's value type (Russo et al. 1983). This study holds the belief that in the context of online shopping EPCs facilitate consumers to plan, evaluate progress, and clarify their needs. The EPCs also support consumer's self-regulated process such as aiding consumers to set appropriate shopping goals according to their needs or revise shopping goals as necessary. The shopping environment of e-commerce with EPCs could foster consumers to perform online shopping tasks metacognitively by directing consumers to either explicitly plan shopping activities or justify their choices, which improves consumer's shopping effectiveness and efficiency. Accordingly, this study investigates the effect of EPCs on consumer's metacognition during online shopping process, which remains untouched in the field. The research aims to bridge the research gap.

## **2.2 Metacognition Theory**

In psychological research, the concept of metacognition is associated with "higher order thinking which involves active control over the cognitive processes engaged in learning" (Livingston 1997, p.2). Metacognition concerns the study of what people know about their own cognition and cognitive processes, as well as how they regulate information processing (Koriat 2006). Metacognitive knowledge and metacognitive regulation are generally recognized as main components of metacognition (Flavell 1979; Garner 1987). Metacognitive knowledge refers to the acquired knowledge about cognitive process including declarative, procedural, and conditional knowledge (Schraw 1998; Schraw & Moshman 1995). Metacognitive regulation is related to know when and why to use specific knowledge for people to control learning or solving problems (Garner 1990; Schraw 1998).

Previous research of metacognition has centered on educational psychology with insight about the cognitive processes involved in learning and problem solving. The research of metacognition is engaged in learning strategies, learning planning, and learning processes monitoring (Koriat 2006). Besides, metacognition has been found that it is crucial to determine the quality of learning studied in the context of online learning (Ally 2004; Garrison & Cleveland-Innes 2005; Salmon 2002). Metacognition exhibits monitoring function on cognitive processes, and in turn controls cognitive processes by control function (Brown 1978; Efklides 2006; Flavell 1979). This research considers that metacognition plays a critical role during consumer's e-commerce shopping process. In this study, consumer's e-commerce shopping process is recognized as a cognitive process which involves processing price and product information and making online shopping decisions. Accordingly, by highlighting the functions of metacognition, metacognition is defined as consumer's awareness of monitoring and control of information processing and decision making in online shopping.

## **2.3 Cognitive Neuroscience and Metacognition**

In cognitive neuroscience, prior research has found that the Prefrontal Cortex (PFC) plays a critical role to control information processing, and engages in metacognitive control during all stages of learning process (Fernandez-Duque et al. 2000; Miller & Cohen 2001; Shimamura 2002a; Smith & Jonides 1999). The neurobehavioral studies have localized metacognition-related brain activities in the cortical region of PFC which monitors sensory signals and exerts control through feedback loops, and explicitly connected metacognitive processes with PFC functions (Dunlosky & Bjork 2008; Fernandez-Duque et al. 2000; Pannu & Kaszniak 2005; Shimamura 1996; Stuss et al. 2001). Furthermore, the PFC has been recognized to amplify and refine neural activities by enhancing sensory signals and reducing exterior noise to coordinate cognitive processes (Shimamura 2008).

The regional specificity within the PFC has been further identified by neuroimaging studies including ventromedial PFC (Brodmann Areas (BA) 11, BA12, or orbitofrontal cortex), anterior PFC (BA 10,

or frontopolar PFC), dorsolateral PFC (BA9, BA46), dorsomedial PFC (BA24, BA32, or anterior cingulate gyrus), ventrolateral PFC (BA44, BA45, BA47) (Shimamura 2008). The regions interconnect with each other and link to cortical regions outside the PFC (Petrides & Pandya 2001; Simons & Spiers 2003). Within the various regions of the PFC, the dorsolateral PFC is associated with the functions to manipulate and update information, and the ventrolateral PFC is related to select and maintain information (D'Esposito et al. 2000; Petrides 1998). Likewise, this study sheds light on the dorsolateral PFC and the ventrolateral PFC which are responsible for monitoring and control functions of metacognition.

### 3 HYPOTHESES DEVELOPMENT

Consumer could be more aware of products and engage in effective and efficient online shopping with the aid of external metacognitive resources (Kirsh 2005). In the context of B2C e-commerce, EPCs provide such external metacognitive support in terms of comprehensive filtering services for consumer to improve effectiveness and efficiency of online shopping process. For example, EPCs can facilitate consumer to make shopping choices within a great number of candidates according to consumer's preferred criteria. With the guidance of EPCs, consumer's shopping information processing and decision making are improved during online shopping process. In particular, online shopping with EPCs helps to reduce consumer's choice complexity and cognitive effort, which in turn improves consumer's metacognition.

