INVESTIGATING COMMON METHOD BIAS VIA AN EEG STUDY OF THE FLOW EXPERIENCE IN WEBSITE DESIGN

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ABSTRACT

Flow experience is a critical lens for investigating the role of website design on consumer satisfaction in online shopping. Since flow is a latent variable that cannot be directly observed, most studies use a questionnaire survey with self-reported data as the predominant method of data gathering. Although many researchers believe that the self-reported approach as a sole measurement method is subject to common method bias (CMB), scholars have different interpretations of this effect. This study designed an experiment with flow experience as a mediator to investigate the relationship between website quality and user satisfaction from a behavioral survey and an electroencephalography (EEG)-based neuroscience method. By adopting Harman's one-factor test and the marker variable technique, the results indicate that the EEG neuroscience method reduces CMB and CMB is not an important issue when considering EEG results.

Keywords: Website design; Flow theory; Neural information systems; Common method bias; Marker variable technique.

1. Introduction

The concept of flow was first proposed by Csikszentmihalyi (2000), who defined it as "the holistic sensation that people feel when they act with total involvement" (p36). "Flow/flow state/flow experience" refers to a mental state of consciousness that is experienced by individuals who are fully focused, absorbed, and engaged in an activity. Hoffman and Novak (1996a) proposed flow as the engaged state occurring while consumers navigate through online environments such as the World Wide Web. Among different theoretical perspectives, the concept of flow has been used to describe pleasant and enjoyable shopping experiences. A large number of studies using the concept have been conducted and reported. Kim and Lennon (2010) suggested that the state of flow influences a level of interaction on effective online shopping. Hausman & Siekpe (2009) argued that given the importance of flow in online shopping, online vendors deliberately design Web environments and atmospheric cues to facilitate the flow experience. Ong et al. (2012) argued that a well-designed retail store provides a platform with potentially better flow opportunities and shopping experience. Flow experience is a critical lens for investigating the role of website design on consumer satisfaction in online shopping. Moreover, the effects of flow on consumers' decision making have been discussed in recent years.

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Lee et al. (2019) explored the role of flow in e-commerce, and found that customers' flow experiences are influenced by website features, and their satisfaction is affected by dimensional flow, which suggests e-commerce managers regard flow as a marketing factor. Kim et al. (2020) investigated how online engagement influences customer experience, and the result indicates that flow is significantly impacted by system quality, and it leads to positive attitudes and continuance intentions, having positive effects on increasing customer engagement.

Since flow is a latent variable that cannot be directly observed, most of the studies used a questionnaire survey with self-reported data as the predominant method of data gathering (Chang & Chen, 2009; Fan et al., 2013; Hausman & Siekpe, 2009; Ladhari, 2010). Psychometric self-reported approaches are considered to be a black box while processing information (Dimoka et al., 2012). The majority of research still continues this approach for objective measurements and for indirectly inferring user behaviors through different experimental settings (Parboteeah et al., 2009) or statistical modeling (Ethier et al., 2006). Although many researchers believe that the self-reported approach as a sole measurement method is subject to common method bias (CMB) (Meade et al., 2007; Podsakoff et al., 2003), scholars have different interpretations of this effect (Cote & Buckley, 1987; Spector & Brannick., 2009).

CMB often occurs when the responses are systematically varied because of the applied method that might distort substantively-driven casual effects (Chin et al., 2012). It may either falsely inflate observed relationships among measures or deflate correlations. While explaining the impact of method factors on responses to individual measures derived from a single-data source, increasingly attention to CMB suggests to adopt various sources to conquer the problem since scholars believe that common methods drive effects more than the hypothesized cause (Conway & Lance, 2010; Pace, 2010). Along the research thread, this study adopted a hybrid approach including a neuroscience approach in the field experiment, and compared the findings with those from the traditional questionnaire surveys.

Recently neuroscience methods that take advantage of neuro-scientific equipment to collect psychophysiological evidence have gained much attention in social sciences and information systems (Dimoka et al., 2012; Kuan et al., 2014; Lai et al., 2018; Riedl et al., 2010; vom Brocke & Liang, 2014). Many neuro-scientific methods are available for social science research, including eye-tracking, magnetic resonance imagining (MRI), positron emission topography (PET), and electroencephalography (EEG). EEG is not only relatively portable, equipped with better temporal resolution, which can accurately reflect subtle shifts in alertness, attention, and workload, but also useful for learning cognitive and emotional responses in the process of performing experimental tasks (Kuan et al., 2014; vom Brocke & Liang, 2014). Hence, this study uses EEG to collect data during the decision process and compare the result with that from the self-reported behavior data.

We designed a study with flow experience as a mediator to investigate the relationship between website quality and user satisfaction. Both the behavioral survey and the EEG-based neuroscience methods demonstrate that a good website design is more likely to generate higher flow experience, which in turn will result in higher user satisfaction. The relative weights of different factors vary when different methods are used to collect data. Harman's one-factor test (Podsakoff & Organ, 1986) shows that all survey factors (convenience, aesthetics, content, interactivity, customization, flow, and satisfaction) have common methods bias with 59.9% of variance explained by the first factor. In terms of EEG-based flow data, the result shows that the first factor explained 49.7% of variance, below the standard threshold of 50%. This indicates that the EEG neuroscience method reduces CMB. The marker variable technique (Chin et al., 2012; Rönkkö & Ylitalo, 2011) was adopted to estimate CMB and found that the marker variable had no significant effects on the endogenous variables and CMB is not an important issue when considering EEG results.

2. Theoretical Background

2.1 Common Method Bias

Common method bias (CMB) has been recognized as a potential problem in behavioral research. Relevant discussions of the biasing effects measuring constructs with the same method have a long history in the behavioral sciences (Campbell & Fiske, 1959; Campbell & O'Connell, 1982) and continuously catch scholars' attention to the present day (Chin et al., 2012; Conway & Lance, 2010; Fuller et al., 2016).

