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Antecedents of flow in online shopping: a test of alternative models

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Abstract. *Flow is an optimal state of experience that has been studied in various situations, including online environments. In such environments, it has been found to be positively related to exploratory behaviour, revisit and purchase intention, and positive attitude towards web sites. Based on flow theory, this study tests the complete structure of the flow model as it was originally formulated in an online shopping context. The role of the preconditions of flow is elaborated and the effect of web site complexity, an important interface design variable, on flow is examined. Results show that web site complexity affects flow through the mediating effects of the three preconditions of flow. Theoretical and practical implications of this finding are discussed.*

Keywords: flow, web site complexity, e-commerce, web site design

INTRODUCTION

A number of researchers in information systems (IS) have studied flow in various situations, including human–computer interaction (HCI) and web use (Agarwal & Karahanna, 2000; Huang, 2003). Flow, as an optimal state of experience, has been found to be positively related to exploratory behaviour, revisit and purchase intentions, and attitude towards web sites (Novak *et al.*, 2000; Koufaris, 2002; Skadberg & Kimmel, 2004). Thus, it is of interest to study the flow experience and factors that induce flow in online environments. However, most studies focusing on flow during interaction with information technologies have used incomplete models of flow (Nel *et al.*, 1999; Jiang & Benbasat, 2005). More importantly, these studies have rarely included all three theoretical preconditions of flow, namely perceived balance of challenge and skill, a clear goal, and fast, unambiguous feedback. The purpose of this study is to investigate the flow model as it was originally formulated including the three preconditions of flow.

Web site complexity is one of the important interface design variables that influence a number of user outcomes. It has been proposed and examined as an antecedent of flow (Huang, 2003). We study its effect in relation to the mediating effects of the preconditions in online shopping. The premise of the study is that the effects of web site complexity on flow will be mediated by the preconditions of flow. Complexity operates to affect flow through its impacts on balance of challenge and skill, goal clarity and feedback. If this model is supported, it will clarify the generative mechanism underlying the effects that web sites characteristics, such as complexity, have on flow.

Flow is a holistic experience that represents a source of intrinsic motivation in human behaviour (Csikszentmihalyi, 1988). In HCI research, studies focusing on the holistic aspect of HCI have been called for (Zhang & Li, 2005). We believe that this study will contribute theoretically to both flow research in particular and HCI research at large, and provide practical insights on web site design as well.

FLOW THEORY

In his research on enjoyment, Csikszentmihalyi developed the concept of flow. Flow 'is the crucial component of enjoyment' (Csikszentmihalyi, 1975, p. 11). Flow represents a 'peculiar dynamic state – the holistic sensation that people feel when they act with total involvement' (p. 36) and an 'ordered, negentropic state of consciousness' (Csikszentmihalyi, 1988, p. 34). In this state, actions transit seamlessly into another, displaying an inner logic of their own. The term 'negentropic' refers to being in harmony and a lack of chaos. The actor experiences a smooth transition and total control of his or her actions without distraction.

In order for flow to occur, the task should have *a clear goal* (GC) and *a fast, unambiguous feedback mechanism* (FB). A clear goal enables actors to focus on the essentials of an activity, and a fast and clear feedback mechanism shows the actor his or her progress in achieving the goal. That is why people often experience flow when playing games such as chess or basketball. These games have clear goals and there are rules one can use to tell how he or she is doing. The model of flow also assumes that the *perceived balance of challenge and skill* (CS) leads to flow. If challenges exceed skill levels, people feel overwhelmed and anxious; on the other hand, if the activity is too easy, people get bored. Studies suggested that both challenge and skill had to pass a certain threshold for flow to occur; otherwise, the person showed apathy towards the activity, even when challenge and skill were in balance (Csikszentmihalyi & Csikszentmihalyi, 1988).

The dimensions of the flow experience as described by Csikszentmihalyi (1988) include: (1) focused *concentration* (C) on task at hand (also referred to as attention and immersion); (2) 'merging of activity and awareness (M)' (*mergence*); (3) a sense of being in *control* (CON); (4) *transformation of time* (TT) that makes time appear to pass very slowly or very rapidly compared to ordinary experience (it is also called time distortion and time dissociation); (5) a loss of self-consciousness and feeling of *transcendence of self* (TS); and (6) an *autotelic experience* (AE), which is intrinsically rewarding; this experience has been simply referred to as enjoyment in some research. Definitions of the dimensions are listed in Table 1. Thus, the original flow model as theorized by Csikszentmihalyi (1988) includes three preconditions and six dimensions of flow. Supposedly, other situational factors affect flow experience via the three preconditions.

Table 1. Dimensions of flow

Dimensions	Definition
Concentration (C)	'A centering of attention on a limited stimulus field' (Csikszentmihalyi, 1975, p. 40) 'Concentration on the task at hand' (Csikszentmihalyi, 1990, p. 58)
Perceived control (CON)	'There is the sense that the outcomes of the activity are, in principle, under the person's own control.' (Csikszentmihalyi, 1988, p. 33) 'Lacking the sense of worry about losing control' (Csikszentmihalyi, 1990, p. 59) 'The sense of exercising control in difficulty situations' (Csikszentmihalyi, 1990, p. 61)
Mergence of action and awareness (M)	'People become so involved in what they are doing that the activity becomes spontaneous, almost automatic; they stop being aware of themselves as separate from the actions they are performing.' (Csikszentmihalyi, 1990, p. 53)
Transformation of time (TT)	'Distorted sense of time' (Csikszentmihalyi, 1988, p. 33) 'Time no longer seems to pass the way it ordinarily does.' (Csikszentmihalyi, 1990, p. 66)
Transcendence of self (TS)	'Lose temporarily the awareness of self' (Csikszentmihalyi, 1988, p. 33) 'There is not enough attention left over to allow a person to consider either the past or the future, or any other temporarily irrelevant stimuli.' (Csikszentmihalyi, 1990, p. 61) 'The loss of the sense of a self separate from the world around it is sometimes accompanied by a feeling of union with the environment.' (Csikszentmihalyi, 1990, p. 63)
Autotelic experience (AE)	'The key element of an optimal experience is that it is an end in itself.' (Csikszentmihalyi, 1990, p. 67)

FLOW RESEARCH IN IS

In IS research, flow has been integrated into studies of computer-mediated communication (Trevino & Webster, 1992) and HCI (Ghani & Deshpande, 1994; Webster *et al.*, 1993). Flow theory has also been applied in studies of a variety of internet activities (Hoffman & Novak, 1996; Chen *et al.*, 1999; Koufaris, 2002). In more than 50 empirical studies, flow or variables similar to it have been found to be related to desirable e-commerce outcomes, such as positive affect (Chen, 2006), positive perceptions of and attitudes towards web sites (Agarwal & Karahanna, 2000; Huang, 2003), exploratory behaviour with increased learning (Skadberg & Kimmel, 2004), and future intentions to revisit and purchase (Koufaris, 2002; Siekpe, 2005; Wu & Chang, 2005). Therefore, investigating what factors facilitate flow experience in online shopping and other activities is of both theoretical importance and practical relevance.