As far as neural activities are concerned, EPCs facilitate to improve consumer's shopping efficiency and effectiveness by offering high qualified information and service. Such that, relatively less internal efforts are necessary to monitor and control consumer's shopping cognitive process. Accordingly, less metacognitive efforts and lower activation levels in the metacognition-related cortical regions are provoked. To be specific, less neural activities in the dorsolateral PFC and the ventrolateral PFC are demanded for increasing sensory signals or reducing extraneous noise. Thus, in comparison to e-commerce website without EPCs, online shopping with the support of EPCs less activates consumer's metacognition-related cortical regions of dorsolateral PFC and ventrolateral PFC to organize cognitive process of online shopping. The hypotheses are put forward as followings:

*H1a: Online shopping with EPCs is associated with consumer's lower brain activation in the dorsolateral PFC, whereas online shopping without EPCs is associated with higher brain activation in the dorsolateral PFC.*

*H1b: Online shopping with EPCs is associated with consumer's lower brain activation in the ventrolateral PFC, whereas online shopping without EPCs is associated with higher brain activation in the ventrolateral PFC.*

During online shopping process, consumer's information processing is related to the reflection of website's usefulness and the evaluation of presented information in the website (Pengnate & Antonenko 2013). Likewise, consumer's evaluation of e-commerce website is associated with their comprehension of shopping experience and performance. E-commerce website with EPCs enables consumer to shopping online effectively and efficiently, which improve shopping task performance. In this case, less metacognitive effort is invested to monitor and control shopping information processing with the presence of EPCs, which leads to effectiveness and efficiency of information processing as well as consumer's higher evaluation of corresponding e-commerce website. Thus,

*H2a: Consumer's brain activation level in the dorsolateral PFC during online shopping process is negatively related to evaluation of e-commerce website.*

*H2b: Consumer's brain activation level in the ventrolateral PFC during online shopping process is negatively related to evaluation of e-commerce website.*

## 4 RESEARCH METHODOLOGY

### 4.1 Pilot Study

A behavioral study will be conducted prior to the fMRI experiment, and the reasons lie in: 1) calibrate the e-commerce metacognitive design manipulations and experimental procedures for the subsequent fMRI study; 2) compare behavioral data collected from classic lab experiment with the corresponding data from the fMRI study to reduce bias due to the setting and artificiality of the fMRI environment (Dimoka 2010); 3) the pilot behavioral data could be used to refine the stimuli and online shopping tasks of the subsequent fMRI study.

#### 4.1.1 Instrument Development

The pilot study develops a metacognition rating questionnaire by referring to the Metacognition Rating Scale for General Biology which originated to evaluate the metacognition of university students majoring in Biology (Wang et al. 2004). The metacognition rating questionnaire measures consumer's metacognitive awareness in online shopping process on e-commerce websites with or without EPCs. The questionnaire contains 7-point likert scale with items measuring awareness of the extent to which consumer comprehends online shopping tasks and goals and regulates online shopping process. Consumer's evaluation of e-commerce website is measured by the extent to which consumer perceives that the website provides qualified information for shopping decision making.

#### 4.1.2 Experimental Websites Design

The conditions in the pilot study are simulated e-commerce websites with or without EPCs, through which 25 subjects recruited from the local universities will be asked to purchase their preferred digital camera from a number of choices with different features and price. The simulated website with EPCs is manipulated to support filtering function according to products' various features (e.g. Figure 1). Whereas, the subjects who shop on website without EPCs browse web pages with products profiles among which they make shopping decisions (e.g. Figure 2). The subjects will respond to the metacognition rating questionnaire and evaluation questionnaire after online shopping.