While most researchers concern with method bias, there is little agreement about research settings with the potential to manage it (Spector, 1987; Spector & Brannick., 2009). Podsakoff et al. (2012) classified how researchers control CMB into the procedural and statistical remedies. Procedural remedy is to identify what the measures of predictors and criterion variables have in common and to control method variance (Podsakoff et al., 2003). One procedural remedy to manage method bias is obtaining predictor measure(s) or criterion measure(s) from different individuals or data sources. This approach can diminish or eliminate a common rater to bias the predictor-criterion relationship and control method bias. However, it is not always appropriate for all cases, particularly when both the predictor and criterion variables are designed to catch an individual's sole attitude and perceptions. This technique is noted that it is not feasible for self-referential attitude and perception constructs since it is hard to accurately infer an individual's perceptions based on the observation of his/her

behavior (Brannick et al., 2010). Meanwhile, it is also difficult to obtain archival data to accurately represent one of the constructs of interest and this technique is more time- and labor- consuming work for most of researchers.

When it is impossible to obtain data from different sources, another procedural remedy is to separate predictor or criterion variables through temporal, proximal, or psychological separation. Despite the fact that the temporal separation is an effective manner for some method bias, the increased complexity, nonmethodological factors, and the difficulty to determine the appropriate delay are the potential challenges for this approach (Podsakoff et al., 2012). Not to mention that this approach is based on the assumption that the relationship between constructs is relatively stable over the time period of the delay and the method bias dissipates over time.

From the perspective of context effects and question order effects (Tourangeau et al., 2003), the proximal separation is introduced to be effective approach on the method bias. However, the proximal separation increases the length of the questionnaire leading to fatigue, low response rates, and more costs. In terms of psychological separation, it depends upon the credibility of the cover story. Therefore, it requires a considerable amount of creativity and ingenuity to develop its cover story to ensure its effectiveness.

Although the procedural remedies could minimize possible effects of method biases, researchers may have difficulty to plan the implementation that meet all of their needs beforehand. In such a case, statistical remedies are becoming a more feasible and practical alternative. As with self-reports as the predominant method of data gathering, Harman's single-factor test is one of the widely used techniques that is often adopted into any exploratory factor analysis (Aulakh & Gencturk, 2000) and to determine the number of necessary factors accounting for the variance in the variables. Although the test can identify whether a single factor accounts for the covariances among the items, it is just an intensive diagnostic technique which does nothing to control for any bias (Podsakoff et al., 2003).

According to Williams et al. (2010), the correlational marker variable technique has been widely used for controlling method variance since Lindell and Whitney (2001) introduced such an easy-implemented approach. However, researchers criticized this technique from various perspectives. First, the marker variable was suggested as the variable with the smallest correlation with the substantive variables. Without sharing method characteristics with substantive variables, it is hard to demonstrate the goal behind the use of marker variables (Williams et al., 2010). This technique also ignores measurement errors and controls for method bias at the scale level but the item level. In addition, the assumptions of this technique are problematic. It assumes that method bias can only inflate but deflate among the substantive variables, which is incorrect (Podsakoff et al., 2003). It also assumes that the method factor represented by the marker variable doesn't interact with the substantive variables of interest and has an identical effect on every substantive variables, which has been criticized by researchers (Podsakoff et al., 2003; Richardson, Simmering, & Sturman, 2009). Such a technique with problematic assumptions without incorporating unequal method effect in different research settings is hard to control for method bias since different types of variables may contain different method variance (Williams et al., 2010). Since this test requires the expected sampling distribution of the correlations between the constructs, such a feature makes the test incompatible with Partial least squares (PLS) analysis, which does not require any particular sampling distribution (Dijkstra, 1983).

Williams et al. (2010) proposed the three-phase confirmatory factor analysis (CFA) marker technique to share measurement characteristics with the substantive variables of interest and control for method biases. This approach models the effects of method biases at the indicator level, provides a statistical test based on model comparisons, and examines whether method biases affect all measures differently (Podsakoff et al., 2012). However, a few problems are still required to be noted. That is this approach couldn't capture the nature of the method bias which also leads to ambiguous conceptual meaning of the latent method factor. Without a strict constraint on the relationship between marker variables and the substantive constructs, marker variables might come from a scare for a recognized construct, which might affect the loadings of the marker variables on this latent construct in both CFA model and their baseline model (Podsakoff et al., 2012). This technique is sensitive to the specific variables used for the net effect of the method characteristics. Moreover, it requires fixing parameter estimated in phases I and III, which may not provide correct standard errors and goodness-of-fit statistics for testing the fit of the resulting model (Kennedy, 2008).

Another thread of research adapted PLS path modeling as an alternative to structural equation modeling (SEM) to control the influence of CMB analyses. Liang et al. (2007) introduced an ad hoc unmeasured latent method construct (ULMC) approach in PLS, that was quickly embraced by the information system (IS) community. Herath and Rao (2009) explored the incentive role of penalties, pressures, and perceived effectiveness of employee actions in security policy compliance intentions in organizations. In their study, they conducted the Harman's single factor test (Podsakoff et al., 2003) and the ULMC model (Liang et al., 2007) to investigate CMB of their study. Lacovou et al. (2009) assessed the magnitude of the CMB risk in their study, and they adopted the approach proposed by Liang et al. (2007) when investigating selective reporting behavior through a dyadic-level study. Further Chin et al. (Chin et al., 2012) adopted Monte Carlo simulations to examine the ULMC approach and demonstrate that this approach does not consistently identify CMB, challenging the

core findings of Liang's study (2007) without a reliable technique. Given the importance of eliminating CMB, the objective of this study was to examine whether different research methods may affect the findings of empirical research and whether the data from both subjective and objective manners could provide an alternative way to detect CMB and provide IS research more insights from their results.