Several qualitative studies of flow in computer-mediated environments provide evidence that the effects of three preconditions of flow – CS, GC and FB – are relevant to the IS context (Rettie, 2001; Pace, 2004; Pilke, 2004; Shoham, 2004; Kiili, 2005). In these studies, flow experience is characterized as a highly focused state, during which the individuals seem to automatically react to a web site and enjoy full control of navigation. They do not realize the passage of time, and sometimes forget about other concerns. The experience leaves them feeling refreshed and awake. These studies suggest that all dimensions in the original flow model are present to some degrees when people experience flow in online environments.

However, the majority of quantitative, model-testing studies of flow in IS have used incomplete flow models. Most studies have included only a partial set of the flow preconditions and dimensions. A set of selected flow studies is summarized in Table 2. As Table 2 shows, one or more of the preconditions of flow have been omitted from most studies. Feedback has been included in six studies (Webster & Ho, 1997; Chan & Ahern, 1999; Chan & Repman, 1999; Davis & Wiedenbeck, 2001; van Schaik & Ling, 2003; Chen, 2006), and the same is true for GC (Chen *et al.*, 1998; Chan & Ahern, 1999; Chan & Repman, 1999; Davis & Wiedenbeck, 2001; van Schaik & Ling, 2003; Chen, 2006). More studies have examined the effects of challenge and skill on flow. However, in several studies, these were treated as separate constructs (Ghani *et al.*, 1991; Novak *et al.*, 2000; Koufaris, 2002; Skadberg & Kimmel, 2004), rather than the 'CS' presented in flow theory. Table 2 also shows that most studies do not include all dimensions of flow. The dimensions of C, CON, TT and AE are frequently studied, while M and TS figure in only a handful studies (Davis & Wiedenbeck, 2001; Moon & Kim, 2001; van Schaik & Ling, 2003; Chen, 2006). Only four studies incorporate all dimensions and preconditions of flow (Chan & Ahern, 1999; Chan & Repman, 1999; Chen & Nilan, 1999; Chen, 2006). However, in these studies, dimensions and preconditions of flow were not differentiated as in the original flow theory. Thus, there is a discrepancy between these models and the original flow model, which incorporates all preconditions and dimensions. This result of different operationalizations of flow and inconsistent flow models in IS field, as Finneran and Zhang (2005) observed, is difficulty in generalizing and difficulty in pinning down the mechanisms by which flow is influenced by IS. Although studies of partial flow models have yielded informative results, a study using the original flow model is necessary to fill the gap.

According to flow theory, other situational factors should affect flow via their effects on the preconditions. Several studies have investigated the effects of web site features, such as interactivity, download speed, attractiveness, design features and quality, and complexity on flow-related constructs (Novak *et al.*, 2000; Huang, 2003; Skadberg & Kimmel, 2004). These studies, however, treat these factors as direct effects on flow, omitting the mediating preconditions. The current study focuses on complexity, a general feature of visually-based media such as web sites and, as such, a fundamental design parameter. We posit that complexity is a determinant of flow in online environments and our assumption is that complexity influences flow through its influence on the mediating constructs: CS, GC and FB.

WEB SITE COMPLEXITY

Complexity has been defined in terms of the information load that users perceive (Huang, 2003). Another conceptualization of web site complexity is as the degree of difficulty that the users feel when they try to understand, process and interact with the form and content of the web site in the performance of online tasks (Nadkarni & Gupta, 2007). This definition advances a broad and holistic conceptualization of perceived site complexity that captures not only the structural complexity, but also objective and subjective views. A measure of perceived complexity has been developed, and it was posited that perceived complexity was influenced by

Table 2. Summary of selected research on flow

Authors	Dimensions	Antecedents	Methodology
Ghani *et al.* (1991)	Concentration; control; autotelic experience	Challenge; skill	Experiment on face-to-face vs. computer-mediated groups
Hoffman & Novak (1996)	Mergence; temporal displacement; loss of self-consciousness; telepresence; gratifying state	Balance of skill and challenge; interactivity; focused attention	Conceptualization
Webster & Ho (1997)	Focused attention/engagement	Challenge feedback	Multiple experiments in teaching using authorware vs. powerpoint presentations
Chen *et al.* (1998)	Enjoyment; attention; temporal displacement	Calculated balance of challenge and skill; clear goal	Experience sampling during web browsing
Chan & Ahern (1999)	Concentration; control; mergence; transcendence of self; transformation of time; autotelic experience	Balance of challenge and skill; goal clarity; feedback	Experiment on instruction mode: hypermedia vs. traditional
Chan & Repman (1999)	Concentration; control; mergence; transcendence of self; transformation of time; autotelic experience	Balance of challenge and skill; goal clarity; feedback	Field experiment of four types of web-based instruction activities
Chen & Nilan (1999)	Concentration; control; mergence; transcendence of self; transformation of time; autotelic experience	Balance of challenge and skill; goal clarity; feedback	Experience sampling during web browsing
Nel *et al.* (1999)	Control; attention focus; curiosity; intrinsic interest	Web site type (content, audience focus)	Experiment comparing four types of web sites
Agarwal & Karahanna (2000)	Temporal dissociation; focused immersion; heightened enjoyment; control; curiosity	Personal innovativeness; playfulness	Survey of web browsing experience
Novak *et al.* (2000)	One-dimensional	Telepresence; time distortion; challenge/arousal; skill/control; interactivity	Survey of online shopping experience
Davis & Wiedenbeck (2001)	Concentration; control; mergence; transcendence of self; transformation of time	Goal clarity; feedback	Experiment comparing training software: menu vs. command line
Moon & Kim (2001)	One-dimension factor with items regarding concentration, transformation of time and autotelic experience	No antecedents	Survey of web usage

Table 2. cont.

