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The Dissertation Committee for Ji Hyun Park
certifies that this is the approved version of the following dissertation:

Flow in Multitasking :

The Effects of Motivation, Artifact, and Task Factors

Committee:

Randolph Bias, Supervisor

Andrew Dillon

Yan Zhang

Min Liu

Dawna Ballard

Flow in Multitasking : The Effects of Motivation, Artifact, and Task Factors

by

Ji Hyun Park, B.F.A.; M.F.A.

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Dedicated to my family

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Flow in Multitasking :

The Effects of Motivation, Artifact, and Task Factors

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The aims of this dissertation study are 1) to examine how the interplay of motivation, artifacts, and task interconnectedness affect users' flow experience, 2) to understand users' multitasking patterns by analyzing approaches and strategies in multitasking environments through a participatory design session, and 3) to come up with design insights and implications for desired multitasking environments based on findings from the quantitative and qualitative data analysis and synthesis. This dissertation employed the PAT (Person-Artifact-Task) model to examine factors that affect users' flow experience in computer-mediated multitasking environments. Particularly, this study focused on users' flow experience - sense of control, focused attention, curiosity, intrinsic interest and interactivity - in the context of multitasking. The dissertation begins with perspectives on human multitasking research from various disciplines. Emphasis is placed on how researchers have defined the term multitasking and the scope of previous multitasking research. In addition, this study provides definitions of the

term task switching, which also has been used to describe human multitasking. The second section of this dissertation focuses on the literature, which characterizes factors and theoretical frameworks of human multitasking research. In this section, human multitasking factors were classified into internal and external factors to analyze factors from the micro to the macro perspective. More detailed definitions and comparisons are also addressed. To summarize and conclude the literature review, this study provides a synthesis framework of internal and external factors of human multitasking contexts. In section III, this dissertation introduces theoretical frameworks that include the constructs of the PAT (Person-Artifact-Task) model and flow model. The next three sections present the research design and two research methods - the experiment and participatory design. The results and discussion section includes the implications of interpreting people's flow experience with motivation, artifact (technology affordance type), and task interconnectedness through the PAT model. The study findings and implications should extend our understanding of multitasking behaviors and contexts and how the interplay of person, artifact, and task factors affects humans' flow experience. A concluding chapter explores future work and design implications on how researchers and designers can take contextual factors into consideration to identify the most effective multitasking in computer-mediated environments.

Table of Contents

List of Tables

List of Figures

Chapter 1

Introduction

1.1 Research Background

1.1.1 The Development of Information and Communication Technologies

The rapid development of information and communication technologies (ICTs) and wireless networking has led to many users owning multiple digital devices (e.g., mobile phones, laptops, tablets) and using them simultaneously in everyday life. People carry their laptops and smart phones to connect online at coffee shops, conferences, airport boarding gates, and even on airplanes in the sky. As a result, multitasking behavior with electronic devices has become a part of users' everyday lives (e.g., checking emails while chatting with friends online using a laptop). Salvucci and colleagues (2009) state, "User interfaces have rapidly spread from standard desktop settings into real-world multitasking environments due to the proliferation of portable computing devices (e.g., mobile phones, tablets, and laptops)" (p. 1819). The Pew data (Fox et al., 2009) indicated that 54% of American Internet users have accessed the Internet wirelessly via a laptop, cell phone, game console, or other mobile device and these numbers are increasing. Data from Pew and an Internet project called "mobile access to data and information" (Horrigan, 2008) support the view that the ubiquity of Web services on portable devices is significantly changing users' computing environments and information behaviors.

1.1.2 Multitasking Generation

Wallis (2006) coined the term “multitasking generation” to refer to people who are engaged in multiple tasks continuously with their portable devices. Jessica Ried, an associated director at Research & Insights (2011), reported on the traits of digital millennials, the multitasking generation born between the years of 1982 and 2000. Ried states that; “57% of teens simultaneously watch TV and search for information on the Web (OTX and eCrush, 2007)” (p. 20) and “Unstructured free time has decreased by 37% since 1981 (Strauss and Howe, 2006)” (p. 20). Ried identifies “a proliferation of engaging digital touch points (e.g., non-linear and cross-channel) as a new customer journey” (Ried, 2011, p. 42). Ried argues that the multitasking generation has emerged as a primary user group in computing environments. It is thus crucial that designers understand users’ attributes and behaviors of this specific group in terms of multitasking. Carrier et al., (2009) found that the multitasking generation, the so-called “Net-generation”, born between 1980 to the present (Tapscott, 1997), engaged more in multiple tasks and that particular generation found multitasking to be easier than other generations.

1.1.3 Rich Media Environments

Rich media environments are also another key factor that compels users’ multitasking. Social network Web services promote users’ multitasking due to the growth in Web accessibility. Thirty-nine percent of users who own four or more mobile devices are more likely to post their status on Twitter, one of the most popular micro-blogging services, than those who own fewer than four devices (Fox et al., 2009). These data indicate that people likely perform multiple information tasks simultaneously with their devices at places like home, work, and school. Cloud computing technology allows users to exchange information, such as images, texts, and videos easily on the Web. Social network Web services, such as Facebook, Twitter, and YouTube, have made it convenient for users to engage more frequently in creating, managing, and sharing information with people. Thus, the variety of social media platforms and applications support users' immediate interaction with people and information (Ophir et al., 2009). In addition, research shows that the popularity of online learning including MOOC (Massive Open Online Course) is exponentially increasing (e.g., Coursera.org, Open classroom developed by Stanford University, edX developed by Harvard University and MIT) (Parry, 2010; Markoff, 2011; Lewin, 2012; Harvard University, 2012; Mahraj, 2014). Online learning environments provide a greater selection of courses, media aids, and learning material than offline ones. For that reason, an online class requires students to expend a great deal of effort managing multiple tasks than in-person classroom settings (Park & Bias, 2012). Rosen (2010) claimed that multitasking is inevitable in online learning environments and thus general guidelines for designing learning environments is necessary to help students organize multiple tasks in an effective way instead of discouraging multitasking without better solutions.

1.1.4 Summary

The development of ICTs, the emergence of the multitasking generation, and increasingly rich media environments has evoked it so engaging in multitasking has become the representative nature of operating in computing environments (Salvucci et al., 2009). Nonetheless, the positive effects of multitasking have been seldom addressed in the previous multitasking research studies. People require some degree of concentration while they are exposed to multitasking environments. Salvucci and Taatgen (2011) claim that only focusing on the drawbacks of multitasking discourages scholars to look at the positive factors in multitasking environments such as factors that could improve productivity. Therefore, it is important to understand what factors play an important role in amplifying the effectiveness of multitasking environments by extracting the postive factors of multitasking contexts. Broadly, the temporal aspects of multitasking environments could shed the light on the positive aspects of how to coordinate and manage time. As Bluedorn and Denhardt (1988) cite time as an important resource in organization and management, "there has been a clear understanding that time is closely related to organizational productivity and that time can be viewed as a resources to be managed in the pursuit of organizational objectives" (p.303). Based on this claim by Bluedorn and Denhardt (1988), we could make the potential research extension from the understanding of multitasking contexts to how people handle time in planning and coordinating supportive artifacts and further organizational environments beyond multiple tasks. In this dissertation research, we will review what topics were covered in previous multitasking studies and address under-examined areas so that we could extend our attention more into the what factors that help people have positive effects such as flow experience.

1.2 Research Agenda

1.2.1 Statement of the Problem

The capabilities of information technology stimulate users to employ multiple information resources, media channels, and communication technology platforms. In particular, users are connected; this creates the expectation of immediate reactions from information tasks, such as e-mail responses and instant messaging. Multitasking behaviors and characteristics cause both positive and negative effects on multitasking outcomes. In spite of the prevalence of multitasking in computing environments, surprisingly, many studies have focused on the negative consequences of multitasking. Since users' multitasking behaviors tend to be treated as complicated and undefined resulting from the dynamic nature of multitasking contexts, there has been little attention to research that examines the benefits of multitasking, which could yield positive outcomes (Salvucci et al., 2009; Wickens, 2008). One of the potential positive consequences of multitasking is managing spare time efficiently. Rosen (2010) states that people multitask to replace unstructured free time with productive time by working on another task, such as reading a book or sending an email. Another positive consequence is enhancing learning and creativity. Weinberger (2007) argues that multiple decentralized contexts take apart established orders and information structuring; this might help users gain a richer understanding of the original information. More specifically, Vega (2009) claims, "the non-linear and decentralized structure of information on the web, which is potentially contributing to media-multitasking behaviors, has potential to promote learning and creativity" (p. 5). Therefore, understanding the multitasking factors and flow relationship will help develop positive multitasking interactions in computer-mediated environments, which yield not only efficiency but also an optimal experience.

1.2.2 Purpose of the Study

There are two goals of the dissertation study. One goal is to examine and understand the dynamics of multitasking, which result from interactions among multitasking factors - motivations, artifacts, and tasks. With that in mind, this study will focus on what factors affect users' flow experience which is the optimal experience that occurs between boredom and frustration in computing environments. To answer the first research question, "To what extent do PAT factors affect users' flow experience in computer-mediated multitasking environments?," the study will conduct an experiment with multitasking factors to examine users' flow experience. Consequently, the analysis of the multitasking characteristics will provide insights into what factors should be taken into consideration to decrease the disadvantages of multitasking and increase its advantages. Another goal of this dissertation is to extract users' multitasking patterns by analyzing users' approaches and strategies from a participatory design session in which participants will share their thoughts and stories by composing post-it notes on a paper and engage in discussions. Based on findings from the quantitative and qualitative data analysis, this study will derive design insights and implications for desired multitasking environment design. If we understand the factors that affect users' flow experience in multitasking, we can provide better system design evidence to support effective multitasking in fields such as computer-mediated environments where multitasking frequently occurs.

Chapter 2

Literature Review

2.1 Previous Human Multitasking Research

2.1.1 Confusion of the Term - Multitasking

Previous researchers have interpreted the term multitasking in various ways depending on their perspectives. The term multitasking originally referred to computer operating systems, however researchers have started to use the term "multitasking" to look at human behaviors (Abaté, 2008). Multitasking refers to the situation in which more than two tasks are occurring simultaneously. Many researchers use the term task-switching and multitasking interchangeably (e.g., Kushleyeva et al., 2005; Carrier et al., 2009; Judd & Kenndy, 2011). Other phrases include concurrent multitasking (e.g., Salvucci & Taatgen, 2008), and sequential multitasking (e.g., Calson & Sohn, 2000; Bendy and Kalwowski, 2007; Benbunan-Fich et al., 2011). Salvucci et al. (2009) define concurrent multitasking as when "the tasks are performed at the same time" and sequential multitasking as when "a longer time (minutes to hours) might be spent on one task before switching to another" (p. 1819). Arthur T. Jersild coined the term "task-switching" in 1927. Since then, cognitive psychologists have published most of the literature in task-switching (e.g., Burgess, 2000; Pashler et al., 2001; Rubinstein et al., 2001; Gilvert & Shallice, 2002; Monsell, 2003; Altmann & Gray, 2008; Salvucci & Taatgen, 2009). Primarily, cognitive psychologists have focused on interventions (Monsell, 2003) to measure primary task-switching factors: switching cost (e.g., Altmann & Gray, 2008) and error rates (e.g., Brumby & Salvucci, 2009; Borst et al., 2010). The cognitive researchers found that "subjects' responses are substantially slower and, usually, more error-prone immediately after a "task switch," and "this 'switch cost' is reduced, but not eliminated, by an opportunity for preparation" (Monsell, 2003, p. 134). Based on Salvucci and Taatgen's (2008) notion, Altmann and Gray (2008) claim an important constraint of the multitasking situation is that "task switches have to be scheduled such that neither task starves for attention" (p. 602). Benbunan-Fich and Truman (2009) state that multitasking occurs when users switch their attention to more than one independent task in a situation where multiple tasks occur at the same time. Many researchers have defined multitasking as humans switching from one task to another to manage the constraints of multiple tasks (e.g., Rubinstein, Meyer, & Evans, 2001; Spink & Park, 2005).

There also has been a great demand for studies and models that consider how multiple factors impact task switching. Benbunan-Fich et al. (2009b) posit that the notion of concurrency implies that users carry out multiple tasks within a unit of time. Similarly, Preece et al. (1994) define multitasking as a temporal perspective in which users alternate between tasks to conduct more than two tasks within a time-period. Benbunan-Fich and colleagues (2009a) defined multitasking behaviors specifically in computing environments. The researchers examined that a user performs several unrelated computer-based tasks concurrently with one or more computer-based applications. Monsell (2003) pointed out, "Although single-factor models of task switching continue to be proposed, most authors now acknowledge a plurality of causes, while continuing to argue over the exact blend" (p.137). Monsell claims that multitasking is a complicated situation and examining the interplay of multiple factors is necessary to understand the contexts of multitasking environments. If we look at multitasking as a process, which is affected by multiple factors, we can better understand the multitasking situations and create guidelines for a more efficient system design that can provide users an optimized experience.

2.2 Factors and Theoretical Frameworks of Human Multitasking Research

The primary factors in the multitasking context include users, tasks, technologies, and situations (Benbunan-Fich, 2009b; 2011). This dissertation study classifies multitasking factors as internal and external based on the literature review. Internal factors refer to multitasking factors that are associated with human brain mechanisms, such as memory (Rohrer and Pashler, 2003) and attention (Pashler et al., 2001). Whereas, external factors of multitasking refer to factors that focus on tasks, technologies, and situations that affect human multitasking behaviors, such as communication patterns (Su and Mark, 2004), usage tendencies of multiple devices and applications (Benbunan-Fich et al, 2009b; Gonzalez and Mark, 2004), and systems for managing multiple tasks (Adamczyk, 2004).