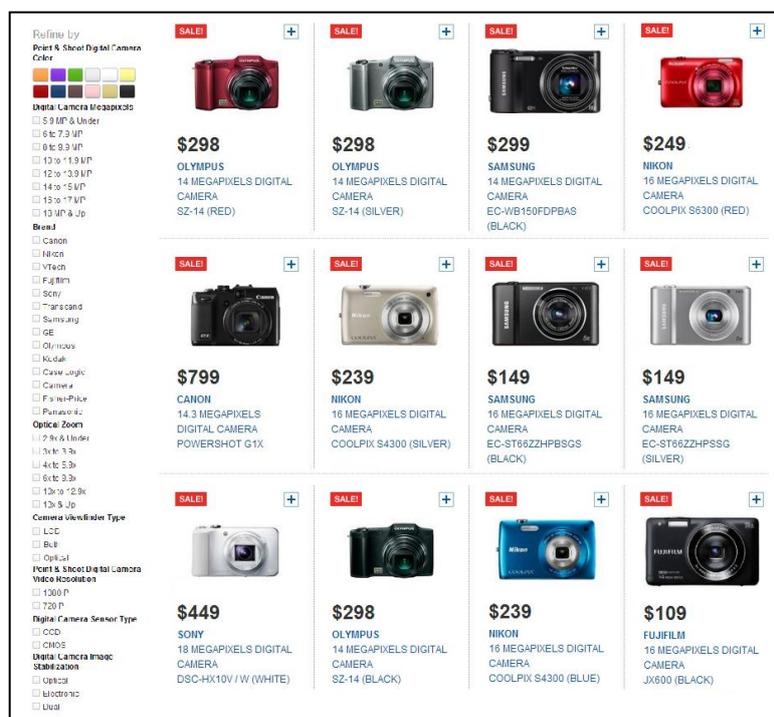


Figure 1. Simulated e-commerce website with EPCs support

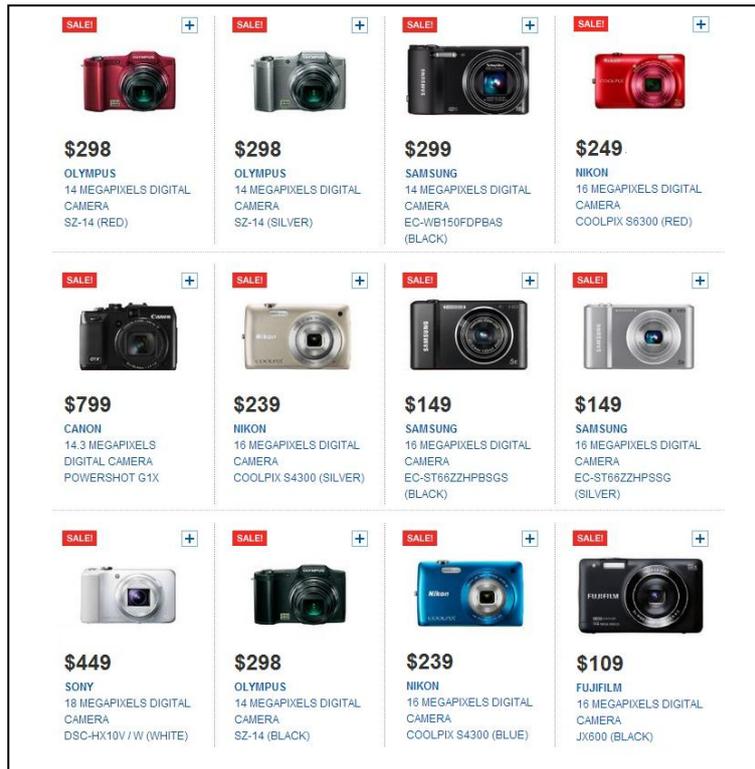


Figure 2. Simulated e-commerce website without EPCs support

## 4.2 fMRI Study

fMRI is utilized to capture the subjects' cerebral activation when they perform similar online shopping tasks as the behavioral study. To ensure fMRI safety, the subjects from the local universities will be pre-screened for physiological problems, metal piercings and medical implants. 12 qualified subjects will be recruited for fMRI study, which meets the criterion of 80 percent power for statistically significant brain activation at a threshold of  $p < .05$  (Desmond & Glover 2002). A 3T fMRI-scanner (e.g. Magnetom Trio, SIEMENS, Erlangen, Germany) will be adopted for the fMRI study.

### 4.2.1 fMRI Experimental Design

The manipulated e-commerce websites with and without EPCs are experimental stimuli conditions in a within-subject design. The subjects undertake online shopping tasks on manipulated websites to purchase digital camera during the fMRI session. The visual stimuli for subjects are projected by fiber-optic goggles which are linked to a PC (e.g. Figure 3). By browsing manipulated websites with a fiber-optic mouse, the subjects decide preferred digital camera on one e-commerce website, and then they switch to the other e-commerce website for similar shopping task. A 7-point likert scale is shown on the screen for the subjects to evaluate the e-commerce websites after each shopping task. To eliminate the irrelevant cortical activation due to external noise instead of experimental stimuli, a baseline condition is designed in the experiment (Dimoka 2010; Friston 2002). The sources of noise in this study are recognized as the subjects' motions to use fiber-optic mouse when they browse e-commerce websites. Accordingly, the baseline condition is designed in the way that the subjects are instructed to click hyperlinks on similar web pages as the experimental conditions. The subjects' neural activities will be scanned and recorded during their shopping procedures for the stimuli conditions and the baseline condition.