2.2 Flow Theory and EEG

Flow experience has been found to be an essential determinant on users' online behavior (Hausman & Siekpe, 2009; Koufaris, 2002; Novak et al., 2000). Flow is the mental state when users are fully immersing in a feeling of a concentration, full involvement, and pleasure in the process. This kind of focus on operational situations without considering time is the key concept in "Flow Theory" identified by psychologists (Csikszentmihalyi, 1977). In Trevino and Ryan' study (1993), the flow state is defined from four dimensions: 1) the user perceives a sense of control over the computer interaction, 2) the user perceives that his/her attention is focused on the interaction, 3) the user's curiosity is aroused during the interaction, and 4) the user finds the interaction intrinsically interesting. Hoffman and Novak (1996b) defined flow in terms of the experience of flow, behavioral properties of the flow activity, and its antecedents such as skill/challenge balance, focused attention, and telepresence.

Research on flow experience began with the investigation of happiness by Csikszentmihalyi (1992). The research shows when describing enjoyment (or flow), people tend to mention the following components: 1) a narrowing of the focus of awareness, 2) loss of self-consciousness, 3) a responsiveness to clear goals and feedbacks, and 4) a sense of control over the environment (Csikszentmihalyi, 1992). With the development of computer use and popularity of the Internet, scholars have applied the flow theory to human-computer interaction and network activities (Liang et al., 2020, 2021). Liang et al. (2020) explored how different brain areas are connected in different decision processes , and developed a better understanding of how the two subsystems of brain (i.e., intuitive and deliberative) work; further, the effects of the contextual factors on escalation decisions, which is a common bias in human decision making, have been investigated through brainwave activations (Liang et al., 2021). More and more literature explored people's flow experience in online shopping environment, including focus, time distortion, reducing the individual consciousness, joy, and control/skills (Bilgihan et al., 2014, 2015; Koufaris, 2002; Novak et al., 2000; Rong & Min, 2005a), which reflect the characteristics of the flow theory from Csikszentmihalyi.

EEG is a process of recording brainwave activity, and commonly used in the health and medical realms such as research on epileptic seizure (Yuan et al., 2017) and sleep disorder (Siddiqui et al., 2013). In recent years, EEG has been applied in other fields, including multimedia education learning (Moldovan et al., 2017; Ni et al., 2020), brain-computer interface (Korovesis et al., 2019; Menezes et al., 2017), and neuromarketing research (Ariely & Berns, 2010a). For example, analyzing learners' interest and attention based on EEG data in mobile learning (Moldovan et al., 2017; Ni et al., 2020), using EEG activity to control external devices, such as robots or virtual environments (Korovesis et al., 2019; Menezes et al., 2017), and developing market strategies through neuromarketing (Ariely & Berns, 2010b). Since EEG is regarded as a psychophysiological measurement closely related to people's mental state (Wang & Hsu, 2014), the relationship between flow experience and EEG has been widely investigated in gaming (Chanel et al., 2011; Klasen et al., 2012; Nacke et al., 2010). Additionally, EEG activity has been adopted to develop a detection of students' flow state (Wu et al., 2021) and identified to be related to a high level of cognitive control and the immersion aspect of flow (Katahira et al., 2018).

3. Research Design

In order to test the difference between research methods and explore possible common method bias of research methods, a flow study was designed and conducted.

3.1 Conceptual Model

Online retailers benefit from building quality websites by manipulating factors that favorably affect consumer satisfaction. When the state of flow for customers is increasing, a successful purchase is more likely to happen. This study aims to examine the effect of flow experience on compelling service experience of online retailing and to test the relationship between website quality factors and user satisfaction. Our research model is illustrated in Figure 1 and elaborated in this Section.

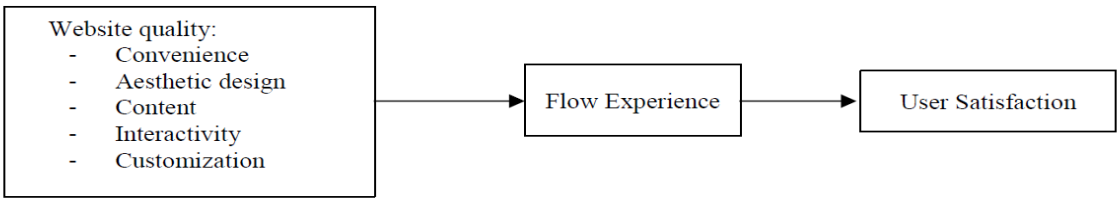

Figure 1: Research Model

Although previous studies have investigated the impact of website quality and flow experience separately, most of them are centered on the definition or measurement structure but not their empirical relationships. For instance, Pace (2004) applied the grounded theory to explore the flow experiences of Web users engaged in information-seeking activities. Carlson and O'Cass (2011) examined the impact of website quality on compelling service experience. Their results show that communication, technology, aesthetics, and information exchange process have positive influences for the user's flow experience in e-commerce sites. Zhou (2013) discussed the main factors of the use of a mobile phone game. Ease of use, connection quality, and content quality are the main factors to affect users' flow experience in a mobile game.

The relationship between website quality and flow has not been adequately discussed in the literature. For example, Zhou et al. (2010) pointed that neither flow has been considered as a focus on website quality nor website quality has been deliberated as an impact on the antecedents of flow in the prior research. Recent studies indicated that convenience, content, aesthetics, and interactivity of website quality can be important determinants of flow and the flow-related online shopping behaviors in C2C e-marketplaces (Fan et al., 2013). Also, Gao and Bai (2014) found that website atmospheric cues including informativeness, effectiveness, and entertainment are positively related to the development of flow, purchase intention and satisfaction in online travel agencies. Learning from the literature on different website quality issues for flow experience, we expect that website quality would have similar effect on flow experience.