2.2.1 Theoretical Frameworks of Internal Factors

This section provides three prominent theoretical frameworks of human multitasking based on internal factors. Each framework synthesizes internal factors with distinctive perspectives: 1) Wickens' 4-D multiple resources model (2008), 2) Altmann and Gray's cognitive control model (2008), and 3) Salvucci and Taatgen's multitasking continuum model (2008). These frameworks characterize how mental resources are associated together to achieve multiple tasks and how information resources affect multiple mental processes, such as memorizing (Ophir et al., 2009), and attention (Pashler et al., 2001).

2.2.1.1 Four-dimensional multiple resources model (Wickens, 2008)

Wickens (2008)'s 4-D multiple resources model represents four dimensions associated with task interference and the relationship of resources with a brain structure (Figure 2.1). This model shows the relationship among different dimensions of cognitive factors and helps visualize users' mental workload while interacting with multiple resources at the same time. The 4-D multiple resources model provides the multi-dimensional matrix that contains the axes of; 1) stages (perception, cognition, and responding), 2) sensory modalities (auditory versus visual), 3) responses (manual, spatial, vocal, and verbal), and 4) visual processing (focal versus ambient).

Wickens (2008) presents four different aspects/criteria of internal factors - stages, modalities, visual processing, and responses - that are relevant to human information processing while multitasking. For example, the four-dimensional

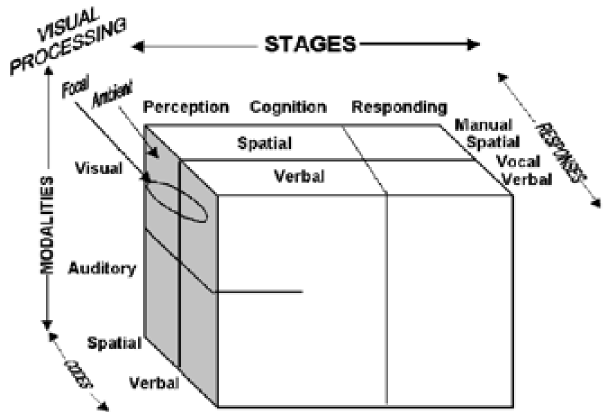


Figure 2.1: The 4-D multiple resources model (Adopted from Wickens, 2008)

multiple resources model can be used to analyze human multitasking behaviors with mental resources factors based on multi-dimensional criteria including the stages (perception, cognition, and perception), where information processing occurs while multitasking. In addition, the model also provides understanding of the relationship among human mental resources and stimuli (e.g., information forms - images, texts, or audio), such as how different types of modalities (e.g., visual or auditory) are associated with means of response (e.g., manual, spatial, vocal or verbal). Although Wickens' (2008) 4-D multiple resources model (Figure 2.1) describes resources that are associated with making decisions or paying attention to a certain task while human multitasking, it does not explain how each element influences each other and the relationships among tasks.

2.2.1.2 Integrated cognitive control model (Altmann and Gray, 2008)

Altmann and Gray (2008) developed an integrated Cognitive Control Model (CCM), which describes a relationship among human perception, semantic

Integration in CCM	Description
Empirical integration	Mechanistic relationship between diverse effects that might otherwise seem to be unrelated
Theoretical integration	All the constructs represented in CCM are familiar from other domains: mostly memory, but also attention and perception
Procedural integration	One set of mechanisms can account for performance in multiple task-switching procedures, including the two used in the bulk of studies that make up the task-switching literature

Table 2.1: Integration of Cognitive Control Model (Altmann and Gray, 2008)

memory, and episodic memory in the computational implementation of the CCM. Each cognitive mechanism interactively involves users' information-processing procedures while users perform multiple tasks. The model characterizes associative links among the cognitive elements, not an independent link to each element. Altmann and Gray claim that, "Percepts are symbols represented within the system when a task cue or trial stimulus is presented, which then have to be identified by retrieval of their meaning" (Altmann and Gray, 2008, p. 608). The components in the CCM show organic interaction with each other rather than an individual independent effect. Subsequently, Altmann and Gray (2008) suggested three aspects of integration in the cognitive control model (CCM): Empirical integration, theoretical integration, and procedural integration (p.628, Table 2.1). Particularly, among these integration efforts, procedural integration explains multitasking with a set of mechanisms through the lens of the cognitive control model.

2.2.1.3 Multitasking Continuum (Salvucci and Taatgen, 2011)

Salvucci and Taatgen (2011) have distinguished two separate types of multitasking based on time spent before switching tasks: concurrent and sequential multitasking. Concurrent multitasking refers to switching tasks in less than one minute, while sequential multitasking takes more than one minute in terms of time intervals between tasks. Salvucci et al. (2009) posited that these two areas can be overarched into a unified theoretical framework that will help explain complex multitasking environments. Salvucci et al. synthesized concurrent multitasking and sequential multitasking as a multitasking continuum based on Newell's (1990) concept of continuum. Basically, Salvucci and Taatgen's (2011) approach investigates examining users' mental workload with a spectrum of multitasking situations with a temporal perspective.

Salvucci and Taatgen (2008; 2011) proposed the threaded cognition theory, a unifying theory of multitasking: 1) The multitasking continuum: from concurrent to sequential tasks, 2) The application continuum: from laboratory to applied tasks, and 3) The abstraction continuum: from milliseconds to a month (Figure 2.2).

2.3 Summary of Theoretical Frameworks of Internal Factors

Wickens (2008), Altman and Gray (2008), and Salvucci and Taatgen (2008; 2011) interpreted multitasking factors from humans' internal activity-oriented approaches focusing on analyzing the mechanisms of human brain activities while multitasking (Table 2.2). The integrated frameworks of mental workload (Wickens, 2008) and cognitive control architecture (Altmann & Gray, 2008) describe the

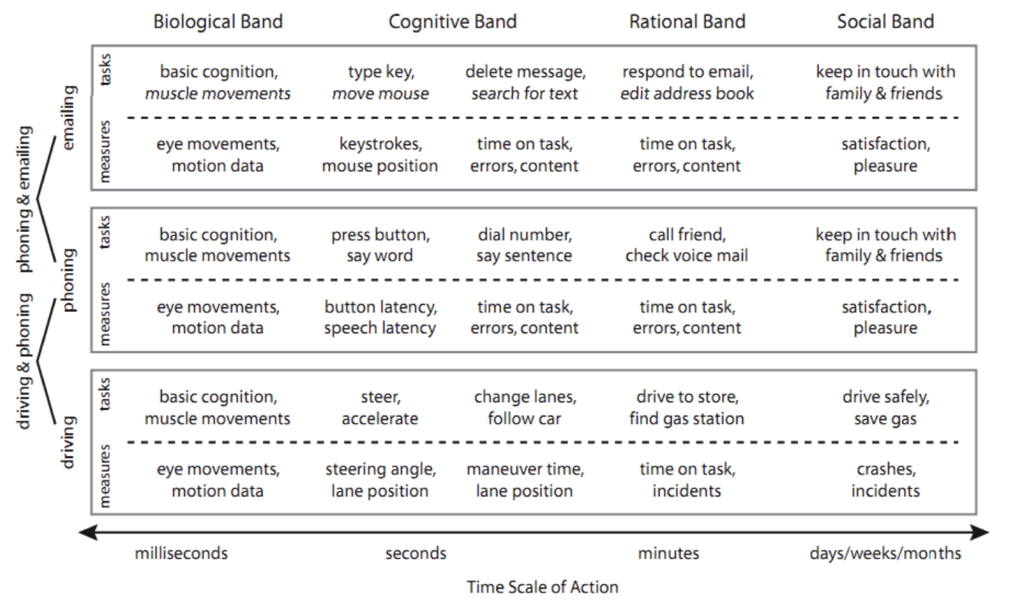


Figure 2.2: The Abstraction Continuum [based on Newell, 1990]. (Adopted from Salvucci and Taatgen, 2011)

relationships among various elements of humans' mental resources while multitasking. However, these models do not address users' needs in specific situations from diverse multitasking contexts. In order to apply the integrated process and interaction of the internal factors in a design process, products and services should be designed that support humans' multitasking behaviors. In the next section, I present external factors of human multitasking and theoretical frameworks for external factors.

2.3.1 Theoretical Frameworks of External Factors

The external factors include information formats, input methods, digital media platforms, communication and interaction processes. These factors focus

Frameworks	Perspectives	Factors
4-D Multiple Resources Model: Wickens (2008)	Stages Sensory modalities Responses Visual processing	Perception, cognition, and responding Auditory vs. visual Manual, spatial, vocal, and verbal Focal vs. ambient
Cognitive Control Model: Altmann & Gray (2008)	Empirical integration Theoretical integration Procedural integration	Human perception Semantic memory Episodic memory
Multitasking Continuum Model: Salvucci &Taatgen (2008; 2011)	Multitasking continuum	Sequential multitasking Concurrent multitasking
	Application continuum	Laboratory tasks Real-world tasks
	Abstraction continuum	Biological band (milliseconds) Cognitive band Rational band Social band (months)

Table 2.2: Theoretical Frameworks of Internal Factors of Human Multitasking

on artifacts and environments used to understand how multiple tasks and people's behaviors are connected, and what factors cause people to shift from one task to another. In the following section, I discuss four prominent theoretical frameworks for external factors: *Multitasking Interplay, Activity-based Multitasking Metrics, The Model of Attention in Computing and Communication and Communication Chains.*

2.3.1.1 Multitasking interplay (Spink and Park, 2005)

Spink (2010) characterizes multitasking information behavior as "the process of seeking information concurrently over time in relation to more than one, possibly evolving, set of information tasks (including changes or shifts in beliefs, cognitive, affective, or situational states) (Spink et al., 2002; Spink et al., 2006)" (Spink, 2010, p. 48). For example, while retrieving information, people engage in multiple information tasks simultaneously (e.g., searching for a journal article while simultaneously looking for flight ticket prices). Spink and Park (2005) developed a multitasking interplay model between information and non-information tasks that provides an overview of human task-switching contexts (Figure 2.3). Spink and Park used the terms "task switching" and "multitasking" interchangeably. Spink and Cole (2008) defined multitasking information behavior as "the coordination and interplay among information seeking, foraging, sense-making, organizing, and use tasks" (p. 109).

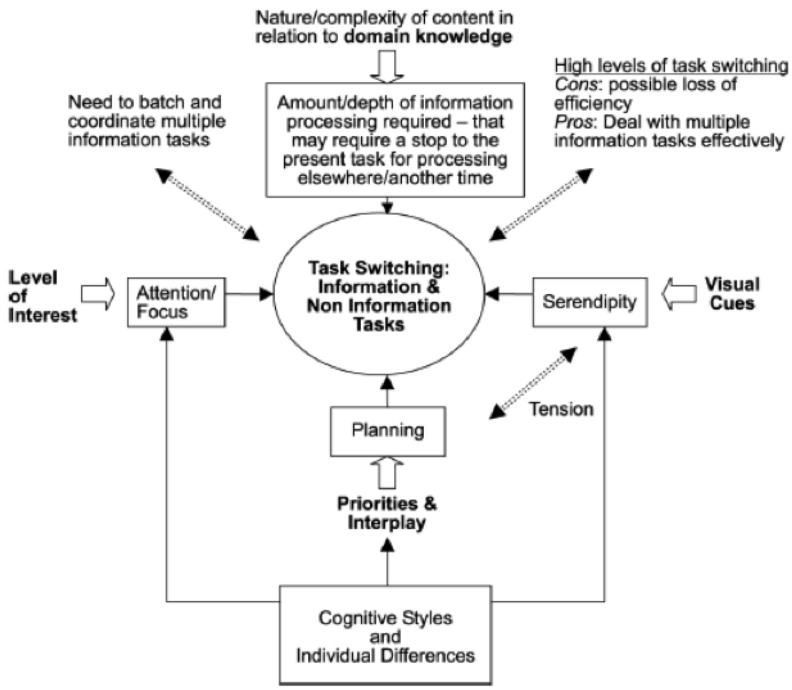


Figure 2.3: Model of Multitasking Interplay (Adopted from Spink and Park, 2005)

In addition, the model illustrates advantages and disadvantages of information multitasking behaviors, such as "possible loss of efficiency" as a negative effect and "dealing with multiple information tasks effectively" as a positive effect. Spink and Park (2005) proposed an integrated model that explains the relationship among different factors, and task switching between information and non-information tasks. However, although the multitasking interplay model is distinguished from previous multitasking studies from cognitive perspectives, this may not adequately describe the interaction process of individuals' multitasking information behaviors with media and technology supports.

2.3.1.2 Activity-based multitasking metrics (Benbunan-Fich et al., 2009b; 2011)

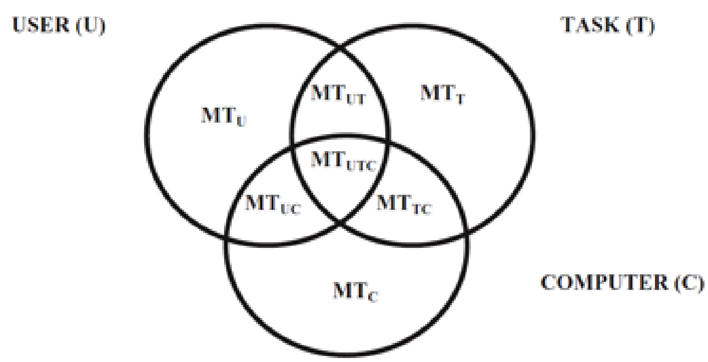


Figure 2.4: Diagram of Activity-based Multitasking Metrics (Adopted from Benbunan-Fich et al., 2009)

Benbunan-Fich et al. (2009b; 2011) developed metrics for multitasking based on activity-based theory, which measures computer-based multitasking behavior. They identified a triad of factors for multi-tasking (MT) with subscripts to indicate each factor's relation to the user (U), task (T), or computer technology (C) (Figure 2.4) based on Burton-Jones and Straub's (2006) IT (Information Technology) usage measurement criteria. In order to develop the Activity-based Multitasking Metrics, Benbunan-Fich et al. (2009b) emphasized task independence and performance concurrency as their central premises. In addition to these principles, the model was developed focusing on a single information technology (IT) platform. The model of Benbunan-Fich et al. (2009b) presents the relationships among three different facets of a user, task, and technology component. However, there is a limitation to the model because multitasking increasingly occurs in the contexts of multiple platforms and windows. Although Benbunan-Fich et al. (2011) acknowledged that the usage of tools (computing devices) affect human thoughts and behaviors, their model describes only multitasking in the context of a broader perspective of computer usage.