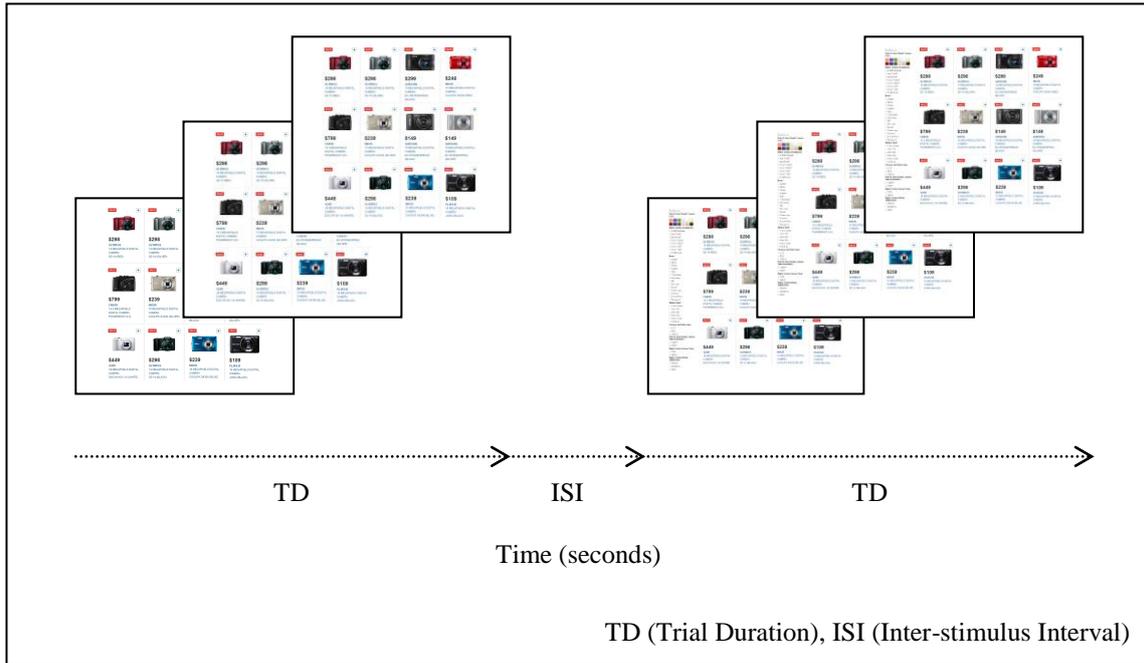


Figure 3. fMRI visual stimuli

## 5 DATA ANALYSIS

The fMRI data analysis checks whether the difference between the experimental conditions can result in difference in hemodynamic response within the identified active area (Culham 2006; King-Casas et al. 2005). Likewise, this research adopts region of interest (ROI) analysis to examine the statistical parametric maps in metacognition-related regions with t-value of 3D pixels at a  $p < .05$  threshold. The data collected during the fMRI study will be further compared with the corresponding data during pilot behavioral study, which aims to ensure that the subjects' psychometric responses in the fMRI environment are similar to the behavioral experiment (Dimoka 2012).

## 6 CONCLUSION

Focusing on Electronic Product Catalogs (EPCs), this study examines how consumer's metacognition is influenced by the IT artefact which is developed to provide high qualified product information by implementing product filtering mechanism. In comparison to e-commerce website without EPCs support, EPCs facilitate to enhance consumer's monitoring and control of cognitive information processing, which further advances consumer's metacognition in the procedure of online shopping. Besides, consumer's evaluation of e-commerce website is argued to be impacted by the metacognition during online shopping experience.

From the perspective of cognitive neuroscience, the study combines neurophysiological methodology with traditional psychometric measures to develop a better understanding of consumer's metacognition in online shopping. The fMRI (functional Magnetic Resonance Imaging) study is designed to capture consumer's neural activities during experiment of online shopping through distinct e-commerce websites. The region of interest (ROI) related to metacognition during consumer's shopping process is scanned across the conditions of e-commerce websites with and without EPCs in a manipulated online shopping scenario. Besides, the study tests consumer's evaluation of the distinct e-commerce websites and its correlation with metacognition.

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