Website quality is a multi-faceted concept that is a measure of shoppers' perception of the overall transaction (Chang & Chen, 2009). Scholars have attempted to propose different dimensions for describing website quality (Bauer et al., 2006; Parasuraman et al., 2005). Although website quality was postulated in many studies as a determinant of website success, effectiveness, preference, and customer satisfaction, the assumptions were not always supported with the empirical evidence (Ethier et al., 2006). To concentrate on the website as an online store's "atmospherics", this study focuses on the components of website quality that are related to the design of a web environment. We adopted four components of website quality from Chang and Chen (2009) including convenience, aesthetics, interactivity and customization as well as the dimension of content proposed in (Aladwani & Palvia, 2002; Fassnacht & Koese, 2006; Ladhari, 2010). Around two-thirds of e-commerce transactions are incomplete because shoppers cannot easily get what they need on the site and the site fails to encourage shoppers to complete their transactions (Chang & Chen, 2009). The zone of tolerance for consumers' expectations leaves no margin for any inconvenience experience. Yang et al. (2005) indicated that the adequacy and usefulness of a website's content influence users' perceptions and satisfaction of the service. Several studies found that aesthetic features such as text, icons, colors, and visual cues influence arousal and pleasure (Davis et al., 2008; Eroglu et al., 2003). Meanwhile, interactive features of online stores allow consumers to obtain information actively instead of merely receiving it passively. Interactivity enables consumers to control what messages they receive and it has been found to affect consumers' attitude toward online advertising (e.g., Li, Yang, & Liang, 2015). In addition, customization has been credited with positive effect on supporting decision making (Ho & Bodoff, 2002; Treiblmaier et al., 2004) and efficiently meeting customer's needs (Dewan et al., 2000; Thirumalai & Sinha, 2009). The ability of a website to tailor content for each user increases the possibility that users find what they want and further enhances their purchase intention.

Since flow experience is a positive mental state of a user, scholars argued that flow facilitates online behaviors such as shopping, browsing and purchasing (Hoffman & Novak, 1996a; Smith & Sivakumar., 2004). Flow experience is found to be positively related to user satisfaction and further to purchase intentions and intentions to revisit the website (Hausman & Siekpe, 2009). Thus, we believe that the perceived state of flow would increase the satisfaction and willingness of consumers to continually use the site and have the intentions of their purchase on the site.

3.2 Procedure

We chose real online retailing websites in the experiment. A pilot study was conducted to select proper experimental websites. We first chose 8 popular websites in Taiwan and China with 4 shopping websites and 4 gift websites. Their websites qualities were assessed by 20 recruited participants. Each participant was assigned four websites randomly and asked to use the websites and rate their experience with the website on 1-5 Likert scale for quality dimensions including convenience, content, aesthetic design, interactivity, customization, and the overall quality. The pilot study includes 80 samples and each website was assigned and used 10 times on average. According to the average score of the overall quality, the pilot study identified two high-quality and two low-quality websites for the formal experiment. The shopping websites with the highest and lowest quality are Paipai.com and ASAP.com; for the gift websites, the results are Citiesocial.com and liyi99.com. To make sure that the participants would not be affected by their website familiarity, the selected websites had not been (frequently) used by the participants.

Figure 2: The Experimental Setting

Participants were then recruited for the formal experiment. Each participant was asked to complete two experimental sessions. In the first session, the subjects were asked to provide their background information and get familiar with the experiment. In the second session, they were asked to wear an EEG device for measuring their brand waves (as shown in Figure 2). They were then asked to shop on two randomly assigned experimental websites. They had to fill out questionnaires after completing each shopping session. A five-minute break was given between two shopping sessions. Figure 3 shows the procedure.

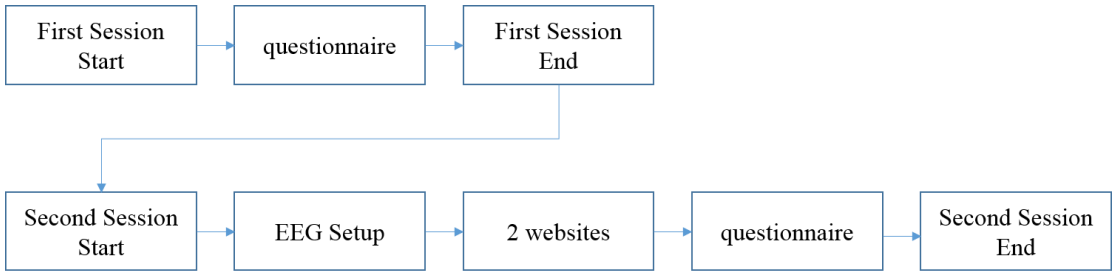

Figure 3: Experiment Procedure

3.3 Experimental Tasks

Four websites were chosen for the experiment after the pilot test. They are described below:

1. ASAP.com (Taiwan) - A comprehensive e-tailing website that emphasizes on quick delivery (24-hour arrival) (Figure 4a).
2. Paipai.com (China) - A website sponsored by Tencent - the second largest e-commerce platform in China, which provides safe and convenient online transaction service (Figure 4b).
3. Citiesocial.com (Taiwan) - A website selling daily necessities with special design, suitable for gift giving, featuring the spirit of "Discover through food and design" (Figure 4c).
4. liyi99.com (China) - A website that provides different types of gifts and gift design (Figure 4d).