2.3.1.3 Attention in computing and communication

External factors consider different types of information platforms and artifacts. Compared to Benbunan-Fich et al.'s (2009b) multitasking metrics, Horvitz and colleagues' (2003) model - Attention in Computing and Communication - shows specific components of external factors in multitasking in the computing environments, specifically, the model shows multitasking environments including: information sources (e.g., information formats and activities) and communication platforms (endpoints).

Subsequently, the framework describes how the notification system they developed is affected by information sources and communication platforms in the computing context (Figure 2.5). Horvitz et al.'s (2003) study shows the relationship among different types of information platforms and information sources. However, examining Horvitz et al.'s (2003) model closely, this model does

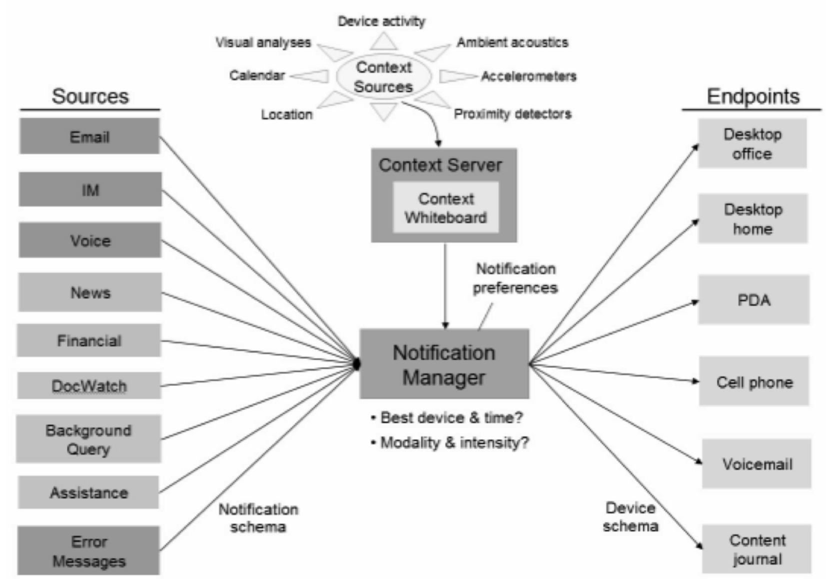


Figure 2.5: Model of Attention in Computing and Communication (Adopted from Horvitz et al., 2003)

not show the dynamics of the users' situations and interactions with information on multiple platforms.

2.3.1.4 Communication chains (Su and Mark, 2008)

Su and Mark (2008) developed the concept of Communication Chains, which was originated by Reder and Schwab in 1990. The researchers defined the term *communication chains* as communication acts that play a role of linking. Each link stands for a face-to-face, email, phone, or Instant Messaging (IM) communication act where there is a perceptible target and source. In particular, Su and Mark (2008) investigated the structures of communication chains with the research question of "how communication chains are integrated (or not) into the solitary work pattern of multitasking" (p. 84). They hypothesized that *media choice* and *organizational context* will be factors in shifting communication chains from one to another. The analysis from participants' self-reported results showed that media choice affects different multitasking patterns in terms of communication chains. For example, "*email-initiated chains* had longer links on average but were of shorter duration than chains initiated by synchronous communication (IM-initiated chains were even shorter)" (p. 91). Su and Mark (2008) found media selection and change of context as the main factors affecting human multitasking. Consequently, the theoretical framework of communication chains helps interpret multitasking behaviors and supports analysis of the causes and effects of multitasking in work environments in a systematic way.

2.3.2 Summary of Theoretical Frameworks of External Factors

In sum, each theoretical framework of external factors investigated different focuses to characterize human multitasking to develop a theoretical model (Table 2.3). Most frameworks of previous multitasking studies have shown the interaction among different characteristics of external factors, such as information sources and types of computing platforms in the context of multitasking. However, there is a lack of an integrated perspective that presents human multitasking interaction from a holistic point of view.

Frameworks of External Factors	Perspectives	External Factors
Multitasking Interplay (Spink and Park, 2005)	Coordinating between Information & Non-Information Tasks	Domain Knowledge Level of Interest Visual Cues Priorities & Interplay – Amount/depth of information Attention/Focus Serendipity Planning Cognitive Styles/Individual differences
Activity-based multitasking behavior metrics (Benbunan-Fich et al., 2009b)	Computer-based multitasking behavior	User Task Computer (Technology)
Attention in computing and communication (Horvitz et al., 2003)	Multitasking Support: Notification Preferences Notification scheme Device scheme	Sources: email, instant messaging (IM), voice, news, financial, background query, and error messages Endpoint (Platforms): desktop (office), desktop (home), PDA, cell phone, voice mail, and journal
Communication Chain (Su and Mark, 2008)	Organizational Contexts	Work Home, Company, Outside

Table 2.3: Theoretical Frameworks of External Factors of Human Multitasking

2.4 Methods and Findings of Human Multitasking Research

Multitasking has been difficult to conceptualize and measure despite multitasking being prevalent in everyday life (Benbunan-Fich et al., 2011). Multitasking research has been conducted in many different disciplines resulting in the development of various criteria and methods from controlled laboratory experiments to observation in realistic settings (e.g., naturalistic driving studies [Neale et al., 2005]). In order to examine the internal factors, researchers examined humans' mental workloads while multitasking with microsecond levels of measurement. In contrast, researchers conducted observation, laboratory experiments, and self-report methods to understand external multitasking factors.

2.4.1 Methods and Findings of Internal Factors

In terms of internal factors, researchers address the relationship between humans' multitasking and brain activities. Specifically, researchers are interested in how human brains process and react to different types of stimuli, such as, visual, audio, and tactile information resources. Cognitive psychologists have focused on examining what is happening in human brains and minds while multitasking. In addition, they have looked at what factors affect humans' information processing and cognitive control in negative and positive ways. Cognitive scientists have studied many aspects of multitasking or task switching for decades (Miyata & Norman, 1986; Ophir et al. 2009). Specifically, they have built extensive research literature on task switching (Monsell, 2004) and parallel distributed processing (Gillbert & Shallice, 2001).

In order to measure the internal factors of multitasking, researchers examined how users' brain mechanisms respond to multiple stimuli. Cognitive psychologists examined factors with criteria such as cognitive control, mental resources, and information processing capabilities. For example, Bailey et al.

(2006) analyzed the effects of interruption on task completion time, error rate, annoyance, and anxiety.

2.4.1.1 Laboratory experiments

Altmann and Gray (2008) demonstrated an integrated model of cognitive control in task switching. This model is based on their findings from a randomized-runs procedure, where "their experimental participants completed a large number of trials in sequence" (p. 602). Altmann and Gray (2008) used the Cognitive Control Model (CCM) to examine basic behavioral effects including; 1) first-trial effects, 2) within-run effects, and 3) other effects by measuring four factors: run length, position, switching, and congruency. Specifically, the first-trial effects examined the effect of longer preparation time and time delay while switching tasks. At the second stage of within-run effects, the researchers looked at increasing time delays and errors, and average duration of errors. Finally, they looked at other effects including congruency (e.g., fewer errors and faster latencies as participants repeat responses to the same stimulus) and failure to engage effects (e.g., time delay is affected depending on preparation time interval). Based on these experiments, Altman and Gray specified the characteristics of tasks based on whether they are familiar to a participant or not and how the results affect participants' multitasking performances. They focused mostly on measuring time delay and the number of errors while task switching. However, as human multitasking occurs increasingly in everyday life, it does not require time-critical performance to users at times. Therefore, it is necessary to explore and investigate new perspectives of internal factors of human multitasking.

Ophir et al. (2009) also conducted a laboratory experiment to compare the differences in information processing styles with cognitive control aspects between heavy media multitaskers (HMMs) and light media multitaskers (LMMs). In order to compare the two groups, the researchers conducted cognitive experiments including a task-cued stimulus-classification procedure, where "participants were presented a number and a letter, and performed either a letter (vowel or consonant) or a number (even or odd) classification task depending on a cue presented before the stimulus" (p. 11585). Through five sections of cognitive experiments, the results showed that if there was no distraction, no difference of task-set switching abilities was presented between HMMs and LMMs. However, in cases where a distraction was present, "the data suggest that HMMs are less likely to filter irrelevant representations arising from either external or internal sources" (p. 11585). Ophir et al. (2009)'s study demonstrates that "heavy media multitaskers are distracted by the multiple streams of media they are consuming, or, alternatively, that those who infrequently multitask are more effective at volitionally allocating their attention in the face of distractions" (p. 15585).

Accordingly, internal factors of human multitasking have been examined by laboratory experiments with testing traditional tasks such as recognizing a correct number and a letter with or without interruptions. However, interdisciplinary researchers have conducted practical experiments. For example, Iqbal et al. (2010) investigated users' divided attention while simultaneously performing secondary tasks, such as making phone calls, while performing a primary task, such as driving. They examined how the characteristics of different types of phone conversations affect both performances while driving. Their findings indicate that depending on the extent of the complexity of interactions and driving, specifically, when drivers need excessive cognitive demands beyond the resource availability, problems with driving may arise. However, there is another interesting aspect in terms of automaticity that develops habitual patterns of behavior. Well-practiced tasks require less attention compared to tasks people face for the first time (Ricker, 2010; Schneider and Chein, 2003). The consideration of automaticity might be helpful for developing interface designs that supports efficiency of human multitasking and mitigates the complexity of human information processing.

2.4.1.2 ACT-R cognitive architecture

ACT-R (Adaptive Control of Thought - Rational) is a cognitive architecture, developed by John Robert Anderson at Carnegie Mellon University (Anderson, 2007; Anderson et al., 2004) based on Newell's (1994) unified cognition theory. Particularly, the computational implementation of ACT-R has been broadly adapted to many cognitive experiments in order to measure how a human brain recognizes, perceives and memorizes information processing as an interpreter of a special coding language. Salvucci and Macuga (2001) describe the ACT-R cognitive architecture as "a production system architecture based on condition-action rules that execute the specified actions when the specified conditions are met" (p. 97). Many multitasking studies have adapted the ACT-R cognitive architecture in order to implement researchers' abstract assumptions into concrete interpretation (Salvucci & Macuga, 2001; Sohn & Anderson, 2001; Salvucci, 2006; Salvucci & Taatgen, 2008). For example, Altmann and Gray (2008) implemented their abstract level of the CCM into a computational system of the Cognitive Control Model (CCM) by using the ACT-R cognitive architecture simulator (version 4). Specifically, the system converted a representation of every task cue in episodic memory, called a task code, into a coded form. The task code is used "to guide cognitive behavior over subsequent trials, until the next cue is presented" (Altmann & Gray, 2008, p. 604). Through the computational implementation of the CCM, they found support for their assumption that "when the cognitive system needs to retrieve a task code, memory returns the one with the highest activation at that instant" (p. 604). From their experiment results, they describe "activation dynamics" which implies every component of the cognitive system is linked and operates together. Examples of linked components included "interference, decay, priming, focal attention, encoding, retrieval, and semantic and episodic memory" (Altmann & Gray, 2008, p. 628). The computational simulation methods have helped quantify multitasking tasks in a complex situation (e.g., modeling drivers' multitasking behavior [Salvucci, 2006]) in a systematic interpretation.

Many scholars have employed laboratory experiments in order to examine internal factors of multitasking. Most of these examples illustrate that researchers who focus on internal factors investigated multitasking as simultaneous stimuli changes and examined how humans react to the changes depending on different circumstances and conditions. Specifically, researchers looked at time spent on switching tasks and intervals while changing from one task to another. Also, they examined attention changes and the relationship between the familiarity of the tasks and the extent of mental efforts (e.g., automaticity [Schenider & Chein, 2003]).

2.4.2 Methods and Findings of External Factors

External factors cover a broad range of societal and technological factors of multitasking. For example, researchers have responded to research questions such as "why people shifted from a solitary work mode" (Su and Mark, 2008, p. 84), and examined "where they switched among multiple tasks, to a type of communication mode, and where they showed patterns of switching among multiple communication partners with different media"(Su and Mark, 2008, p. 84). In another example, Gonzalez and Mark (2004) conducted an observation to understand"how individuals spend their time, and the usage of digital and physical artifacts, [...] and how activities switch throughout the day" (p. 115). In order to answer these questions, Gonzalez and Mark examined different types of interactions with tendency and frequency of multitasking throughout the day.

2.4.2.1 Laboratory experiments

A laboratory experiment is a popular way to measure the external factors of multitasking. Here are a few examples of laboratory experiments employed in the exploration of external factors influencing humans' multitasking. Czerwinski et al. (2000) conducted laboratory experiments with 12 participants aged 25 to 49. The participants were asked to complete three tasks in order to compare two different types of searches on multitasking. The first task was scanning the list for the given title. The next task was scanning the list for the title of the book associated with a given description. And the last task was responding to the message by solving the math problem and then returning to the search task to continue until the correct book title was found. Their experiment results show that “receiving notifications reliably slowed down performance on the primary task of searching for a book title” and “searching for the title of the book was reliably faster than using the gist of what the title was” (Czerwinski et al., 2001, p. 359). Su and Mark (2008) also conducted laboratory experiments and found that the experiment results varied depending on the media and the duration time of each performed task. Consequently, the researchers reached a conclusion that synchronous events in which multiple events occur at the same time took longer compared to non-synchronous events where events occur one after another in a timely manner. In terms of organizational contexts, Su and Mark expected that communication patterns might differ depending on the communication partners' organizational context. Additionally, they also assumed that different media usage might also affect communication sequences. The experiment results support their assumptions that when information workers work from the outside, which has a distance from the office, the workers try to align to their colleague's media preferences by using a variety of media channels (Su and Mark, 2008).