Authors	Dimensions	Antecedents	Methodology
Koufaris (2002)	Shopping enjoyment	Product involvement; web skill; challenge; value-added search	Questionnaire right after shopping on a specific web site
	Concentration	Product involvement; web skill; challenge	
Novak *et al.* (2003)	Flow; flow verbatim	Goal directed vs. experiential activities; skill; challenge novelty; importance	Survey of online shopping experience
Huang (2003)	Attention; control; curiosity; interest	Complexity; novelty; interactivity	Survey of web browsing experience
Finneran & Zhang (2003)	Flow	People: trait and states task; artifact	Conceptualization
van Schaik & Ling (2003)	Concentration; control; mergence; transcendence of self; transformation of time	Goal clarity; feedback	Experiments on web survey design in terms of response format and orientation support
Skadberg and Kimmel (2004)	Enjoyment; lost track of time; telepresence	Interactivity; attractiveness; proposed but dropped: domain knowledge/skill; information in the web site/challenge	Questionnaire right after browsing a web site
Li & Browne (2004)	Focused attention; enjoyment; control; curiosity; temporal dissociation	Need for cognition	Survey of web usage
Hsu & Lu (2004)	One-dimensional	Perceived ease of use	Survey
Siekpe (2005)	Challenges; concentration; curiosity; control	No antecedents	Survey of online shopping experience
Jiang and Benbasat (2005)	Control; attention focus; cognitive enjoyment	Visual control; functional control	Experiment of visual control of commercial sites
Chen (2006)	Concentration; control; mergence; transcendence of self; transformation of time; autotelic experience	Balance of challenge and skill goal clarity; feedback	Experience sampling during web browsing

objective aspects of site design and reflects the cognitive aspects of individuals (Nadkarni & Gupta, 2007). However, the relationship between perceived and objective complexity is complex. Measurement of complexity using objective indices is usually conducted on the basis of a systematic sample of representative pages and procedures for navigating the web site in order to ensure consistency of classification across sites. But this is at odds with the more spontaneous and idiosyncratic behaviour that users typically display during browsing. As a result, the level of complexity perceived by users may differ considerably from objective scores on complexity. Moreover, different users may apprehend the same site as having different levels of complexity, depending on their specific browsing trajectory through the site. Our conjecture is that, experienced complexity affects the flow experience. Hence, perceived complexity, which taps the users' experience of the site, is the appropriate construct for the present model.

The structure of the web site is not the only factor influencing perceptions of complexity. For example, during shopping, the nature of the product also contributes to perceived complexity, specifically via the complexity of the product per se and the shoppers' prior knowledge concerning the product. These factors are reflected in perceived complexity, challenge and skill to some degrees. Thus, characteristics of product and site content and the subject's prior knowledge are peripheral to this study, which is concerned with web site design impacts on flow.

THE RESEARCH MODEL (RM) AND ALTERNATIVES

Several web site features have been studied in relation to flow. However, none of these studies utilized the original flow theory when examining exogenous effects on flow. The original flow model would posit that the impact of IS features on flow would be mediated by the three preconditions of flow (CS, GC and FB). In this study, we will examine the original flow model with web site complexity as an exogenous factor.

In the model, flow was conceptualized as a global, second-order factor with six first-order factors, corresponding to the dimensions of flow in the original model: C, CON, M, TT, TS and AE. This conceptualization of flow as a reflective construct is supported by previous studies (Jackson & Marsh, 1996; Siekpe, 2005). According to taxonomies of multi-dimensional constructs, three possible types of models exist based on the relationships between the overall construct and its dimensions: profile, reflective and formative (Law *et al.*, 1998; Edwards, 2001). As articulated by Csikszentmihalyi (1988), flow is a reflective construct with the dimensions of flow serving as indicators. Flow exists at a different level from its dimensions, and thus is not a profile construct. Moreover, the flow model indicates that the precursors of flow are CS, FB and GC; the dimensions of flow are clearly indicators, not constituents of the holistic flow experience. The dimensions of flow are intercorrelated, which reflects the effect of an underlying higher-order construct.

The core flow model specifies three direct preconditions of the flow experience: CS, GC, and FB. We posit that exogenous factors impact flow in online environments through the mediating

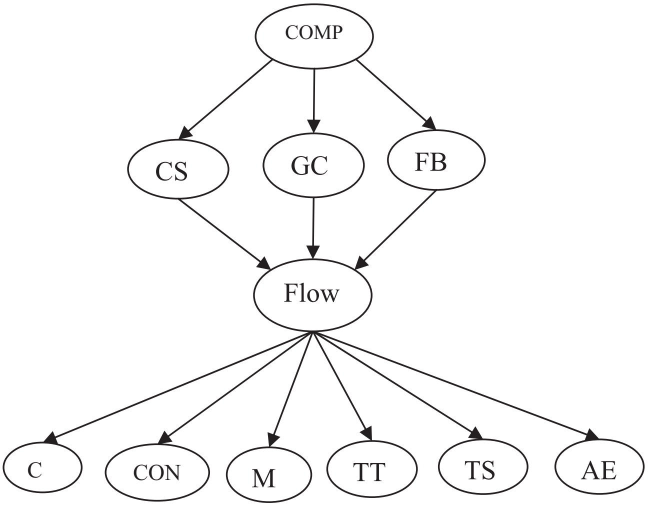

Figure 1. The research model (RM).

effects of CS, GC and FB. In this study, the exogenous factor is *perceived web site complexity* (COMP) (Figure 1). Complexity is expected to have negative effects on CS, GC and FB. Complex web sites with large sizes, unfamiliar content and terminology, and unpredictable links and structures cause users to become lost (Otter & Johnson, 2000). Agarwal & Venkatesh (2002) linked usability with clear goals and feedback, suggesting that with a less usable web site, users are more likely to feel lost or disorientated. Excessive complexity also makes processing information harder. The greater the complexity of a web site, the more difficult it is for the user to figure out a way in which to accomplish his or her objectives. At high levels of complexity, the user is likely to feel challenged and overwhelmed, which is likely to decrease his or her estimation of skill in using the site. Complexity also interferes with goal attainment and inhibits formation of clear goals. Finally, the more complex the site, the more difficult it may be for the user to discern feedback and to see the results of responding to feedback. Feeling that his or her skill is not up to the challenge, lacking clear goals and not being able to process or act immediately on feedback is likely to impede the development of flow or disrupt the flow experience.