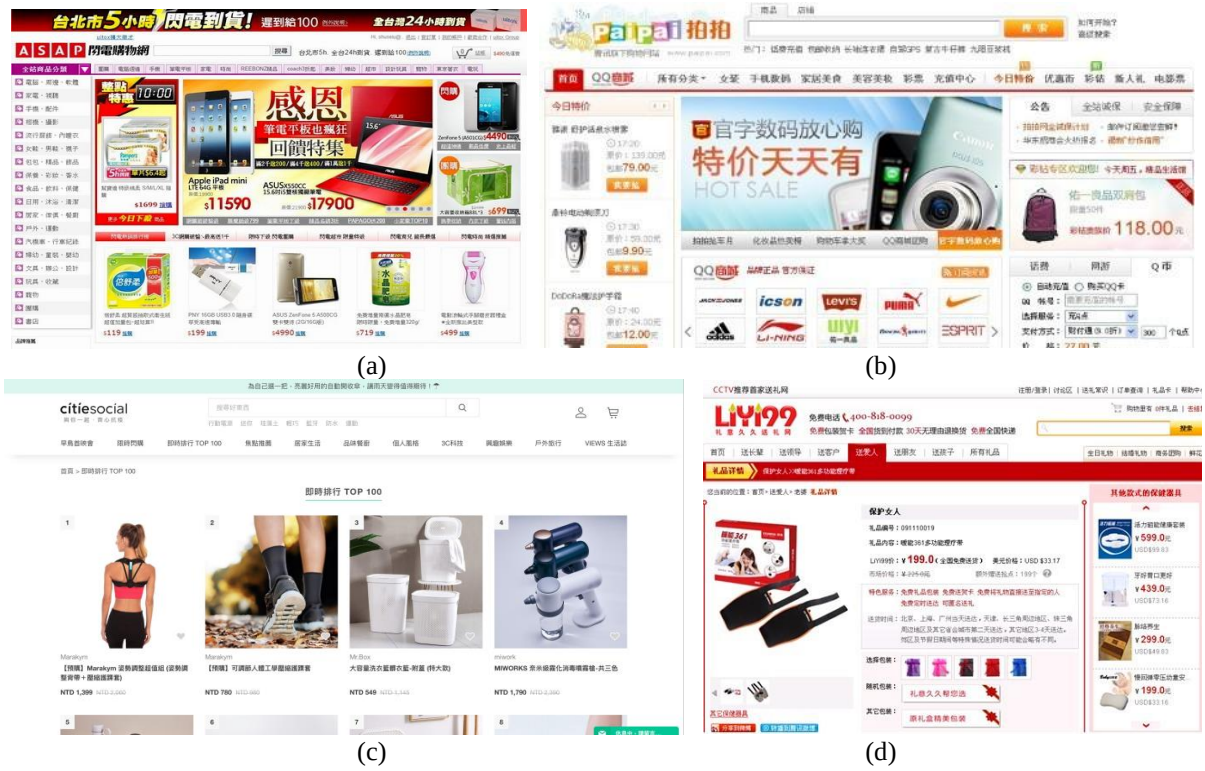

Figure 4: Interface of the Four Websites in the Formal Experiment

The participants were given a scenario in which they received a birthday allowance of NT$1000 to purchase gifts from a website. They were asked to visit a designated website and to choose an item and put in their shopping cart. They had the opportunity to receive their chosen products in a lottery pick.

3.4 Measures

Both self-reported and EEG measures were recorded during the experiment. Self-reported measures, covering aesthetics, content, convenience, customization, and interactivity, were collected by questionnaires. Measurement items of the five indicators were designed based on Chang and Chen's (2009), Ladhari's (2010), and Fan's (2013). Measurement items of flow were adapted from Fan (2013) and Gao and Bai (2014). User satisfaction measurements were from Chang and Chen (2009). Seven-point Likert-scale was used to measure user responses, ranging from "strongly disagree" (1) to "strongly agree" (7). The detail of the questionnaire surveys can be found in Appendix A.

To collect users' brainwaves, we adopted Mindset EEG headset developed by NeuroSky Inc. The neuro headset captures neural activity through three dry electrodes, one at the forehead for collecting brainwave data and the other two on the earlobe as the reference points. Traditionally, EEG devices contain multiple wet electrodes for EEG measurements, which are expensive and require conductive liquid to deploy the electrodes. Comparing to the traditional EEG devices, the NeuroSky Mindset EEG headset is relatively inexpensive and easy to apply with gel-free sensors. According to the patterns (Alexander et al., 2012; Jin et al., 2012; Luo et al., 2014; Nguyen et al., 2014), the dry sensor module of the NeuroSky Mindset headset comprises an instrumentation amplifier, a band-pass filter, a notch filter and an amplifier. It amplifies the raw brainwave signal to an output signal and eliminates Electromyogram (EMG) noise by the ThinkGear AM (TGAM) EEG sensor (NeuroSky, 2017). Benchmark tests conducted by Neurosky show that the signals of the dry EEG, the Neurosky system, and a well-known wet electrode EEG, the Biopac system, are very similar (NeuroSky Incorporation, 2009).

Several studies have examined the usability of NeuroSky EEG headset. Rebolledo-Mendez et al. (2009) utilized NeuroSky EEG headset to measure players' reading attention in the Second Life[1]. Their finding shows that there is a positive correlation between brainwave measurements from the EEG device and self-reported attention levels from the questionnaires. Crowley et al. (2010) conducted a Stroop Colour-Word Interference test and a Towers of Hanoi test to investigate the suitability of NeuroSky EEG headset for individual attention. Their study confirmed that NeurosSky EEG is indeed an appropriate instrument for measuring an individual's attention. Wang and Hsu (2014) explored individuals' cognitive attention allocating for the learning task by using Neurosky EEG device. The findings of their study also show that the perception of challenge-skill balance

[1] http://secondlife.com

influences learners' attention and confirmed that NeuroSky EEG headset could be used to examine the relationship between attention and flow experience. In addition, Perhakaran et al. (2015) investigated meditation effectiveness between virtual reality-based stress therapy and imaginary technique by utilizing NeuroSky EEG measurement and questionnaire approaches. According to their findings, the EEG result shows that VRT is more effectiveness for a stress therapy, which is similar to questionnaire results. Besides, NeuroSky EEG headset is again confirmed to be valid and reliable for evaluating meditation effectiveness in their experimental settings.

This study uses NeuroSky EEG headset to collect brainwave data for measuring attention and meditation levels during the decision process for examining the role of flow experience in website design and customer satisfaction. The brainwave data captured by NeuroSky EEG headset includes alpha and beta rhythm to measure the level of users' meditation and attention (Noachtar et al., 2004). We used the eSenseTM algorithm to process the captured brainwave data and convert the data into the relative meditation and attention levels between 1 to 100. The higher eSense value of alpha rhythm is, the more relaxed the subject is, whereas the higher eSense value of beta rhythm is, the more attentive the subject is (NeuroSky Incorporation, 2009). Figure 5 shows a sample eSense diagram and the corresponding eSense values and their attention and meditation levels are shown in Table 1. We assume that eSense value higher than 60 is a reflection of the flow experience, since the user is more attentive and relaxed in the flow situation (Ellis et al., 1994; Hoffman & Novak, 1996; Rong & Min, 2005). The brainwave result is also used to compare with the self-reported behavior data to examine the difference between different research methods.