2.4.2.2 Self-report method

In terms of examining external factors of multitasking, there is a great deal of research that has employed a self-report (self-logging) method. Benbunan-Fich et al. (2009b) employed a self-report method to collect participants' computer-based activities and to develop metrics for multitasking using a triangular structure through the lens of activity-based theory (Bødker, 1989, 1996; Kaptelinin, 1996; Nardi, 1996; Bendy et al., 2000; Kuutti, 2006; Kaptelinin & Nardi, 2006). Their participants were asked to produce a self-report manually on a standard form, which included "time, action (open/close/return), application, window (or tab) with file name or website name (if applicable), purpose on window, and reason for going to another window included all of their switches" (p. 11). Benbunan-Fich et al. tried to study users' multi-tasking behavior from a user-centric perspective. However, the researchers found limitations from the self-report data collection methods, which are based on information reported by the subjects themselves. Specifically, they described problems related to the process of manually tracking computer-based activities, which may have affected the flow of work of some participants and resulted in under reporting of some activities. Yet, the advantages of the self-report method have been reported: collecting detailed activities and tasks from participants and having less disruption by observers (Mackay and Watters, 2008). Mackay and Watters (2008) state that the advantage of a diary study for participants is having no disruptions by observers.

Deane et al. (1998) compared data estimates of information system usage between manually recorded self-report data and automatically recorded log data with the same criteria-task duration and task-switching frequency. Although the results showed that self-report data estimates were relatively accurate compared to the results using data log system, when the researchers closely compared the data results from each method, they found that the results showed different patterns: only log data showed a decreasing usage pattern over time for frequency and duration because ”there was a great deal of within sample variation in the log data” (p. 633). Based on the comparison between self-report and log data measures, Deane et al. (1998) suggest an integration of those two methods for measuring information system usage in order to strengthen the accuracy of data results. Deane et al. noted that the comparison result is only applicable to measuring time and duration of system usage. Therefore, a self-report method needs to be integrated with an auto-recording system to reduce biases from participants' involvement or interpretation while multitasking.

2.4.2.3 User testing with research prototype tools

In another examination of external factors, researchers developed prototypes of multitasking support tools to evaluate the effectiveness and usability of system designs. For example, Smith et al. (2003) conducted a longitudinal field study for seven to 10 days with five participants aged 20 to 60. Smith et al.'s (2003) field study examined efficiency and usability of *GroupBar*, which enables users to group and switch tasks with a single mouse click in the Microsoft Windows operating system (OS). In the field study, participants were asked to complete three tasks including "Spreadsheet, Joke, and Image" tasks simultaneously. When examining this method closely, the research procedure provides multitasking researchers effective ways to measure multitasking in a computing environment with usability testing methods: First, before the usability testing begins, the researchers allowed the participants to open and arrange three applications by tasks and layout and size the windows. Second, in order to assure that participants appropriately switched tasks, experimenters intervened at certain points. Specifically, while completing the three tasks, participants were asked to switch tasks five times. The usability testing procedure and requirements of the *GroupBar* research can be applied to general multitasking research, which aims to evaluate computing systems that support multitasking and to analyze users' multitasking strategies in computer environments. Another example of research prototype tools is Scalable Fabric: Flexible Task Management System, developed by Robertson et al., 2004. Compared to the example of GroupBar usability testing above, this prototype research evaluated the efficiency of design features and interfaces of the system that was created for supporting users' multitasking with consideration of attention using a "focus-plus-context display" (p. 85). The "focus-plus-context display" distinguishes a primary and periphery group of windows differently in order to classify windows based on priorities and allow for switching windows easily at a glance. Particularly, as computing environments become more complex by using multiple windows and displays, the necessity of developing innovative interface design that supports human multitasking has been addressed.

Robertson et al.'s (2004) research analyzed users' focus area, the location of the cursor (the drag point). The results showed that the arrangements and capacities of the physical displays affect users' choice of focus area location and size. Also, the results showed that some users using a triple-monitor display tend to define the central monitor as the focus area without any peripheral sections, and the side monitors as the side peripheral section. Consequently, this research provides specific criteria - scaling windows, arranging layouts, and applying color notifications - for the user testing methods to measure computer-based multitasking behaviors interacting with multiple screens and applications.

2.4.3 Summary

The previous section explores human multitasking literature on methods and findings of internal and external factors of human multitasking. To measure internal factors, multitasking researchers employed laboratory experiments and used the computational system of a cognitive architecture model. To measure external factors, researchers employed primarily laboratory experiments, self-report and user testing methods. The existing methods help researchers examine multitasking situations and tasks with specific criteria. However, the previous research showed limitations that researchers focused more on an independent factor rather than the interactions of multiple factors while multitasking. Based on multitasking literature in the sections above, I created Table 4 describing topics and criteria/methods of the internal and external factors of multitasking. In this section, the dominant topics and findings of previous multitasking research studies are interpreted by internal and external factors (see Table 2.4). In the next section, this study will propose a synthesis framework of internal and external factors of human multitasking.

	Internal Factors			External Factors		
Topics	Mental workload (Wickens, 2008)	Multimodal (Ferris & Sarter, 2008)	Parallel processing (Gilbert & Shalllice, 2002)	Multiple devices (Dearman & Pierce, 2008)	Interfaces (Smith et al., 2003; Mattews et al., 2006)	The number of platforms (Horvitz et al., 2003)
	Attention (Pasher et al., 2001; Iqbal et al., 2010)	Memory (Czerwinski et al., 2001)	Cognitive Process (Rubinstein & Evans, 2001)	Work spheres (Gonzalez & Mark, 2004; Kleinmann 2010)	Individual differences (Bluedorn & Lane, 1992)	Communication patterns (Su and Mark, 2008; Reinsch & Tinsley, 2008)
Criteria	Cue-based (Ophir et al., 2009)	Randomized-runs procedure (Altmann & Gray, 2008)	Time Spent (Altmann &Gray, 2008)	Information log (Su and Mark, 2008; Spink et al., 2007)	User testing prototype tools (Smith et al.,2003; Zacarias et al., 2007)	Single & multiple Web sessions (Kay & Watters, 2008)

Table 2.4: Topics, Criteria, and Methods of Internal and External Factors of Multitasking

2.4.4 Synthesis

According to previous literature, there have been efforts on integrating and measuring different types of factors. However, previous multitasking research usually examined either internal or external multitasking factors separately. Based on the literature review, this study will integrate the internal and external factors of humans' multitasking contexts with three layers from micro to macro perspectives. Based on the integration, this study will develop a conceptual framework for describing multiple layers of multitasking environments and their relationships (Figure 2.6). The synthesis framework of internal and external factors of users' multitasking context will consist of three different layers with respect, from a micro to macro perspective of human multitasking factors.

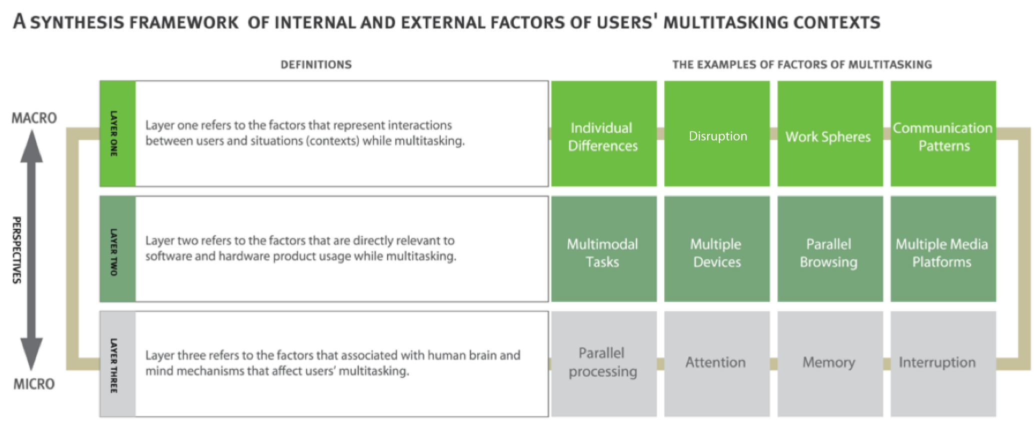


Figure 2.6: The Synthesis Framework of Internal and External Factors of Users' Multitasking Contexts (Park, 2011)

- Layer 1: The factors that represent interactions between humans and tasks (e.g., preferences of tasks, individual differences, balance between skills and challenges, work spheres, and communication patterns).
- Layer 2: The factors directly relevant to software and hardware interactions while multitasking (e.g., multimodal input, multiple devices, parallel browsing Web sessions, and multiple media platforms).
- Layer 3: The factors associated with human brain and mind mechanisms while multitasking (e.g., parallel processing, attention, memory, and cognitive interferences).

Human multitasking is a total set of human-information interaction. Various factors interact and affect human multitasking interchangeably from a micro to macro perspective; such as information resources, information processing, information technology systems, computing environments and communications. Therefore, the integrated human multitasking perspective is situated within the Information Studies field as an interdisciplinary practice. There has been little study focusing on the exploration of human multitasking in computer-mediated environments from an Information Studies perspective in addition to interaction design. Understanding human information behaviors in multitasking contexts may provide designers and researchers insights and help define users' needs in multitasking situations.

2.5 Multitasking and Flow

2.5.1 Previous Research on Negative Effects of Human Multitasking

Predominantly, researchers have studied the negative consequences of human multitasking. Researchers have focused on the causes of interruption while multitasking, such as the types of tasks, human characteristics, or communication patterns. Specifically, for example, social scientists have examined disruption factors in work spheres. Gonzalez and Mark (2004) have analyzed information workers' computer use logs to see how much time they spent on switching from one task to another. Czerwinski, Cutrell, and Horvitz (2000; 2001) have explored the effects of instant messaging and interruption on performances with different types of tasks. Cognitive psychologists have examined interruption factors such as cognitive control, mental resources, and information processing capabilities. For example, Iqbal and Bailey (2006) developed a model that can predict cost of interruption depending on characteristics of task structure. Su and Mark (2008) demonstrated that the media impacted the time duration for each performed task. With communication chain metrics, they measured between-tasks (chain) duration, chain length, media switches and organization switches. Su and Mark (2008) examined how interruptions affect communication chain properties. The results of the experiments suggest that external interruptions tend to compel people to switch to different and novel media combinations to accomplish goals derived from initial external communication acts. As multitasking becomes a more common behavior in computing environments, multitasking research needs to investigate the potential positive effects to extract factors that can evoke the advantages of multitasking such as flow experience. The meaning of flow experience will be explained in the next section.

2.5.2 Multitasking and Flow Perspectives

Csikszentmihalyi, a psychologist best known for his theory of flow, describes “Flow” as the state of experience in which people are fully involved in tasks with balancing between frustration and boredom. It also refers to optimal experience (Csikszentmihalyi, 1975): “Flow tends to occur when a person faces a clear set of goals that require appropriate immediate feedback to their actions and a balance of challenges and skills” (Csikszentmihalyi, 1997, p. 29). Flow has been studied for a decade in many fields such as psychology, HCI (Human-Computer

Interaction), consumer behaviors, information management systems, and business management. Specifically, researchers have studied flow in human-computer interactions such as computer-mediated environments (Finneran & Zhang, 2002; 2003), online environments (Novak et al., 1999), Web activities (Novak & Hoffman, 1997; Chen et al., 1999; Nel et al., 1999; Rettie, 2001; Skadberg & Kimmel, 2004), online learning (Pearce et al., 2005), and information technology use (Pilke, 2004).

Researchers have posited that the flow framework has three stages in general: flow antecedents, flow experience, and flow consequences (Ghani, 1991; Trevino & Webster, 1992; Ghani & Deshpande, 1994; Chen, 2000; Finneran & Zhang 2003). Based on Csikszentmihalyi's (1975) and Malone's (1981) definitions, flow researchers extracted five antecedents that characterize the flow state, those being balance of skill and challenge, control, attention focus, curiosity, and intrinsic interest. Hoffman and Novak (1996) measured skill and challenge congruence, telepresence, and focused attention to understand customers' experience of the Web usage. Nel et al. (1999) also measured users' website usage experience with flow antecedents while people are using commercial web sites. Trevino et al. (1999) have found that website usage and customer involvement are relevant to playfulness and enjoyment (flow constructs). Although human-computer interaction researchers have examined flow in computing environments, little study has focused on multitasking and flow experience.

In terms of research methods, the consideration of the contexts is critical to understand flow in human computer interactions (Finneran & Zhang, 2003). The self-recorded measurement without controlled and consistent settings has a limitation that cannot measure the effects of interactions between specific factors in computing environments (Hoffman & Novak, 1996; Pilke, 2004). In contrast, some studies have provided a specific website to measure flow experience in online environments (Skadberg and Kimmel, 2004). Chen et al. (1999) found that self-inspired involvement is the factor that most frequently yielded flow experience while using the Web (37.5%, n=96). Ghani (1995) has studied flow focusing on three constructs - the balance between skills and challenges, perceived control and cognitive spontaneity (Figure 2.7).