In addition to the main RM, we also wanted to look into three alternative models in light of previous research. The first alternative model (AM1) dealt with the possibility of a direct effect of COMP on flow, which has been documented in one previous study (Huang, 2003). In that study, the effect of site COMP on flow was explained as it distracted users' attention, thus impeding flow. Thus, AM1 was a step further from RM in that we modelled both direct and indirect effects of COMP on flow.

Although CS has rarely been included in previous studies of flow in IS, the two separate components, i.e. perceived challenge (PC) and perceived skill (PS), have been studied (Novak *et al.*, 2000; Koufaris, 2002; Skadberg & Kimmel, 2004). The potential issues of measurement with compound constructs, like CS, are obvious. Using separate constructs reduces the difficulty to some extent and provides the opportunity to study them individually and the dynamics between them. On the other hand, this approach moves away from the theoretical formulation of flow and misses the point of the 'balancing' effect, which is crucial in flow theory. It is useful to compare these two approaches and to explore the relative impacts of PC and PS on flow in IS contexts, because it is possible that one of the two constructs outweighs the other as a mediator of IS impacts. Thus, we substituted PS and PC for CS in RM1 and AM1, resulting in two more alternative models (AM2 and AM3). A confirmatory approach was taken in data analysis regarding these four models.

METHODOLOGY

Real web sites have been used effectively in other research (Koufaris, 2002; Skadberg & Kimmel, 2004). Although the use of existing commercial sites imposes some limitations in terms of design styles and control over manipulation, it provides the compensating advantage of realism. Thus, we decided to use existing web sites in this study. In selecting web sites, we followed a procedure similar to those in previous studies by Nadkarni and Gupta (Nadkarni & Gupta, 2007). The final set of web sites used in the study were systematically sampled from a range of web sites in order to ensure variation in COMP and to control for particularities in web site implementation and for subject familiarity with web sites. Raters evaluated over 30 popular web sites in five categories based on a dozen of criteria, such as average page length, product information comprehensiveness, average depth of site structure, and number of shopping aids. Based on the ratings and online effectiveness scores from Bizrate.com, cluster analysis was conducted to separate more complex sites with less complex ones. Eventually, eight web sites within two product categories: (1) books and magazines and (2) computers, at two different levels of COMP were chosen for this study. Web sites used in the study were amazon.com, booksamillion.com, jr.com (J&R Music and Computer World), newegg.com, barnesandnoble.com (Barnes & Noble), buy.com, gateway.com and pcconnection.com. The first four were more complex than the rest, according to the ratings. Details on the procedure for selecting the sites can be found in Guo (2004). We believe that including various web sites help induce different levels of COMP.

Subjects from a variety of majors were recruited from a major American university. A package of documents and instructions was given to subjects when they arrived for the study. Upon agreeing to participate in the study, subjects were randomly assigned to one of the eight pre-selected web sites and were asked to act like a real shopper to find something they were interested in purchasing on that site. Task description is in Appendix 1. Data were collected while subjects were surfing the site. The questionnaire was presented to the subjects by a series of pop-up screens 6 to 8 minutes after the subjects started browsing. The questionnaire was implemented using Visual Basic forms. The time of administration of the questionnaire was set based on previous research (Chen *et al.*, 1998) and our pilot studies that had shown that this amount of shopping was sufficient to induce flow. The exact time of administration was varied within the 2-minute period and the subjects were told so, so that subjects would not be distracted by trying to anticipate when the questionnaire would be administered. The subjects were instructed to answer the questionnaire right away.

Three flow preconditions and six dimensions were measured using items adapted from the Flow State Scale (Jackson & Marsh, 1996) and other previous flow research in IS (Agarwal & Karahanna, 2000). Items for PC and PS were adapted based on items from previous research (Koufaris, 2002) and the consideration of the multi-faceted nature of these two factors (Ellis *et al.*, 1994). The measure of COMP was adapted from Nadkarni and Gupta (2007). All these measures had exhibited high reliability in previous studies. All the questions were in a 7-point Likert scale format with 1 as 'strongly disagree' and 7 as 'strongly agree'.

RESULTS

A total of 354 subjects participated in the study, including 211 female and 143 male students. Among over 50 items on the questionnaire, no differences in responses, because of gender, were found, except for a single item for the PS dimension and one item for M. The average age of the subjects was 21.2 years. Subjects assigned to more complex web sites reported significantly ($p < 0.01$) higher in terms of COMP than those assigned to web sites with lower rated complexity, indicating that the manipulation of complexity was successful. However, in terms of absolute response values, none of the web sites was viewed very complex by subjects as the average COMP of the eight web sites range from 2.90 to 3.82 on a 7-point Likert scale.

In investigating the proposed relationships among key constructs, structural equation modeling (SEM) was used because relationships between the constructs are complex and involve mediating effects. A two-phase approach was utilized in data analysis (Anderson & Gerbing, 1988). First, the measurement model was fitted and measures were examined in terms of reliability and construct validity. Second, the structural models expressing our hypothesized RM and alternative models with directional paths were estimated. Both the measurement and the structural models were estimated by AMOS 6.0 package.

We first conducted reliability analysis and a confirmatory factor analysis on the measurement models to test construct validity. Consistent with standard procedures, the measurement models fit correlations between all pairs of constructs, and set the loading of one indicator per construct to 1. Four items were dropped from the COMP measure because of low loadings. Measurement properties of constructs based on the final measurement model of the RM are listed in Table 3. Reliability of each construct ranged from 0.73 to 0.93 and was above the acceptable level of reliability of 0.7 (Nunnally & Bernstein, 1994; Straub *et al.*, 2004).