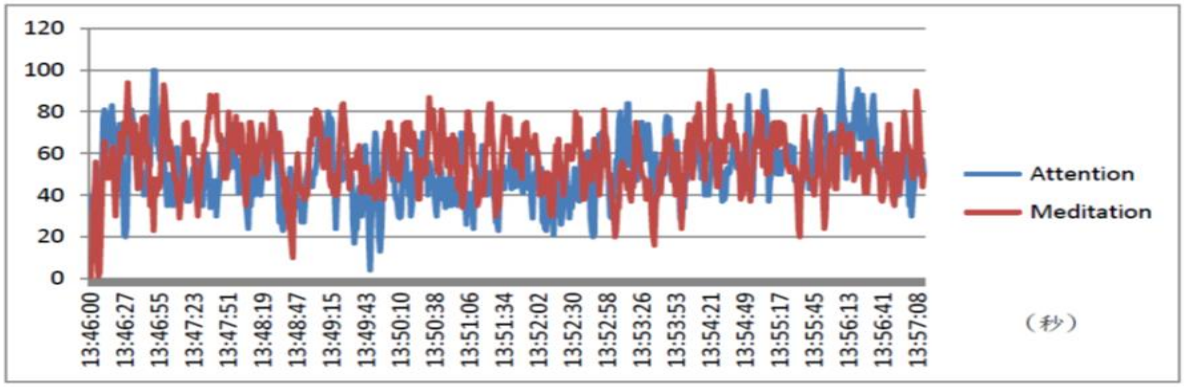

Figure 5: A Sample eSense Data Diagram over Time

Table 1: eSense Value Status

eSense Value	**Attention**	**Meditation**
80-100	highly attentive	highly relaxed
60-80	rather attentive	rather relaxed
40-60	medium attentive	medium relaxed
Below 40	distracted	nervous

3.5 Participants

We recruited 79 participants in Taiwan in the formal experiment. All of them had previous experience in online shopping but not the experimental websites. None of them had previous experience of wearing an EEG device. All collected data were reviewed for quality and 9 of them were removed due to invalid data. This results in 70 valid participant data for further analysis, including 34 males and 36 females, with ages ranging from 18 to 30. With regard to the educational levels, thirty-nine had undergraduate and thirty-one had master education. All participants had extensive Internet usage experience, 45.7% of them had 3 to 6 hours, 34.3% had more than 6 hours, and the rest had 1 to 3 hours of usage a day.

Table 2: The Demographic Data of Subjects

		Number of people	Percentage (%)
Gender			
	Male	34	48.5
	Female	36	51.5
Age			
	< = 25	65	92.8
	> 26	5	7.2
Educational level			
	Undergraduate	39	55.7
	Master education	31	44.3
Mental state			
	More tired than normal	17	24.3
	Normal	32	45.7
	More energetic than normal	21	30.0
Time spent on Internet per day (hour)			
	1-3	14	20.0
	3-6	32	45.7
	> 6	24	34.3
How often to purchase online			
	A week	6	8.6
	A month	29	41.4
	Three months	24	34.3
	Half a year	9	12.9
	A year	2	2.8

4. Data analysis and results

Self-reported data were checked for reliability and validity. SmartPLS, a partial least squares (PLS) software, was used for data analysis. Reliability was accessed using Cronbach's alpha and composite reliability. The results are presented in table 3. All Cronbach's alpha and composite reliability values were found to be higher than recommended threshold of 0.7 (Nunnally et al., 1978). Construct validity is established by calculating the average variance extracted (AVE) for each factor and confirming convergent validity when the shared variance accounted for 0.50 or more of the total variances. Discriminant validity presented in table 3 show that all AVE's meet the requirement. Hence, the survey data are good for testing hypotheses.

The resulting structural model by SmartPLS (resampling size =5000) with sign changed is shown in Table 4. Model 1 is the result from survey data, whereas Model 2 is from the EEG data. That is, the flow experience in Model 1 was substantiated with the survey data, while the flow experience in Model 2 was substantiated with the average of the measured attention and meditation levels in eSense. All other constructs in these two models are from questionnaire survey.

To test CMB, business researchers often apply post-hoc statistical techniques. Harman's one-factor test (also called Harman's single-factor test) is widely used to identify problematic CMB (Podsakoff & Organ, 1986). Researchers often applied this technique to load all of the variables into an exploratory factor analysis and examined the unrotated factor solution to determine the number of first factors that accounts for the variance among variables. If a single factor accounts for the majority of the covariance among the measures (e.g., >50%), it is concluded that a substantial amount of CMB is present. In this study, we compared EEG results with the result from the self-reported behavior data. Our results show that all survey factors (convenience, aesthetics, content, interactivity, customization, flow, and satisfaction) have common methods bias with 59.914% of variance explained by the first factor. In terms of EEG-based flow data, the result presents that first factor explained 49.797% of variance below standard threshold 50%. This indicates that EEG neuroscience method reduces common methods bias.