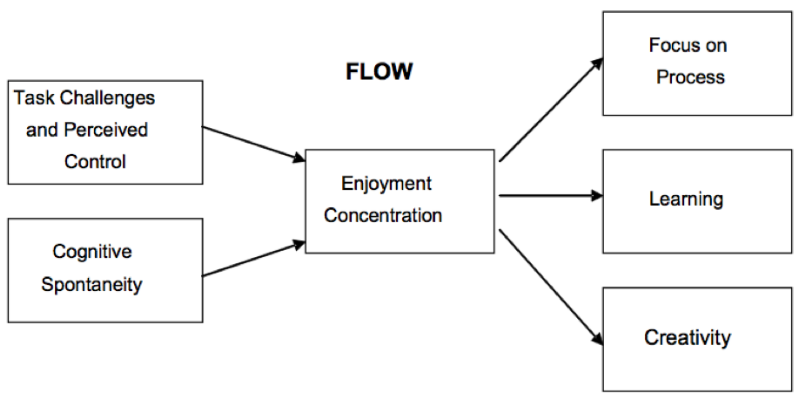


Figure 2.7: Model of Flow in Human Computer Interaction, adopted from Ghani, 1995, Finneran & Zhang, 2005, p. 84

In the context of multitasking, the complexity of computing interaction is increasing tremendously. Therefore, knowing the way of coordinating multiple tasks is crucial to help designers create a better user experience in computing environments.

Flow constructs are a suitable measurement that provide a way of examining positive experiences in multitasking environments. Flow focuses on users' experience in the process of events and the characteristics of flow is

Study	Contexts/Tasks	Flow Antecedents	Flow Consequences
Webster et al. (1993)	Characteristics of the software (Lotus 1-2-3 software)	Control Attention focus Curiosity Intrinsic interest	Playfulness Work outcomes
Ghani (1995)	Online environments	Balance of challenges and skills Perceived control Cognitive spontaneity	Focus on process Learning Creativity
Hoffman & Novak (2003)	Web usage	Flow Experiential vs. goal-directed Skill and challenge Novelty Importance	Compelling experience
Chen (2000)	Web activities -Researching on the Web -Discussing/debating on newsgroups -Reading/writing e-mail	Clear goals Immediate feedback Matched skills and challenges	Autotelic experience Positive affect
Skadberg & Kimmel (2004)	Web browsing	Balance between skills and challenges Skill: visitors knowledge of the website topic Challenge: web page content Telepresence Attractiveness -Experience with websites Interactivity -Speed -Ease of use	Increased learning changes of attitude and behavior
Pearce et al. (2005)	Online Learning	Challenge and skill mapping	Different flow patterns for different learners
Nel, Niekert, Berthon, and Davies (1999)	Web usage (commercial sites)	Control Attention focus Curiosity Intrinsic interest	

Table 2.5: Previous Flow research context, flow antecedents, and flow consequences

situational. That is, human multitasking is also affected by characteristics that may affect flow antecedents such as sense of control, focused attention, curiosity, intrinsic interest, and interactivity. If we can measure and analyze the factors of users' flow experience in multitasking, designers can develop systems that can help users multitask efficiently with less interruption and more flow experience. Therefore, the flow model is applicable to human multitasking research to conduct an experiment with in-situ conditions and to measure which factors and interactions significantly affect users' flow experience in multitasking environments. This dissertation study examined how multitasking factors affect users' flow experience in which people feel fully involved in tasks with a clear set of goals. Particularly, this dissertation study employed the PAT (Person - Artifact - Task) model (Finneran & Zhang, 2003) to extract situational multitasking factors. The PAT model allowed us to illustrate how these factors impact users' flow experience while multitasking in computer-mediated environments. The next chapter will introduce the PAT model and synthesize the PAT factors for the multitasking research.

Chapter 3

Theoretical Frameworks

3.1 PAT (Person-Artifact-Task) Model

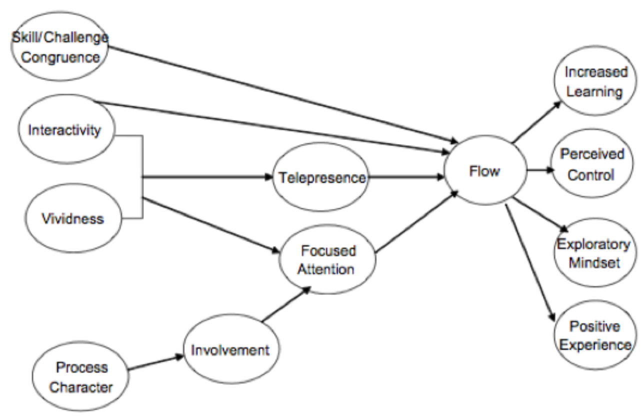


Figure 3.1: Conceptual Model of Flow within a Computer-Mediated Environment Adopted from Hoffman and Novak (1996), Finneran & Zhang (2005, p. 85).

Finneran and Zhang's (2003) PAT model provides a holistic point of view with a focus on flow antecedents (person, artifact and task), which examines flow experience in computer-mediated environments (Figure 3.2). The researchers claim that the interplay of three distinct but interacting components - person, task, and artifact factors - affect optimal experience. Unlike previous existing flow studies, the researchers differentiated the artifact factor from the task, because they claimed that an artifact is also an important factor that affects users' flow experience in computer-mediated environments (CMEs):

> "Within CMEs, the artifacts are not as simple to operate and usually are not completely within the users' control. Thus, an artifact plays a more prominent role in the entire experience because likelihood of its presence being noticed by the person is much higher. Secondly, the characteristics of the artifact itself may influence the likelihood of an optimal experience" (Finneran & Zhang, 2003, p. 480)

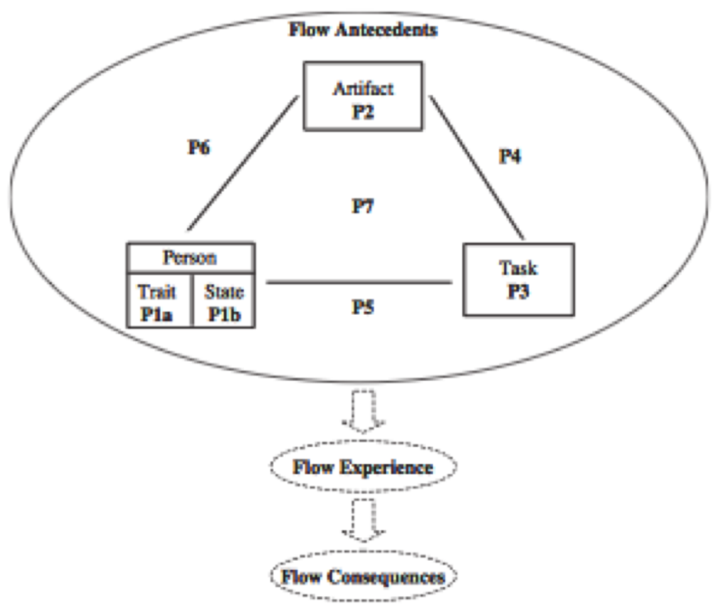


Figure 3.2: Adopted from Finneran & Zhang (2003): "Stages of flow and the person-artifact-task model of flow antecedents" (p. 479).

The PAT model describes the interaction between these three factors - person, artifacts, and tasks (Figure 3.2). However, the among seldom discuss how different conditions of each factor may affect the interplay of the flow antecedents and flow consequences significantly. Instead, their proposition focused on each component individually and the interaction between three flow antecedents in a broad manner. For example, "assuming all of the other components are the same, a person is more likely to experience flow if there is a clear fit between task and the artifact" (Finneran & Zhang, 2003, p. 487). In this case, the meaning of task and artifact is ambiguous and broad. Based on the PAT model, this dissertation study triangulates the components of the PAT (person, artifact and task) model to examine multitasking factors for flow experience in computer-mediated environments with an emphasis on motivation, artifacts, and task interconnectedness.

3.2 Multitasking PAT Factors

This dissertation study particularly focuses on humans' multitasking situations and emphasizes multitasking characteristics with three PAT factors: motivation as the Person component, technology affordance type as the Artifact component, and task interconnectedness as the Task component (Figure 3.3). This study employs the PAT model to integrate the three primary multitasking factors. In addition, each factor has two levels to examine how characteristics of each factor influence flow experience negatively or positively in multitasking conditions. This approach helps to analyze how the different conditions of the PAT factors and interactions significantly influence users' flow experience in multitasking environments.

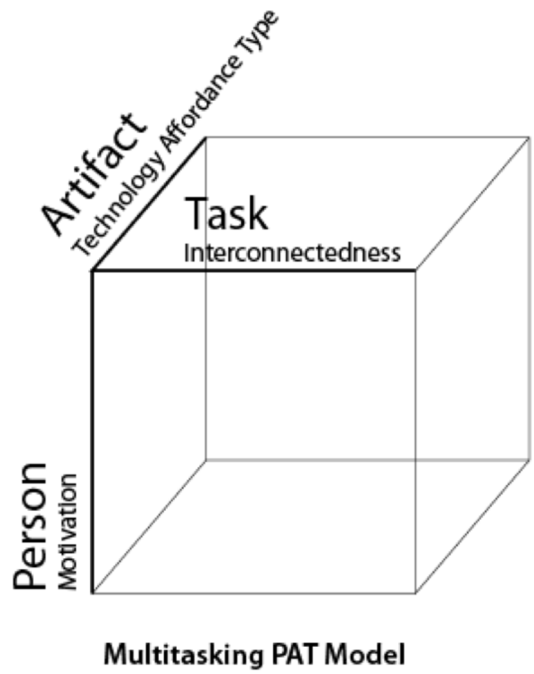


Figure 3.3: Multitasking PAT model for the study

3.2.1 The Person Factor: Motivation

The person factor in the PAT model originally refers to a person's characteristics and capability (Finneran & Zhang, 2003), such as one's balance of skills and challenges, and motivation. In this study, the person factor refers to motivation in multitasking environments. Self-determination theory explains motivation as a *self-determination continuum*, which ranges from amotivation to intrinsic motivation by the extent of how much the motivation is controlled by different types of regulations (Gagné & Deci, 2005). Several motivation theorists emphasize the importance of identifying motivation types. This is because the types of motivation appear to wield a great amount of influence. Indeed, within any motivational state, how one acts and whether one perceives the quality of an experience negatively or positively is influenced by the extent to which that state is self-determined (Ryan & Connell, 1989; Vallerand et al., 1992; Reeve, 2002; Reeve, 2005). According to Reeve (2005), environmental events and cues evoke humans' motivation either intrinsically or extrinsically, which results in changing actions (switching tasks). The researcher characterized motivation as a dynamic process that continually waxes and wanes (Reeve, 2005). These characteristics of motivation imply that motivation might play an important role in multitasking environments where conditions impel people to move back and forth from one task to another.

In this study, the Motivation factor has two levels: goal-directed motivation and experiential motivation. Goal-directed motivation in multitasking refers to a situation where people receive external goals and task orders, all of which are set by environmental conditions. In contrast, experiential motivation in multitasking refers to a situation where people have self-determined, inner-set goals and task orders. Novak and Hoffman (2003) distinguished between goal-directed behavior and experiential behavior to examine the influence of each on flow experience in online environments (Table 3.1).

Based on Novak and Hoffman's (2003) approach, this dissertation study focuses more on examining whether flow experience is affected differently by goal-directed motivation and experiential motivation in computer-mediated multitasking contexts with different task and artifact factors. Novak and Hoffman's (2003) study suggested that, within Web activities, flow experience could be an outcome of both

Distinctions Between Goal-Directed and Experiential Behavior

Goal-Directed	Experiential
Extrinsic motivation	Intrinsic motivation
Instrumental orientation	Ritualized orientation
Situational involvement	Enduring involvement
Utilitarian benefits/value	Hedonic benefits/value
Directed (prepurchase) search	Nondirected (ongoing) search;browsing
Goal-directed choice	Navigational choice
Cognitive	Affective
Work	Fun
Planned purchases; repurchasing	Compulsive shopping; impulse buys

Table 3.1: Distinction between goal-directed and experiential behavior. Adopted from Novak & Hoffman, 2003, p. 4

goal-directed and experiential types of activities. They found that experiential use of the Web was less likely to yield a flow than goal-directed use. However, Novak and Hoffman's study only focused on Web activities and did not examine flow experience in multitasking contexts. Novak and Hoffman (2003) claimed that researchers have yet to fully understand whether flow experiences are affected by the underlying construct values, such as goals and motivations.

3.2.2 The Artifact Factor: Technology Affordance Type

The term technology affordance type in this study refers to an intended function of technology, which notifies users with either a passive and active intervention to take an action (Conole and Dyke, 2004). This study provides two technology affordance types for an experiment: modal (active intervention) and non-modal (passive intervention) to examine the extent to which the forced pause and interplay between multitasking factors affect - positively or negatively - users' flow experience in multitasking. It might significantly affect the complexity of multitasking depending on the types of technology affordance that work differently in certain situations.

3.2.3 The Task Factor: Task Interconnectedness

Previous studies have examined flow experiences in various human-computer interaction contexts from specific website types to the Web and computer usage in general (Ho & Kuo, 2010; Finneran & Zhang, 2003; Nel et al., 1999; Skadberg & Kimmel, 2004; Webster et al., 1993). Few empirical studies on flow have specified task characteristics yet some researchers assigned task environments such as particular websites (Noort et al., 2012; Pearce et al., 2004; Skadberg & Kimmel, 2004) (Table 3.2). To understand flow during multitasking, a researcher should clearly consider and specify task characteristics so that the effect of task factor can be measured. Identifying task characteristics distinguishes the task factor from the artifact factor (e.g., the focus is different: task - writing an e-mail, artifact - email application). In terms of task characteristics, previous human-computer interaction studies have focused primarily on autonomy, variety, and complexity (Finneran & Zhang, 2003; Fleishman, 1975; Sims et al., 1976). These task characteristics may yield different levels of flow depending on each participant's balance of skills and challenges concerning certain tasks.