Several measures of fit were adopted to assess the models, including the ratio of χ^2 and degrees of freedom (χ^2/d.f.), Goodness-of-Fit Index (GFI), Comparative Fit Index (CFI), Bentler-Bonett Non-Normed Fit Index (NNFI), and Root Mean Square Error of Approximation (RMSEA) (Bentler & Bonett, 1980; Byrne, 2001; Doll & Torkzadeh, 1988; MacCallum, 1998; Marsh & Hocevar, 1985). In evaluating the models, CFI and RMSEA were used as the main indices because of their stability (MacCallum, 1998). A ratio of χ^2/d.f. below 2 indicates a good

Table 3. Measurement properties

	Mean	SD	Loading*	c.r.†
Perceived Complexity				
(Cronbach's Alpha = 0.84)				
Open/cluttered	4.14	1.83	0.62	–‡
Coherent/incoherent	2.58	1.30	0.71	10.63
Logical/illogical	2.29	1.18	0.79	11.34
Predictable/unpredictable	2.50	1.27	0.60	9.32
Organized/non-organized	2.31	1.32	0.80	11.44
Balance of Challenge and Skill				
(Cronbach's Alpha = 0.74)				
My abilities matched the high challenge of the situation.	5.43	1.32	0.69	–‡
I felt I was competent enough to meet the high demands of the situation.	5.54	1.35	0.85	11.91
Goal Clarity				
(Cronbach's Alpha = 0.93)				
I knew clearly what I wanted to do.	4.55	1.82	0.85	–‡
I had a strong sense of what I wanted to do.	4.69	1.70	0.91	23.08
I knew what I wanted to achieve.	4.94	1.64	0.91	22.85
My goals were clearly defined.	4.72	1.59	0.84	20.02
Feedback				
(Cronbach's Alpha = 0.88)				
It was really clear to me that I was doing well.	5.20	1.44	0.74	–‡
I was aware of how well I was performing.	4.57	1.49	0.81	15.10
When shopping, I had a good idea about how well I was doing.	5.02	1.57	0.87	16.22
I could tell by the way I was surfing how well I was doing.	4.48	1.54	0.80	15.02
Concentration				
(Cronbach's Alpha = 0.90)				
My attention was focused entirely on what I was doing.	5.23	1.53	0.72	16.83
It was no effort to keep my mind on what was happening.	5.18	1.52	0.77	18.42
I had total concentration.	4.90	1.63	0.93	26.60
I was completely focused on the task at hand.	4.97	1.55	0.90	–‡
Perceived Control				
(Cronbach's Alpha = 0.90)				
I felt in total control of what I was doing.	5.68	1.36	0.80	17.63
I felt like I could control what I was doing.	5.71	1.32	0.84	18.74
I had a feeling of total control.	5.47	1.45	0.87	19.76
I felt in total control of my action.	5.60	1.34	0.82	–‡
Mergence of Action and Awareness				
(Cronbach's Alpha = 0.73)				
I reacted to the web site automatically.	5.27	1.51	0.82	12.10
I did things spontaneously and automatically without having to think.	4.88	1.61	0.71	–‡
Transformation of Time				
(Cronbach's Alpha = 0.75)				
Time appeared to go by very quickly.	3.91	1.72	0.92	18.91
I lost track of time.	3.73	1.73	0.71	14.63
Time flew.	3.20	1.66	0.84	–‡

Table 3. cont.

	Mean	SD	Loading*	c.r.†
Transcendence of Self				
(Cronbach's Alpha = 0.82)				
I was not concerned with what others may have been thinking of me.	5.88	1.619	0.71	13.00
I was not concerned with how I was presenting myself.	5.67	1.49	0.83	14.90
I was not worried about what others may have been thinking of me.	5.85	1.50	0.79	–‡
Autotelic Experience				
(Cronbach's Alpha = 0.91)				
I really enjoyed the experience	4.29	1.56	0.78	19.01
I loved the feeling experienced and I want to capture it again.	3.36	1.54	0.83	20.90
The experience left me feeling great.	3.67	1.49	0.90	24.52
I found the experience extremely rewarding.	3.66	1.57	0.90	–‡

*These are standardized loading estimated using AMOS 6.0 software package.
†c.r., Critical Ratio.
‡Indicates a parameter fixed at 1.0 in the original solution.

fit and a ratio between 2 and 5 indicates a reasonable fit (2.1 in this study, $\chi^2 = 1399.42$, d.f. = 693). A good fitting model should have a GFI greater than 0.90 (0.85 in this study), an AGFI (Adjusted GFI) greater than 0.90 (0.82 in this study), a PGFI (Parsimony GFI) greater than 0.50 (0.69 in this study), an NFI greater than 0.90 (0.88 in this study), an NNFI greater than 0.90 (0.93 in this study), an IFI (Incremental Fit Index) greater than 0.90 (0.94 in this study), and a CFI greater than 0.95 (0.94 in this study). RMSEA should be less than 0.05 (0.055 in this study with an interval of 0.050 to 0.060). Based on these criteria, the goodness of fit of the measurement model for the RM was reasonable.

To assure convergent validity, all factor loadings of the items in the measures should be significant and their standardized value should be greater than 0.60 (Bagozzi & Yi, 1988). In this study, the critical ratios of *t*-values ranged from 9.32 to 26.60, significant at $p < 0.01$ level. Standardized loadings ranged from 0.60 to 0.93, at or exceeding the suggested value of 0.60 for establishing convergent validity.

AM2 and AM3 were designed to test the independent effects of PC and PS on flow. In AM2, CS is replaced by the separate constructs PC and PS. AM3 was constructed in a similar manner as AM1 to RM, with a direct effect of COMP on flow dimensions. The measure for PC consisted of three items and that for PS of four items. Both PC and PS measures showed acceptable levels of reliability, with Cronbach's Alphas of 0.75 and 0.84 for PC and PS, respectively. Similar analyses were run to examine the goodness of fit for the measurement models of AM2 and AM3. The results were similar to that for the RM ($\chi^2 = 1359.67$, d.f. = 684, χ^2/d.f. = 1.99, GFI = 0.83, AGFI = 0.80, PGFI = 0.69, CFI = 0.93, NFI = 0.87, NNFI = 0.92, IFI = 0.93, RMSEA = 0.053). All loadings were significant and ranged from 0.58 to 0.93, with one item of the COMP measure and one item of the PC measure slightly below 0.60.