Table 3: Reliability and Validity of Self-report Constructs

Construct	AVE	Composite reliability	Cronbach's alpha
Aesthetics	0.885	0.958	0.935
Content	0.875	0.955	0.928
Convenience	0.742	0.895	0.822
Customization	0.789	0.918	0.866
Interactivity	0.755	0.902	0.839
Flow	0.688	0.868	0.772
Satisfaction	0.860	0.948	0.918

Table 4: Discriminant Validity Results of Self-report Constructs

	Aesthetics	Content	Convenience	Customization	Interactivity	Flow	Satisfaction
Aesthetics	0.941						
Content	0.631	0.936					
Convenience	0.547	0.689	0.861				
Customization	0.621	0.626	0.448	0.888			
Interactivity	0.693	0.736	0.652	0.695	0.830		
Flow	0.676	0.760	0.704	0.683	0.765	0.869	
Satisfaction	0.614	0.807	0.562	0.652	0.749	0.690	0.927

While self-reports remain the prominent research method to investigate empirical estimates of relationships among variables, shared variance associated with the use of self-reports (e.g., respondent's consistency motifs, transient mood states, illusory correlations, item similarity, and social desirability) might contaminate the estimates (Podsakoff & Organ, 1986). Over the years, researchers have investigated various issues of method variance. Burke, Brief, and George (1993) adopted a partial correlation approach to investigate method effects. Williams et al., (2002) and Podsakoff et al. (Podsakoff et al., 2003) examined confirmatory factor analysis (CFA) approaches to a variety of method variance problems. Lindell and Whitney (2001) introduced a correlational marker technique for controlling method variance using a marker variable (unrelated to other items in the survey) of the same scale type. Williams et al., (2010) proposed a comprehensive CFA marker technique analysis to overcome the limitations of partial correlations. To this extend, this study also adopted the marker variable technique (Chin et al., 2012; Rönkkö & Ylitalo, 2011) to estimate common method bias and found that the marker variable had no significant effect on the endogenous variables. First, we identified three marker items (age, sex, Internet usage daily) in our empirical data set, which are not included in the research model and do not have any explicit theoretical influence on the items of the constructs in our research model. Additionally, these marker items showed only low correlations to the study items. We then included the marker items as additional latent variable into our model and analyzed its impact on all endogenous variables like the approach proposed by Rönkkö & Ylitalo (Rönkkö & Ylitalo, 2011). The path coefficients from convenience to flow has change from significant to none significant difference in the model 1 (survey only) and model 3 (survey + marker variable). The test results indicate that a common method bias is a serious problem in the survey study. However, when considering EEG results with survey, the marker variable had no significant effect on the endogenous variables in the model 4 (survey + EEG + marker variable). The path coefficients among the constructs were not significantly differ between the model 2 (survey + EEG) and model 4. The test results (shown in Table 5) indicate that a common method bias is not an important issue when considering EEG results into analysis.

5. Discussion and Conclusion

This study examined the effect of flow in website design from the perspective of CMB. An experiment was designed and conducted. Both a questionnaire survey and a neuroscientific method (EEG) were used to collect data from participants. Several major findings have been observed for discussion.

First, results from both methods indicate that websites with better quality can create a higher level of the flow experience, which in turn has positive effects on user satisfaction. These findings are consistent with the argument of the flow theory and findings from previous studies. For example, Carlson and O'Cass (2011) studied e-commerce website and found website quality is a critical factor to affect flow experience. Hsu et.al (2012) investigated the impact of website quality on customer satisfaction and found good website quality could increase users' satisfaction through users' flow experience. When people get into a flow state, they concentrate on ongoing activities and get positive experience (Csikszentmihalyi, 2000). Meanwhile, the flow experience induces inside happiness and positive effect to increase customer satisfaction (Ellis et al., 1994; Hausman & Siekpe, 2009).

As our survey results indicate that all five design factors, including aesthetics, content, convenience, interactivity, and customization, had significant impact on the flow experience, designing a high-quality website should take all of them into consideration. When users experience higher flow in the browsing process, they have better feelings and are more likely to have higher satisfaction levels (Ellis et al., 1994; Hausman & Siekpe, 2009). However, the effect of aesthetic and interactivity were found negatively correlated to the flow experience from our EEG experiment, which is contradictory to the survey result. This contradictory finding triggers an interesting issue in using multiple methods.

Table 5: Results of the Marker Variable Technique

	Model 1 (Survey)		Model 2 (Survey + EEG)	
Path	**Coefficient**	**t-statistic**	**Coefficient**	**t-statistic**
Aesthetics -> Flow	0.191	2.323*	-0.275	2.602△△
Content -> Flow	0.199	2.420*	0.378	2.907**
Convenience -> Flow	**0.153**	**1.998***	**0.360**	**3.215****
Customization -> Flow	0.235	2.832**	0.353	4.263***
Interactivity->Flow	0.215	2.461*	-0.427	3.14△△
Flow->Satisfaction	0.749	17.600***	0.372	6.297**
Marked variable-> Flow				
Marked variable->Satisfaction				

	Model 3 (Survey + marker variable)		Model 4 (Survey + EEG + marker variable)	
Path	**Coefficient**	**t-statistic**	**Coefficient**	**t-statistic**
Aesthetics -> Flow	0.188	2.248*	-0.275	2.545△△
Content -> Flow	0.209	2.452*	0.378	2.896**
Convenience -> Flow	**0.138**	**1.836**	**0.360**	**3.114****
Customization -> Flow	0.238	2.951**	0.353	4.215***
Interactivity->Flow	0.218	2.533*	-0.427	3.089△△
Flow->Satisfaction	0.775	17.992***	0.371	5.842**
Marked variable-> Flow	0.116	2.143*	0.001	0.017
Marked variable->Satisfaction	-0.221	2.623*	-0.058	0.813

Aesthetic design of a website has a negatively influence on the flow experience as measured by EEG. A possible reason is that when a user concentrates on finding the specific products, the user may prefer a simpler design than an artistic one. The focus on aesthetic features may increase the complexity and deviate the attention in the browsing process. In addition, several studies (Angeli & Kyriakoullis, 2006; Fan et al., 2013; Reinecke & Bernstein, 2011) posit that aesthetic design with cultural preferences could affect users' trust level and further influence their flow experience. The negative effect of aesthetic design on the flow experience might be caused by the selection of experimental websites from working on the Chinese websites. Our participants are mainly Taiwanese who might not be familiar or feel comfortable to use the Chinese websites. This, however, cannot be found from our behavior study.

The effect of website interactivity on the flow experience as measured by attention and meditation also is negatively. Although the significance level is marginal, it does shed much light onto the effect of research methods on the findings. This may be because the interactive process in the experimental website deviated the subject's attention or meditation. The interactive design of the website might cause information overload and distraction from the actual content (Kurelovic et al., 2016). Customers with distraction and information overload may have negative feeling and hence decrease the flow experience.