To operationalize the task variable, this study focuses on task interconnectedness among multiple tasks to quantify the multitasking research. Multitasking with high task interconnectedness and low task interconnectedness

Empirical Study	Task
Trevino and Webster (1992)	No task specified: general work communication
Ghani (1995)	Class assignment which required specific graphics software
Novak et al. (2000)	No task specified: general Web use
Chen (2000)	Use the Web for user-selected task
Huang (2003)	No task specified: regularly visited websites
Pearce et al (2004)	Learn about physics through online learning exercise website
Skadberg and Kimmel (2004)	Visit a tourism website for a particular place (Texas Coastal Bird Trail)
Noort et al. (2012)	Visit a well-known coffee brand website

Table 3.2: "Tasks the subjects are involved with for empirical flow studies" Adopted from Finneran & Zhang, 2005, p. 92 and updated.

may yield different effects on flow experiences. In empirical multitasking research, a researcher should specify task characteristics in a multitasking context; indeed, each task requires several actions towards a single goal or multiple goals. Goal-systems consist of two types of cognitive properties: structural and allocational. In particular, the structural property of goal-systems, interconnectedness, is a crucial factor that explains how tasks are connected to each other as well as the relationship between a user's cognitive process and interactions with multiple tasks. This dissertation study applies the interconnectedness concept in goal-systems theory to the task interconnectedness factor in multitasking with two levels: interconnected and disconnected tasks.

Chapter 4

Research Methodology

4.1 Research Questions

This dissertation study has three goals: 1) Examining to what extent the interplay of motivation, artifacts, and task interconnectedness affect users' flow experience, 2) better understanding users' multitasking patterns by analyzing approaches and strategies in multitasking environments through a participatory design session, and 3) deriving design insights and implications for desired multitasking environments based on findings from the quantitative and qualitative data analysis and synthesis.

To achieve these three goals, the research questions are as follows:

1. To what extent do person, artifact, and task (PAT) factors influence users' flow experiences in computer-mediated multitasking environments?

    - To what extent do person, artifact, and task factors affect sense of control in multitasking environments?
    - To what extent do person, artifact, and task factors affect focused attention in multitasking environments?
    - To what extent do person, artifact, and task factors affect curiosity in multitasking environments?

- To what extent do person, artifact, and task factors affect intrinsic interest in multitasking environments?
- To what extent do person, artifact, and task factors affect interactivity in multitasking environments?

2. How can we understand users' multitasking patterns such as approaches and strategies in computing environments?
3. What are the key insights and design implications that researchers and designers should take into consideration for to better coordinate a multitasking environment?

4.2 Research Methodology

In order to examine those three questions, the study employed the theoretical frameworks of the PAT (Person-Artifact-Task) model and flow model (Figure 4.1). The initial proposition for this study is to examine whether the motivation, technology affordance type, and task interconnectedness factors affect users' flow experience in computer-based multitasking environments. If we understand how the interplay of motivation, artifacts, and task interconnectedness affects users' flow experience differently, designers can provide effective user experience design for computing environments based on contexts such as online learning environments.

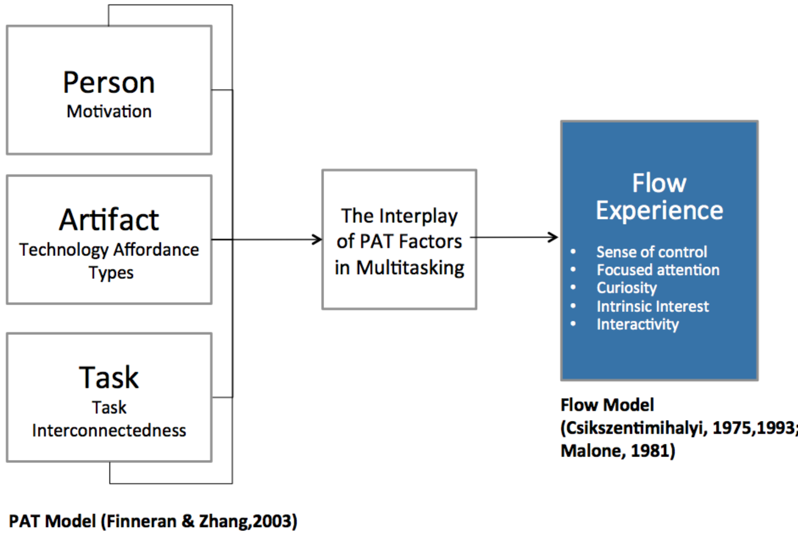


Figure 4.1: Research framework for this dissertation study

4.3 Operational Definitions

This section provides definitions of the independent variables and operational definitions of the dependent variables for Study I - experiment. In this study, the independent variables are motivation, technology affordance type, and task interconnectedness. The dependent variables are five flow constructs that include sense of control, focused attention, curiosity, intrinsic interest, and interactivity.

4.3.1 Independent Variables

This dissertation study has three independent variables: motivation, technology affordance type, and task interconnectedness.

4.3.1.1 IV 1: Motivation

The motivation variable has two levels: goal-directed and experiential motivation. These terms' definitions are given below.

- Goal-directed motivation refers to the state when people are asked to perform tasks with directed goals in a context where there are also specific task orders to follow within a pre-arranged setting. This condition has less freedom to change the artifacts and task orders and the monitor screen layout.

- Experiential motivation refers to the situation where people perform multiple tasks followed by a self-determined direction including task orders and the monitor screen layout without external restrictions.

4.3.1.2 IV 2: Technology affordance type

The technology affordance type variable has two levels: modal and non-modal types. The definitions of technology affordance type at two levels are described below.

- Modal: The modal condition notifies participants of a prompted new task with a separate pop-up window so that the participants can notice the task immediately and take an action. In the modal condition, users have to take an action whenever the modal window is shown.

- Non-modal: The non-modal condition does not provide any indication that shows a new task was given. Rather, users have to find a cue themselves and take an action as soon as they notice it.

4.3.1.3 IV 3: Task interconnectedness

The task interconnectedness variable has two levels: high task interconnectedness and low task interconnectedness. Their operationalized definitions are given below.

- Interconnectedness: This condition asks participants to perform highly interconnected tasks in terms of contents toward a single goal.
- Disconnectedness: This condition asks participants to perform disconnected tasks in terms of contents towards separate goals.

4.3.2 Dependent Variables

For this dissertation study, the dependent variables are the five antecedents of flow experience (i.e., sense of control, focused attention, curiosity, intrinsic interest, and interactivity). This dissertation study employed a 19-item scale to measure flow as a combination of 1) sense of control, 2) focused attention, 3) curiosity, 4) intrinsic interest, and 5) interactivity. The flow-measuring instrument (Appendix D) is modified from Webster and colleagues' (1993) flow measuring instrument and adapted and expanded a flow scale from Novak and Hoffman, (1998) that was based on the research of Ghani and Deshpande (1994) and Steuer (1992). This section will provide operationalized definitions of each dependent variable.

4.3.2.1 DV flow 1: Sense of Control

The definition of sense of control is operationalized as such: the extent to which people perceive the multitasking interactions with confidence and feel less ambiguous in terms of the task direction.

The sense of control variable refers to the state when people clearly and with confidence perceive their interactions with multiple tasks (Webster et al., 1993). Trevino et al. (1992) found that people felt a sense of control during the course of interactions with a Web browser, from exploring to exiting websites (Nel et al., 1999). According to Webster et al. (1993), in online environments control is associated with the user interface and feedback.

The three-item control scale is from Ghani and Deshpande (1994). The reliability of this particular construct has not been reported in the study. The definition of sense of control is operationalized as such:

Sense of Control (CO)

CO1 clearly know the right things to do/ feel confused about what to do

CO2 feel calm/ feel agitated

CO3 feel in control/ do not feel in control

The items were rated on a Likert-type scale, ranging from 1 = strongly disagree through 5 = strongly agree.

4.3.2.2 DV flow 2: Focused Attention

Focused attention is defined as that the state in which people perceive that their attention is fully focused on the interactions with multiple tasks. Csikszentmihalyi (1975) described focused attention as that state in which people become absorbed in an activity.

To measure the focused attention construct, this study adapted two items (FA1 and FA2) from Ghani and Deshpande's (1994) four-items scale and three additional items (FA3 and FA4) from Pearce et al.'s (2005) and Webster el al.'s (1993) flow-measuring scale. The definition of focused attention is operationalized:

Focused attention (FA)

FA1 While multitasking interactions, my attention is: focused / not focused

FA2 While multitasking interactions, I concentrate fully / do not concentrate fully

FA3 While multitasking interactions, I thought about other things

FA4 While multitasking interactions, I was aware of distractions

FA5 While multitasking interactions, I was totally absorbed in what I was doing

The items were rated on a Likert-type scale, ranging from 1 = strongly disagree through 5 = strongly agree.

4.3.2.3 DV flow 3: Curiosity

Curiosity is defined as that the extent to which people are willing to explore tasks towards the next phases. Manayangara and Toms (2010) noted that curiosity is related to a human's interest, novelty, and openness to new experiences. The researchers also found that curiosity plays a crucial role in motivation for multitasking - "those with a higher level of curiosity are more likely to be influenced by external stimuli and multitask" (p. 52). Malone (1981) suggested that "by varying the stimuli on the website, the sensory curiosity of the user may thus be stimulated" (Nel et al., 1999, p. 111).

To measure curiosity and intrinsic interest, this study adapted Webster et al.'s (1993) three items for each scale, which were adapted and expanded from Trevino and Webster (1992) and based on Csikszentmihalyi (1975), Malone (1980) and Sandelands et al. (1983). Webster et al.'s (1993) reliability of curiosity and intrinsic interest scale items measured by Cronbach's alpha was .82.

Curiosity (CU)

CU1 The conditions of the multitasking experiment excited my curiosity

CU2 Interacting with multiple tasks made me curious about the next step

CU3 The multitasking activities aroused my imagination

The items were rated on a Likert-type scale, ranging from 1 = strongly disagree through 5 = strongly agree.

4.3.2.4 DV flow 4: Intrinsic Interest

Intrinsic interest refers to when people find a multitasking interaction intrinsically interesting. One of the motivations for multitasking is entertainment, including web surfing without a specific purpose, listening to music, watching movies, playing a game, and reading digital books or comics. The capabilities of various functions in one computing device provide more options to choose. Kenyon (2005) found that people spent a great deal of time on entertainment (recreation) while multitasking.

Intrinsic Interest (II)

II1 Involving in multiple tasks on the computer system bored me

II2 Involving in multiple tasks was intrinsically interesting

II3 Involving in multiple tasks was fun for me to do

The items were rated on a Likert-type scale, ranging from 1 = strongly disagree through 5 = strongly agree.

4.3.2.5 DV flow 5: Interactivity

Interactivity is defined: The interactivity variable refers to how people perceive interactivity while multitasking. Steuer (1992) conceptualized interactivity as being composed of three parts: speed of the interaction, the mapping of the interaction (perceived natural and intuitive interaction), and the range of the interaction (possible numbers for action) at a given time.

In addition to Wesbter et al.'s (1993) four dimensions of flow construct (sense of control, focused attention, intrinsic interest and curiosity), this study included the interactivity dimension with the five-item scale, which were modified based on Steuer's (2012) six-item scale in order to adjust items for the multitasking experiments. Steuer (1992) conceptualized the interactivity scale as three-parts: speed of the interaction (IA1), the mapping of the interaction (perceived natural and intuitive interaction; IA2-IA3), and the range of the interaction (possible numbers for action at a given time; IA4-IA5). The reliability of interactivity construct measured by Cronbach's alpha is .627 (Novak & Hoffman, 1998):

Interactivity (IA)

IA1 Interacting with the multiple tasks is slow and tedious

IA2 Navigating multiple tasks with the computer system is not very intuitive

IA3 The computer system allows me to navigate the multiple tasks in a natural and predictable manner

IA4 The range of what can be manipulated on the computer screen is narrow

IA5 At any time, there are many different actions available to me as I use the computer system

The items were rated on a Likert-type scale, ranging from 1 = strongly disagree through 5 = strongly agree.

4.4 Research Design

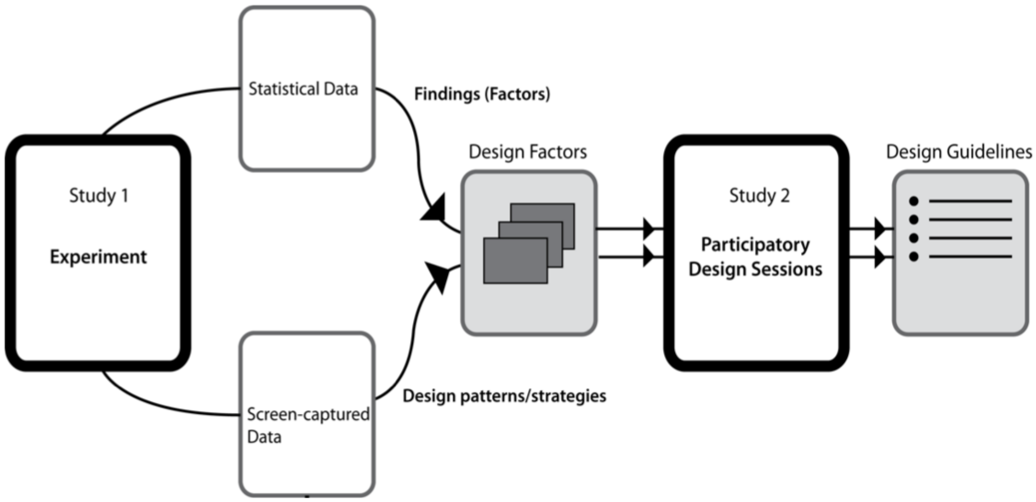


Figure 4.2: Research design

For this dissertation study, two research methodologies were employed: an experiment and the participatory design method. First, I conducted an experiment to examine the effects of PAT factors on users' flow experience. Next, the participatory design method was employed to come up with design guidelines and implications based on extracting users' interaction strategies in multitasking environments (Figure 4.2). Detailed information on each method - experiment and participatory design - will follow in the next chapter.