Discriminant validity was assessed using correlations among the constructs (Table 4). The values on diagonal of Table 4 are the values of Cronbach's Alpha for that construct. To

Table 4. Correlations among constructs and reliabilities

	CS	GC	FB	C	CON	M	TS	AE	TT	PC	PS	COMP
CS	0.74											
GC	0.47**	0.93										
FB	0.47**	0.58**	0.88									
C	0.40**	0.48**	0.60**	0.90								
CON	0.58**	0.42**	0.63**	0.69**	0.90							
M	0.43**	0.41**	0.56**	0.56**	0.59**	0.73						
TS	0.37**	0.19**	0.42**	0.45**	0.60**	0.37**	0.82					
AE	0.19**	0.44**	0.54**	0.48**	0.43**	0.44**	0.24**	0.91				
TT	0.05	0.21**	0.26**	0.32**	0.22**	0.30**	0.15**	0.52**	0.75			
PC	–0.50**	–0.45**	–0.51**	–0.44**	–0.54**	–0.46**	–.21**	–0.43**	–0.20**	0.75		
PS	0.82**	0.59**	0.55**	0.45**	0.62**	0.49**	0.40**	0.33**	0.13*	–0.64**	0.84	
COMP	–0.23**	–0.37**	–0.41**	–0.33**	–0.41**	–0.34**	–0.13*	–0.43**	–0.21**	0.60**	–0.40**	0.84

*Correlation is significant at the 0.05 level (2-tailed).

**Correlation is significant at the 0.01 level (2-tailed).

CS, balance of challenge and skill; GC, goal clarity; FB, feedback; C, concentration; CON, perceived control; M, mergence of action and awareness; TS, transcendence of self; AE, autotelic experience; TT, transformation of time; PC, perceived challenge; PS, perceived skill; COMP, perceived website complexity.

Table 5. Results of model analysis

Models	Description and results	Goodness of fit
RM	CS, GC, FB are all mediating factors of COMP to flow. All but one path are significant at $p < 0.01$ level; GC → flow is not significant.	$\chi^2 = 1295.20$, d.f. = 544, χ^2/d.f. = 2.38, GFI = 0.82, AGFI = 0.79, PGFI = 0.71, CFI = 0.91, NFI = 0.86, NNFI = 0.90, IFI = 0.91, RMSEA = 0.063 (0.058–0.067) AIC = 1467.21, ECVI = 4.16
AM1	A direct path from COMP to Flow is added in RM. All but one paths are significant at $p < 0.01$ level; GC → flow is not significant.	$\chi^2 = 1286.43$, d.f. = 543, χ^2/d.f. = 2.37, GFI = 0.82, AGFI = 0.79, PGFI = 0.71, CFI = 0.91, NFI = 0.86, NNFI = 0.90, IFI = 0.91, RMSEA = 0.062 (0.058–0.067) AIC = 1460.43, ECVI = 4.14
AM2	Substitute CS with PC and PS in RM. All other paths are significant at $p < 0.01$ level; GC → flow and PC → flow are not significant.	$\chi^2 = 1660.92$, d.f. = 722, χ^2/d.f. = 2.30 GFI = 0.80, AGFI = 0.77, PGFI = 0.71, CFI = 0.90, NFI = .84, NNFI = 0.90, IFI = 0.90, RMSEA = 0.061 (0.057–0.065) AIC = 1856.92, ECVI = 5.26
AM3	Substitute CS with PC and PS in AM1. All other paths are significant at $p < 0.01$ level; GC → flow, COMP → flow, PS → flow, and PC → flow are not significant.	$\chi^2 = 1660.92$, d.f.= 721, χ^2/d.f. = 2.30 GFI = 0.80, AGFI = 0.77, PGFI = 0.70, CFI = 0.90, NFI = 0.84, NNFI = 0.90, IFI = 0.90, RMSEA = 0.060 (0.057–0.065) AIC = 1858.92, ECVI = 5.27

RM, research model; AM1, first alternative model; AM2, second alternative model; AM3, third alternative model; CS, balance of challenge and skill; GC, goal clarity; FB, feedback; COMP, perceived website complexity; PC, perceived challenge; PS, perceived skill; GFI, goodness-of-fit index; AGFI, adjusted GFI; PGFI, parsimony GFI; NFI, normal fit index; NNFI, non-normal fit index; RMSEA, root mean square error of approximation; AIC, Akaike's information criterion; CFI, comparative fit index; IFI, incremental fit index; ECVI, expected cross-validation index.

establish discriminant validity, the correlation coefficients among different measures should be lower than the reliability coefficients (Gerbing & Anderson, 1988; Siekpe, 2005). For all four models, RM, AM1, AM2 and AM3, no correlation exceeded 0.73 except for that between PS and CS, providing evidence for the discriminant validity of the scales used to measure constructs in the models.

In the next step, the four models (the RM and three alternative models) were tested. In RM (Figure 1), flow is a second-order factor with six first-order factors, representing the six flow dimensions. In the model, the construct of C was used to set the metric. RM hypothesizes that all three preconditions affect flow directly and that COMP affects flow via its effects on the three preconditions. Model RM exhibited reasonable fit with several fit indices below acceptable values (Table 5). The path from GC to flow was not significant. AM1 incorporates a direct effect of COMP on flow in addition to its indirect effect via the preconditions. All paths in AM1 were significant except for that from GC to flow. The added path from COMP to flow was significant. The fit indices indicated that AM1 had reasonable fit. A chi-squared test comparing the fit of RM and AM1 indicated that AM1 fit significantly better than RM ($\Delta\chi^2 = 8.77$, Δ d.f. = 1, $p < 0.05$).

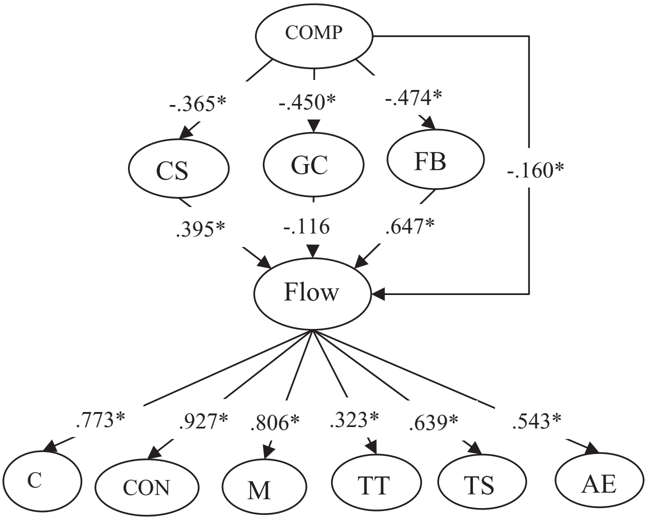

Figure 2. The first alternative model (AM1) with parameter estimates.