It's known that behavioral data collected from a single subject using questionnaires is subject to the common source bias. Hence, the difference between a questionnaire survey and EEG may also come from the potential common method bias associated with the questionnaire survey. Previous survey research on flow experience and user satisfaction may have overlooked the potential common method bias issue in analyzing their data. We tested the common method bias of our survey data. Based on a suggestion by Podsakoffand Organ (1986), we conducted a principal component factor analysis and used the Harman's one-factor test to check whether threats from common method bias may exist. Our results show that the combined three factors accounted for 73.341% of total variance and the first (largest) factor accounted for 59.914%. This indicates that the questionnaire survey is threatened by the common method bias. Findings from the EEG study directly collects psychophysiological data that does not have the common method bias problem. Hence, the findings from our EEG study indicate that certain previous findings from survey studies may be questionable and using multiple methods to collect data may be better for empirical studies in the future.

6. Academic and Practical Implications

Various academic and practical implications for website design may be derived from our findings. For academic researchers, Dimoka et al. (2007) proposed how IS researchers can use functional neuroimaging tools to inform IS phenomena and have seven opportunities to IS research: (1) Localize the neural correlates of IS constructs to better understand their nature and dimensionality; (2) Complement existing sources of IS data with objective brain data that are not subject to measurement biases; (3) Capture hidden (automatic) processes that are difficult to measure with existing measurement methods; (4) Identify antecedents of IS constructs by showing how IT stimuli (e.g., designs, systems) spawn brain activation; (5) Test the outcomes of IS constructs by showing how brain activation predicts decisions, choices, and behavior; (6) Infer causality among IS constructs by examining the timing of brain activations due to a common stimulus; (7) Challenge existing IS assumptions and enhance IS theories that do not correspond to the brain's functionality.

Drawing upon these seven proposed prospects (Dimoka et al., 2007), our research has academic contributions and implications for IS research: (1) Identifying attention and meditation as indicators for measuring consumer reactions in online shopping research; (2) Supplement existing sources of flow data with objective brain data that are not subject to human response biases; (3) Get brain activities (hidden processes) that are difficult to measure with EEG; (4) Find antecedents of flow construct by showing how IT stimuli (e.g., convenience, contents, aesthetics, interactivity and customization of website quality) generate brain initiation; (5) Test the outcomes of IS constructs by showing how flow (brain activation) predicts or explains user satisfaction. (6) Conclude causality of flow theory among IS constructs by examining brain activations; (7) Argue existing IS assumptions and enhance flow theory. Our contradictory findings indicate that results from questionnaire surveys may be questionable without cross-verification by other methods. The psychophysiological method (EEG) may be able to provide more objective measurements to strengthen findings from self-reported data. Moreover, most researchers agree that common method bias is a potential problem in behavioral research. In this study, the R-square value of the survey model is much higher than that of the EEG model. This may be an indication of the common method bias. In this case, EEG may be a good supplementary method to cross-check the findings.

In practice, our findings mostly support the argument that a high-quality website is capable of attracting customer attention and increasing user satisfaction. Web designers must pay special attention to content, customization, and convenient access to website functions. Providing proper level of interactivity may be a good strategy. The degree of active control of a website pertains to the amount of flexibility and complexity. Online shopping websites that have easier way to navigate and provide convenient retrieval and search of product information would make consumers feel more flexibility and controllability. Online shoppers with good flow experience are more likely to be satisfied with the website, which often results in higher customer loyalty.

7. Limitations and Future Research

Although we have used both questionnaire survey and psychophysiological method (EEG) to measure flow experience and have different results, our findings are subject to three main limitations. First, our EEG device is a simplified one that measures only one point in the frontal cortex. This was primarily due to cost and convenience considerations. Future studies may consider using more complex 16 or 32-channel EEG to see whether the flow experience may be measured more accurately. Second, our study uses EEG to measure the attention and meditation in the flow experience, there may be other mental variables that need to be measured and used to indicate the flow level of the subject. Besides, currently we only adopt the commonly used mean value for measuring results, which is relatively simplified but still provide valuable findings for our future work. Third, although we used real shopping websites in our experiment, data were collected in experimental settings. Subjects in the experiment may behave differently from the real shopping websites. Certain factors effective in the real-world shopping may not be considered in the study. Finally, in addition to EEG, there are many other instruments in Neuroscience (such as eye trackers or fMRI) that can be used to measure user behavior objectively, which can be used in future studies to enrich our knowledge of online shopping.

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Appendix A

Construct	Measurement items	Adapted from
Convenience	Conv1. I could shop by myself without any help from this website when I first this website. Conv2. This website is a user-friendly platform. Conv3. This website is easy to use.	Chang & Chen (2009); Ladhari (2010)
Content	Cont1. This website provides useful information. Cont2. This website provides valuable content. Cont3. This website provides compelling information.	Chang & Chen (2009); Ladhari (2010)
Aesthetic	Ae1. This website is designed attractively. Ae2. I enjoyed shopping with this website. Ae3. I felt comfortable to use this website.	Chang & Chen (2009); Ladhari (2010)
Interactivity	In1. I could find the desired product through the search engine provided by this website. In2. This website provides an easy way to compare products. In3. While interacting with this website, I was attracted by this website.	Chang & Chen (2009); Ladhari (2010)
Customization	Cus1. The recommendation provided by this website fulfils my need. Cus2. The commercial or promotion sent by this website is customized for me. Cus3. This website made me feel that I am the unique customer of this website.	Chang & Chen (2009) ; Ladhari (2010)
Flow experience	F1. Overall, I enjoyed this website. F2. When I visited this website, I didn't notice time passing. F3. When I visited this website, I could control this website easily.	Fan (2013); Gao and Bai (2014)
User satisfaction	S1. I am satisfied with the purchase on this website. S2. It is a smart choice to make a purchase at this website. S3. I believe it is a right choice to buy what I need from this website.	Chang & Chen (2009)