Chapter 5

Study I - Experiment

This chapter explains the experiment design, which includes participants, experiment procedure, tasks and conditions, and controlled time. In addition, the data collection method and data resources are also described.

5.1 Experiment design

This dissertation study used an experiment to examine how the interplay of person, artifact, and task factors affects users' flow experience in computer-mediated multitasking environments. A mixed design was employed with one repeated-measure variable (task interconnectedness) and two between-subject variables (motivation and technology affordance type). Each variable has two levels:

- Motivation (between-subject variable): goal-directed and experiential
- Technology Affordance Types (between-subject variable): modal and non-modal
- Task interconnectedness (within-subjects variable): interconnected and disconnected

5.1.1 Participants

This study examined eight different multitasking conditions with the combinations of multitasking PAT factors (Table 5.1). A total of 40 participants took part in the experiment (N=40; Year of birth; M=1988, S.D=5.59). Each participant took part in two different conditions, one after another. Given that the task connectedness factor was a repeated-measures task, two different sets of tasks were needed for the disconnected and interconnected task conditions. Each participant worked individually. Random assignment was applied to assign participants to each experimental group. To avoid the learning effect, this study counter-balanced the order of sessions between the interconnected and disconnected condition (Cozby & Bates, 2012; Shaughnessy et al., 2012).

5.1.2 Procedure

Upon entering the lab, each participant was asked to read a consent form and to answer pre-test questionnaires about the participant's demographic information and multitasking preferences (Appendix E). Next, the participants were given introductory material and they then participated in two experiment sessions. After completing the pre-experiment questionnaire, subjects' flow experience in multitasking was measured at two points: after going through the first condition session and after going through the second condition session. The first and second condition session was counter-balanced for order (Figure 5.1).

Each session provided three primary multitasking tasks such as a document-editing task, web-searching task, and a media task in addition to a

Counter-balanced for order	Motivation (P)	Technology Affordance Type (A)	Task Interconnectedness (T)	Number of Participants
Condition 1	Experiential	Modal	Interconnected	12 participants (M=1988.75, S.D=5.207)
Condition 2	Experiential	Modal	Disconnected	
Condition 3	Goal-directed	Modal	Interconnected	9 participants (M=1990.22, S.D=7.120)
Condition 4	Goal-directed	Modal	Disconnected	
Condition 5	Experiential	Non-modal	Interconnected	11 participants (M=1987.82, S.D=5.193)
Condition 6	Experiential	Non-modal	Disconnected	
Condition 7	Goal-directed	Non-modal	Interconnected	8 participants (M=1987.38, S.D=5.193)
Condition 8	Goal-directed	Non-modal	Disconnected	
Total				40 participants (M=1988.55 S.D=5.866)

Table 5.1: Eight experimental conditions

secondary task (a prompted email task). In order to gather qualitative data, all experiment sessions were video-captured. Additionally, following the sessions, participants were asked to complete post-test questionnaires to determine flow experience (sense of control, focused attention, curiosity, intrinsic interest and interactivity) (Appendix F). Participants completed tasks using a PC platform with the screen-capture software (Morae and QuickTime) installed, and the screen was recorded for these test sessions. Each experiment session lasted no more than 30 minutes including completion of the post-questionnaires. That is, two experiment sessions for one participant took approximately one hour. During the experiment, the facilitator, in a different room, shared the subject's monitor screen. To observe the subject's task activities, remote screen-sharing software was installed on the computer. At the end of the each session, the participants were asked to fill out questionnaires on flow so that participants could perform their tasks without being interrupted to fill out the questionnaires during the experiment sessions. After completing the two experiment sessions, a post-experiment semi-structured interview was conducted so as to ascertain their satisfaction and frustration experience while performing the tasks in the two conditions.

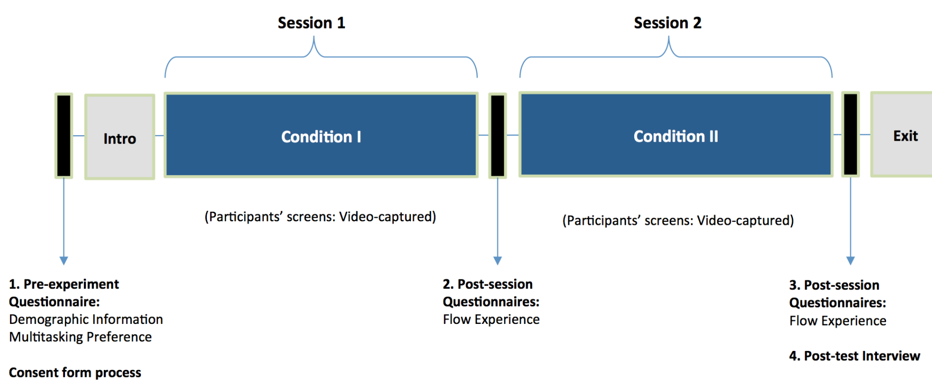


Figure 5.1: Experiment procedure

5.1.3 Tasks

In this study, we used applied tasks, which represent real-world computing environments such as online learning environments (Panepino, 2009; Salvucci and Taatgen, 2010). Each experiment session provided a document-editing (Set A or B), Web-browsing, and media-searching task and asked participants to complete those tasks within 20 minutes. A secondary task included handling a series of prompted email tasks, to keep people multitasking. The prompted emails were sent three times during each session. Salvucci and Taatgen (2011) claimed that procedural, declarative, and perceptual-motor interference can all affect user behavior, and thus should be understood in guiding system design. The researchers found that minimizing learning and memory load reduces interference from humans' hidden cognitive processing while multitasking. Thus, to prevent humans' cognitive interference while multitasking, experiments for this dissertation study minimize participants' learning, memory load, and reconstruction process.

5.1.3.1 Document-editing task (A set)

The document-editing task (A set) has a combined task set of a document-editing and Web-browsing task. One Word document was provided with two sub-tasks inside (Figure 5.2).

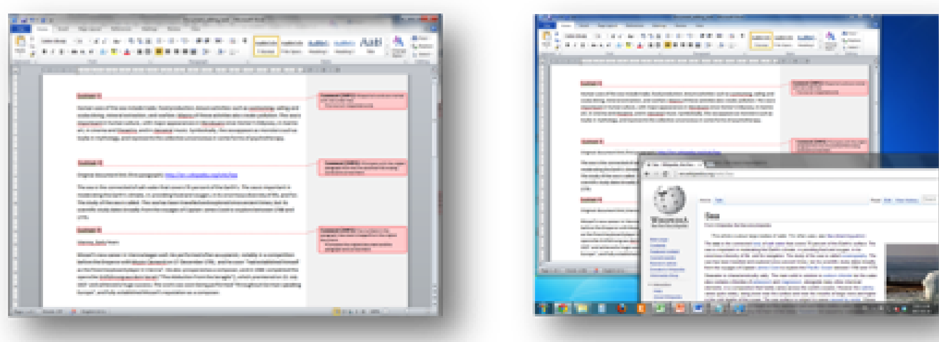


Figure 5.2: Document editing task A

The participants edited the document based on the two comments (sub-tasks). The two document-editing tasks were simple ones, requiring no prior experience. To begin the document-editing task (A set), participants had to open a Web browser to compare and reference the information and edit the original document to follow the task instruction. This task required using installed desktop programs and the Web browser (i.e., Word program and the Chrome Web browser).

5.1.3.2 Document-editing task (B set)

The document-editing task (B set) is another combined task set, which includes document editing and Web-browsing tasks (Figure 5.3). This task set required participants to seek specific information to fill out information in the Excel document. Participants also had to open a Web browser to compare and reference the information and edit the original document to complete the tasks.

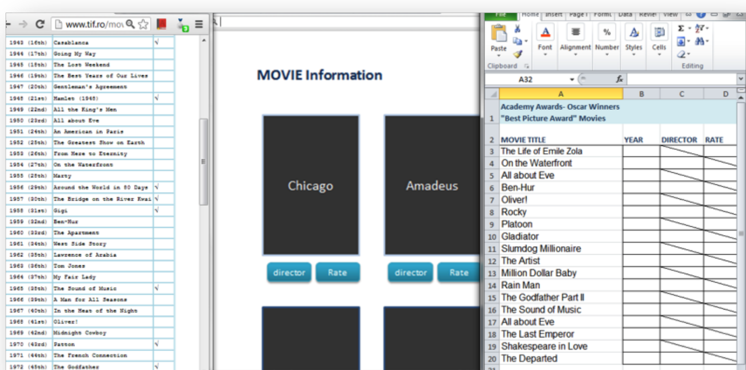


Figure 5.3: Document editing task B

5.1.3.3 Media task

The media-search task asked participants to watch one video clip (each video runs for three to four minutes) and answer questions based on what they have watched in the given video clip (Figure 5.4). The participants were allowed to take notes using the Word program.

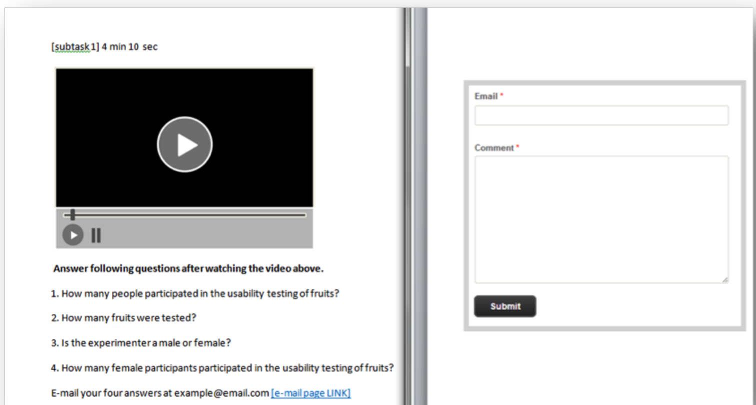


Figure 5.4: Media task

5.1.4 Secondary Task

5.1.4.1 Prompted E-mail task

Throughout the tasks, prompted email messages occasionally arrived to provide a multitasking condition. In each session, participants were prompted by three emails. The facilitator, at the beginning of the experiment, notified participants that e-mail messages might include important task instructions, which requires the subject's immediate attention.

5.1.4.2 Notification pop-up window

Depending on the condition of technology affordance types, the arrival of the new email informed participants in a different way. In non-modal condition groups, the notification message was not shown, thus participants had to set their ways to keep track of emails to avoid missing emails. On the other hand, the modal-condition group was asked to provide immediate reaction to the pop-up notification. That is, as soon as the participants noticed the notification window, they were required to check the emails.

5.1.5 Conditions

5.1.5.1 IV 1: Motivation

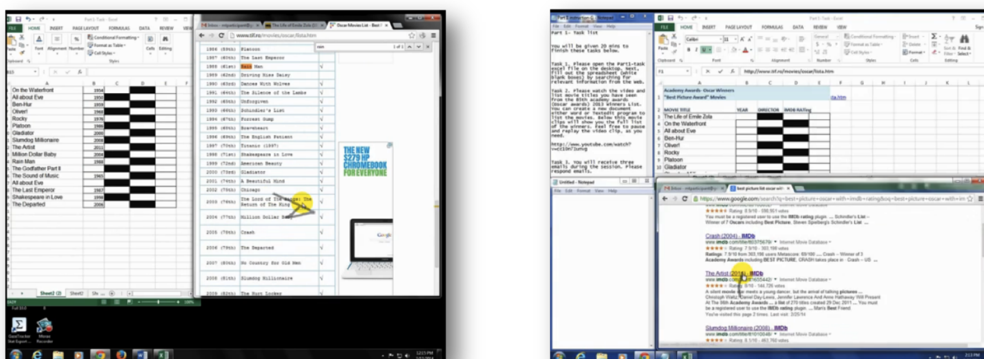
For the person (motivation) factor, there were two conditions: goal-directed and experiential motivation. Goal-directed motivation refers to when participants had to follow specific directions and task orders within the pre-arranged computing settings. The experiential motivation condition refers to the situation where participants were free to switch from one task to another at any time within participants' self-determined window composition on the computer screen (Figure 5.5).

- Goal-directed Motivation:

  For the goal-directed motivation treatment, this study provided list-instructions on the screen so that the participants could follow the instructions step-by-step. Directions provided participants information on how to follow the tasks and directions. Participants were able to switch from one task to another only when the system indicated to do so.

- Experiential Motivation:

  All required tasks were presented on screen at the beginning of the session with context-based instruction. In this condition, the participants had the freedom to determine the task order and directions. This condition allowed participants to switch tasks at any time.



(a) Experiential motivation: Self-determined layouts and task orders

(b) Goal-directed motivation: Pre-arranged layouts with directed task orders

Figure 5.5: Experiential and goal-directed motivation conditions

5.1.5.2 IV 2: Technology affordance type

The artifact (technology affordance type) factor also had two conditions: modal vs. non-modal. Modal is applied to ask participants to check the prompted email message immediately showing up via a separate notification on the screen.