In AM2 and AM3, CS was replaced by PC and PS. Perceived COMP was thought to affect PC and PS, in turn, affecting flow. In terms of goodness of fit, AM2 and AM3 were similar to RM and AM1 on most fit indices except Akaike's Information criterion (AIC). Smaller values represent a better fitting of the hypothesized model (Hu & Bentler, 1995). AM3 had more non-significant paths. The added path from COMP to flow was not significant and the change in χ^2 for AM3 compared to AM2 ($\Delta\chi^2/\Delta$d.f. = 0.00) was not significant. Chi-squared tests comparing the fit of RM and AM2 and AM3 were non-significant, indicating that they did not improve fit over RM. A chi-squared comparison of AM1 and AM3 was also non-significant, indicating that AM3 did not improve fit over AM1. An examination of the results for the RM and alternative models reveals that, overall, AM1 is the best fitting model (Figure 2).

DISCUSSION

This study is among the first to include all theoretical preconditions and dimensions of flow in conceptualization and data analysis. Examining the original flow model, as developed by Csikszentmihalyi (1988) in an online surfing and shopping context, helps to determine the degree to which it applies in the online environment and provides a more coherent theoretical grounding for future research and practice. However, when interpreting the results, it is important to bear in mind that goodness of fit of the models was only reasonable.

The proposed second-order structure of flow with six dimensions (C, CON, M, TT, TS and AE) was supported. However, the relative strengths of relationships between individual, distinctive dimensions and the underlying flow construct varied. In our study, TT had a weaker relation with the flow construct than did other dimensions; whereas, control and M had the strongest relationship. This result suggests that flow in online shopping is featured primarily through CON, M and C.

In our models, both CS and FB had positive significant paths to flow as predicted, while there was no effect of GC. An examination of the models revealed that the three preconditions were significantly correlated. It is possible that GC affects flow indirectly through influence on CS and FB. A model incorporating these indirect effects, instead of direct effects, had slightly improved fit compared to RM and AM1. A chi-squared test for difference in fit between AM1 and this model was significant. This suggests that in online shopping, whether users have a clear goal, plays a role in their assessment of CS and also on their perception on their progress. More complicated relationships might exist among preconditions and flow than was presumed in the original flow model.

It is also possible that online shopping is different in important aspects from other online tasks, such as pure information search, communication (such as email or instant messages) and entertainment (such as playing games), in terms of objectives and GC. While both utilitarian and hedonic activities can have clear goals, goals in hedonic activities can be loosely defined and hard to measure. For example, online games generally have clear goals, while browsing the fashion news has somewhat vaguer objectives, such as to kill time and also to get a general sense of fashion trends. Users' expectations of FB and challenge associated with other tasks may also differ from those of online shopping. Another concern resides in the particular setting and task used in the study. Although subjects were asked to act as real shoppers, they might not have a clear enough goal to begin with in the lab setting. Thus, whether our results can be generalized to other tasks is a matter for future investigation.

AM2 and AM3 with PC and PS were proposed and tested to ascertain which approach was more suitable in terms of model fit: using the single construct of CS or two separate constructs, PC and PS. RM and AM1 had better fit than models AM2 and AM3, respectively. PC had no significant effect on flow in either AM2 or AM3. This suggests that the CS construct not only has stronger theoretical foundation, but also is supported by stronger empirical evidence. However, a study focusing solely on the relationships among CS, PC and PS in the context of online flow experience would be worth pursuing in the future.

The effect of COMP on flow was strong in that it had significant paths to all three flow preconditions; all negative as predicted. The test for a direct effect of COMP on flow yielded some evidence in AM1. The coefficient for the direct effect of COMP on flow (–0.160) was about equal to that of the indirect effect via CS (–0.144), but smaller than that of the indirect effect via FB (–0.307). Overall, the indirect effect of COMP on flow was larger than its direct effect. Although the mediating effects of preconditions on flow do not completely account for the impacts of COMP on flow and are only partial, our study suggests that they are important mediators, providing a starting point and a general model for future research. In this general model, exogenous factors (task, technological, and individual characteristics) affect flow via preconditions in addition to their direct effects.

CONTRIBUTIONS

This research contributes to the HCI and IS literature in two respects. First, based on an assessment of HCI scholarship over the last 13 years, Zhang & Li (2005) call for more research focusing on the holistic experience of HCI. Flow captures an important holistic aspect of human experience by representing one type of intrinsic motivation that can be used to explain and promote usage of both hedonic and productivity technologies. Thus, it provides an important supplement to more traditional, fine grained variables, such as beliefs and attitudes.

Although previous research has provided evidence of flow and its relationships with desirable dependent variables, such as perceived usefulness and increased learning (Agarwal & Karahanna, 2000; Koufaris, 2002; Skadberg & Kimmel, 2004), the antecedents of flow have not been fully investigated. This study tries to fill this gap by testing models as originally formulated, elaborating the role and mechanism of preconditions (CS, GC, and FB), using a comprehensive definition of flow, and incorporating one technological characteristic of web sites – complexity. The results of this study highlight the important role of preconditions in the effects of technological characteristics on flow, and suggest that preconditions should be included as mediators in studies of exogenous factors that are hypothesized to affect flow. In the future, other exogenous factors related to web site and IS design beyond COMP can be included to study their impacts on flow in a similar manner. Our study exemplifies and suggests the value of drawing on well-developed theoretical frameworks like the original model of flow in understanding the impact of IS on users. The finding that some of the six underlying dimensions had stronger relationships with the second-order flow construct than others suggests that future research may well consider components of flow when studying usage of the web and other technologies.

A second contribution of the study is practical insights on interface design. Of the three preconditions, FB, an important aspect of web site design, had the strongest impact on flow. Hence, providing users with clear FB on how they are doing in pursuing their goals may improve user experience in online shopping. Of course, reducing COMP will help in terms of FB as it is easier to know what to do next in a simpler site. In addition, there are ways to provide users with clear FB and visual cues. For example, if a search does not return any match, a message that clearly says so is preferred over a search result page with an empty list, leaving the user to figure out what that means. The other two preconditions, CS and GC, may be hard to control from web site design point of view; however, they remind us of the importance of understanding users better. Knowing the level of skill and objectives of users and designing the interface accordingly will certainly help facilitate flow experience.

The finding that COMP has negative effects on all three preconditions of flow suggests that COMP should be considered carefully in site design. Some degree of COMP is required to make sites interesting, but too much can inhibit desirable flow states. Hence, designers should strive for an optimal level of COMP. The results indicate that the aspects of web sites with the highest loadings on COMP were whether the site seems logical and organized, coherent and open design, and predictability of site behaviour. Thus, in order to calibrate COMP of a site to a desirable level, designers should take a holistic approach that works with multiple aspects of the design simultaneously. For example, linkages among parts of a site should support the typical behaviour of the users and anticipate user moves, so that the navigation pattern prescribed by the site design seems logical and predictable. Using a more organized, more consistent and simpler page style will also help reduce COMP.

LIMITATIONS AND FUTURE RESEARCH

There are several other limitations of the study. First, web site complexity is a difficult construct to define and measure (Nadkarni & Gupta, 2007). Researchers have proposed several different operationalizations of the concept and there is little consensus (Geissler *et al.*, 2001; Huang, 2003). The approach in the current study was to treat perceived complexity as a holistic, one dimensional construct that embodied various aspects of web site, and this had the advantage of simplicity and parsimony. However, it is difficult to pinpoint the impacts of various aspects of web site design on COMP, and, in turn, on flow. In future research, a multi-dimensional conceptualization of web site complexity would provide researchers with more detail on causal mechanisms and practitioners with more specific suggestions regarding web site design.

Other characteristics of flow have been proposed and studied by IS researchers, curiosity and telepresence to name two (Webster *et al.*, 1993; Hoffman & Novak, 1996). It is quite possible that these characteristics are part of the flow experience online because of the nature of computer-mediated environments and the IT-related tasks involved. Further investigation is needed to decide whether it is appropriate to include other dimensions, such as telepresence and curiosity, in conceptualization of flow in online environments. Previous research indicates that flow is positively related to exploratory behaviour, revisit and purchase intentions, and attitude towards web sites (Novak *et al.*, 2000; Koufaris, 2002; Skadberg & Kimmel, 2004) in online shopping and browsing. The current study extends this research by incorporating the theoretical antecedents of flow. We believe it is of benefits and importance to study flow in a more comprehensive model with not only flow experience itself, but both its antecedents and consequences, too.

Another potential limitation is using a sample that mainly consisted of college students, which raises the concern of generalizability. Such a sample is acceptable in online research because college students are not dissimilar to general online population and they are often the targeted market for e-commerce (Han & Ocker, 2002; Abdinnour-Helm *et al.*, 2005). However, in the study of flow, different samples might reveal different insights. For example, perception and tolerance of challenge using computers and the internet differs across various online populations (Rettie, 2001). By including a more diverse sample, future studies will be able to investigate questions related to individual characteristics.

Limitations are also imposed by use of real web sites. We believe that using a set of pre-selected existing commercial web sites makes the task of online shopping and surfing more realistic for the subjects. These sites provide a representative sampling of the types of sites online shoppers are likely to browse. On the other hand, there is less control on other factors associated with existing web sites, such as download delay and visual design. Because we did not collect data on these factors, it is difficult to determine what impact they had on the results.

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Biographies

Yi Maggie Guo is Assistant Professor of Management Information Systems at University of Michigan – Dearborn. She received her PhD from Texas A&M University and her MS from the University of Nebraska at Omaha. Her research interests include e-commerce, online shopping experience, flow theory and agent-based systems in knowledge management. Her work has appeared in *Journal of Organizational and End User Computing*, *Decision Science Journal of Innovative Education*, *Decision Support Systems*, *Information Resources Management Journal*, *Proceedings of Americas Conference on Information Systems* (AMCIS), *Proceedings of Annual Hawaii International Conference on System Sciences*, and edited books, such as *Social and Cognitive Impacts of E-Commerce on Modern Organizations* (M. Khosrow-Pour, ed., ISI Publishing, 2004) and *Advanced Topics of Information Resources Management Volume 2* (M. Khosrow-Pour, ed., IGI Publishing, 2003).

Marshall Scott Poole is Professor of Department of Speech Communication and National Center for Supercomputing Applications in University of Illinois at Urbana-Champaign. He received his PhD in 1980 from the University of Wisconsin and taught at Texas A&M University and the Universities of Minnesota before coming to UIUC. His research interests include group and organizational communication, implementation of information systems, collaborative technologies, conflict management and organizational innovation. His articles have appeared in *Management Science, Organization Science, Information Systems Research, MIS Quarterly, Human Communication Research, Communication Monographs, Small Group Research* and *Academy of Management Review.* He has co-authored or edited 10 books including *Communication and Group Decision-Making*, *Theories of Small Groups: Interdisciplinary Perspectives, Organizational Change and Innovation Processes: Theory and Methods for Research*, and *The Handbook of Organizational Change and Innovation.* He was selected as a Fellow by the International Communication Association in 2004 and was named a Distinguished Scholar by the National Communication Association in 2005.

APPENDIX 1. TASK DESCRIPTION

It is a shopping task without the requirement of a purchase. Once you make a decision on purchase intention (to buy a specific product or not to buy at all), you can stop. However, if you are comfortable, you can make the purchase today on your own cost. **Do not** actually purchase anything **unless** you truly want to acquire the products yourself at this point. I will not be responsible for any cost occurs. If necessary, you should fill out all the forms as if you were going to purchase the merchandise. Stop just short of submitting the information. Rather than providing real information, you can fill out any required forms with a pseudonym instead.

Please approach this task as a real ‘shopper’. We will be asking you questions about your specific ‘purchases’ and about your shopping experiences on this specific site.

Please stay on the assigned site and spend some time, for example, 10 to 15 minutes or longer. It is an individual task. Please focus on your computer and try not to talk to other participants during the experiment. If you have questions, please ask me. Please turn off your cell phone.