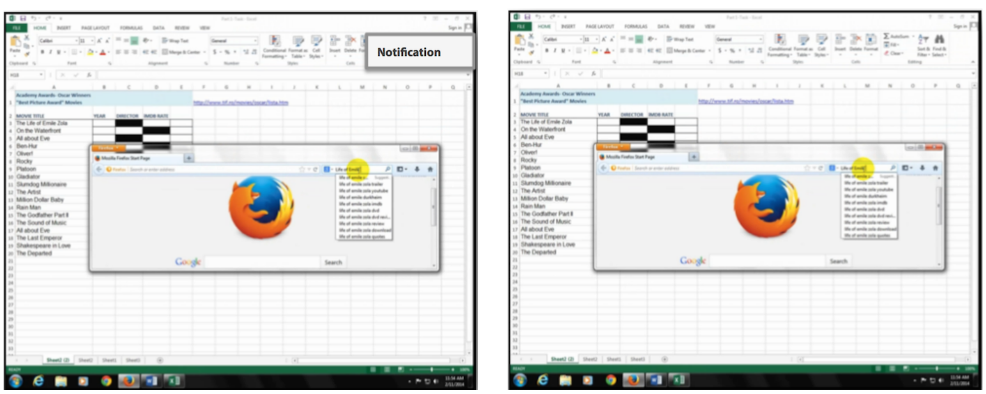
On the other hand, the non-modal condition is used when there is no particular separate window notification for prompted messages (Figure 5.6).

- Modal:

  The modal condition provides a small separate dialogue box on the screen to notify participants of the arrival of the new email so that the participant can pay attention to the secondary task immediately.

- Non-modal:

  The non-modal condition does not provide any separate notification window for secondary tasks.



(a) Modal: Email notification enabled (b) Modal: Email notification disabled

Figure 5.6: Modal and non-modal conditions

5.1.5.3 IV 3: Task interconnectedness

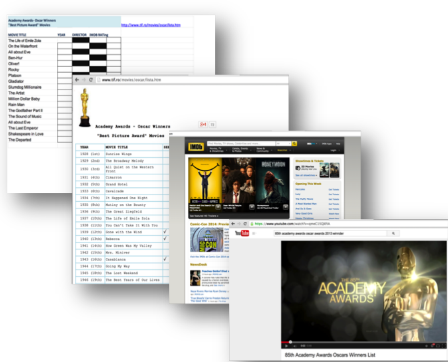
There were two conditions for the task interconnectedness variable: interconnectedness and disconnectedness. The interconnectedness task condition asked participants to perform tasks, which were highly connected in terms of contents' theme. The disconnectedness task condition provided independent tasks, which were not connected to each other in terms of content topics (Figure 5.7).

- Interconnected task condition:

  This condition asked participants to perform multiple interconnected tasks in terms of the content theme toward a single goal.

- Disconnectedness condition:

  This condition asked participants to perform multiple disconnected tasks towards separate goals.



(a) Interconnected Tasks: Connected tasks with a same topic (Movies)

(b) Disconnected Tasks: Disconnected tasks with different topics (Sea, Mozarts, Fruits)

Figure 5.7: Interconnected tasks and disconnected tasks conditions.

5.1.5.4 Controlled time

To prevent participants from being idle or focused on only one task, three prompted emails were sent at random times (sequences), specifically, no sooner than 2 minutes and no later than 6 minutes from the last email was sent during one experiment session. Also, each experiment session provided 20 minutes to complete the tasks, which was set based on the average time for completing one session.

5.1.6 Pilot Study

The experiment condition settings above were designed based on a mini pilot study with two participants. The pilot study findings provided an opportunity to understand which parts should be improved and changed for the Study I experiment.

First, task instructions were refined for the document-editing task. The pilot study found that the instruction did not provide enough context for exhibiting the subjects' multitasking behavior. For example, when one participant was asked to edit two paragraphs based on the original paragraphs that were given, he copied the whole paragraph at once and pasted it, which took him a couple of seconds to complete the task. Thus, the instruction was revised by adding a restriction that participants can copy and paste a maximum of two to three words at once, and not a whole paragraph. Second, emails changed from two prompted emails to three emails. The secondary tasks aimed to keep participants engaging in multiple tasks. However, the pilot study showed that two prompted emails are not enough to provide multitasking contexts, whereas three prompted emails provides the suitable balance and intervals between the main tasks and secondary tasks. Third, based on the pilot study, the maximum time for one session was limited to 20 mins. Fourth, for the motivation condition, which controls the extent of self-determination, the pilot study found that providing only the direction of task orders does not show the big difference between the goal-directed and experiential condition. Therefore, a pre-arranged window setting is also provided in addition to task orders for the goal-directed motivation setting. Based on these four findings from the pilot study, Study I (experiment) was designed. In the next section, the details of Study I (experiment) data collection are described.

5.2 Study I : Data Collection

5.2.1 Pre-Experiment Questionnaire

Before participants commenced the experiment, they were asked to fill out the pre-experiment questionnaire so their demographic information and multitasking preferences and tendencies could be recorded. This study used the polychronicity scale, which can measure the extent of multitasking preference and tendency. Polychronicity is defined as the comfort people feel with working on multiple activities and their preference to perform multiple tasks simultaneously (Kaufman-Scarborough & Lindquist, 1999). Previous research developed polychronicity-measuring scales and demonstrated that the polychronic characteristic was measurable (Kleinman, 2010). For the pre-experiment questionnaire, this study employed polychronic-monochronic tendency scale (PMTS), developed by Lindquist and Kaufman-Scarborough (2007) and indicated as having the highest reliability (Cronbach's alpha: .93) among existing polychronicity measuring instruments (Appendix E).

5.2.2 Post-Experiment Questionnaire

After each session was complete, participants were asked to fill out the post-test questionnaire, which was appeared on participants' monitor screens. The objective of the questionnaires is to measure flow antecedents depending on eight different conditions with motivation, technology affordance type, and task interconnectedness factors in computer-mediated multitasking environments. The operational definitions were described in Section 4.3.2 (Appendix F). Each questionnaire in the flow experiment measurement instrument was rated based on 5 Likert-scale strongly disagree (1) to strongly agree (5).

5.2.3 Semi-Structured Interview

To gain an in-depth understanding of multitasking strategy in situated multitasking contexts, this study conducted a 10-minute, semi-structured interview after the experiment. The open-ended questions addressed participants' multitasking strategy, suggestions to improve multitasking environments, and overall user experience and satisfaction with the experiment's contexts and tasks.

5.3 Experiment Results and Analysis

Forty participants' experiment results were analyzed using Repeated Measures Analysis of Variance (RM-ANOVA) with one repeated-measure independent variable (Task Interconnectedness) and two between-subject independent variables (Motivation and Technology Affordance Types). The descriptive statistics of four groups in two task conditions are summarized in Table 5.2 and 5.3. The multivariate test analysis revealed that each factorial group (here Motivation and Artifact by Task) has a separate mean on the flow measures.

		Interconnected tasks (T1)					
Group	N	Control	Focus	Curiosity	Intrinsic Interest	Inter-activity	Flow
Experiential Motivation × Non-modal	11	8.64 (.35)	20.82 (1.07)	10.00 (2.191)	15.18 (.72)	13.91 (.98)	68.55 (2.17)
Experiential Motivation × Modal	12	8.42 (.34)	17.50 (1.02)	10.92 (1.782)	15.42 (.69)	15.33 (.94)	67.58 (2.08)
Goal-directed Motivation × Non-modal	9	9.00 (.39)	16.22 (1.18)	11.89 (1.364)	16.11 (.80)	16.11 (1.08)	69.33 (2.40)
Goal-directed Motivation × Modal	8	8.50 (.41)	18.39 (1.25)	10.63 (2.925)	14.75 (.85)	13.38 (1.15)	65.64 (2.54)
Total	40	8.63 (1.15)	18.30 (3.82)	10.83 (2.12)	15.38 (2.35)	14.73 (3.30)	67.85 (7.03)

Table 5.2: Descriptive statistics from four experimental conditions - Interconnected tasks (T1). Means and standard deviation in parentheses

The results include two sets of post-questionnaire responses from two separate motivation conditions. The subjects' post-test survey after each experiment was collected and analyzed along with pre-questionnaires including demographics and multitasking preferences. Negative questionnaires were reversed to keep the consistency of the numeric value of responses. That is, questionnaire answers corresponding with "strongly agree–5" represents the highest value and "strongly disagree–1" is calculated as the lowest value. Each flow construct was coded by combining items for each construct and analyzed by RM-ANOVA

(Bordens & Abbott, 2008), a coding and analysis method that was recommended by consultants from the Division of Statistics and Scientific Computation at The University of Texas at Austin. The interval scale data were rated on a Likert-type scale, ranging from 1 = strongly disagree through 5 = strongly agree.

		Disconnected tasks (T1)					
Group	N	Control	Focus	Curiosity	Intrinsic Interest	Inter-activity	Flow
Experiential Motivation × Non-modal	11	7.55 (.32)	19.55 (1.08)	10.00 (1.732)	15.00 (.62)	14.82 (1.01)	66.91 (2.17)
Experiential Motivation × Modal	12	8.50 (.31)	15.50 (1.04)	10.25 (2.261)	15.42 (.60)	14.67 (.97)	64.34 (2.19)
Goal-directed Motivation × Non-modal	9	9.22 (.36)	18.00 (1.20)	12.11 (1.616)	16.44 (.69)	170.00 (1.12)	72.778 (2.52)
Goal-directed Motivation × Modal	8	8.63 (.38)	18.86 (1.27)	10.50 (2.507)	15.00 (.73)	14.13 (1.18)	67.13 (2.68)
Total	40	8.43 (1.20)	17.85 (3.82)	10.65 (2.13)	15.45 (2.06)	15.13 (3.38)	67.05 (7.91)

Table 5.3: Descriptive statistics from four experimental conditions - Disconnected tasks (T2). Means and standard deviation in parentheses

To measure the Sense of Control construct, Q1 and Q2 responses were combined to calculate the mean score for Sense of Control. The mean score is a sum of two scaled questions, where that sum, X, is $2 < X < 10$, so the mean scores on the two Sense of Control questions were 8.63 (interconnected task condition) and 8.43 (disconnected task condition). For Focused Attention, the mean score is a sum of five scaled questions (Q3- Q7), where that sum, X, is $5 < X < 25$ and the mean scores on the five Focused Attention questions are 18.30 (interconnected task condition) and 17.85 (disconnected task condition). The items from Q8 to Q10 for curiosity were measured, so the mean score is a sum of three scaled questions, where that sum, X, is $3 < X < 15$ and the mean scores on the three Curiosity questions are 10.83 (interconnected task condition) and 10.65 (disconnected task condition). To measure the Intrinsic Interest construct, the same approach was applied that the mean scores are the sums of four scaled questions from Q11 to Q14, where the sum, X, is $4 < X < 20$, and the mean scores are 15.38 (interconnected task condition) and 15.45 (disconnected task condition). The Interactivity construct was also measure by combining the items from Q15 to Q18, the mean score is a sum of four scaled questions, where that sum, X, is $4 < X < 20$, 14.78 (interconnected task condition) and 15.13 (disconnected task condition). All 18 items are composed to measure flow as a single variable, the mean score is a sum of 18 scaled questions, that sum, X, is $18 < X < 90$ and the mean scores are 67.85 (interconnected task condition) and 67.05 (disconnected task condition). The reliability of questionnaires for each research construct scale items measured by Cronbach's alpha ranged from 0.647 to 0.906 (Table 5.4). Four out of five construct measurements exceeded the recommended threshold value of .60 (Fornell & Larcker, 1981). Since each variable has two levels of repeated measures, sphericity is not evaluated because the sphericity assumption is always met if a repeated measures factor has only two levels (Hilton et al., 2004; Keselman et al., 2001).

Research Construct	Cronbach's Alpha
Sense of Control (Q1-2)	.647
Focused Attention (Q3-7)	.858
Curiosity (Q8-10)	.813
Intrinsic Interest (Q11-14)	.791
Interactivity (Q15-18)	.906
Flow (composition of Q1-Q18)	.837

Table 5.4: Reliability of flow research constructs and questionnaires

The study investigated a hypothesis that three factors - motivation, artifact, and task - affect flow experience in multitasking environments. To address this question, 40 subjects were chosen at random and divided into 4 groups. The subjects were randomly assigned to one of 4 groups. The study was conducted between January 2014, and March 2014. Participants were asked to read the consent form before they started the experiment. Subjects in both the experiential and goal-directed motivation groups were verbally introduced to the procedure of the tasks with a copy of the task instruction. Besides, participants who were assigned to a goal-directed motivation group had a task direction displayed on the monitor screen and asked to follow the task orders.

5.3.1 Flow Construct 1: Sense of Control

The experiment results revealed that the interaction between the task interconnectedness and motivation factor significantly affects sense of control, $F(1, 36) = 4.701, p < .05$. A three-way - 2 (motivation) $\times$ 2 (technology affordance technology) $\times$ 2 (task interconnectedness) - analysis of variance (ANOVA) was calculated on participants' sense of control. The descriptive statistics data on sense of control is reported in Table 5.5.

Sense of Control	Interconnected Tasks		Disconnected Tasks	
	Non-modal	Modal	Non-modal	Modal
Experiential motivation				
N	11	12	11	12
Mean	8.636	8.417	7.546	8.500
S.D.	1.286	0.793	1.128	1.087
Goal-directed motivation				
N	9	8	9	8
Mean	9.000	8.500	9.222	8.625
S.D.	1.658	0.756	1.092	0.916
Total				
N	40		40	
Mean	8.63		8.43	
S.D.	1.15		1.20	

Table 5.5: Descriptive statistics table of Participants' Sense of Control

There was a significant effect of three-way interactions for sense of control, $F(1,36) = 4.140, p < .05$. This supports the hypothesis: the interplay of motivation and task factor affects flow experience, specifically sense of control. Whereas, there was no significant main effect for the motivation factor, $F(1,36) = 3.018, p = .091$, the technology affordance type factor, $F(1,36) = .078, p = .781$, and the task interconnectedness factor, $F(1,36) = 1.117, p = .298$ (Table 5.6).

The results show the significant effect of task by motivation ($F(1,36) = 4.701, p < .05$) on sense of control within-subjects. The effect of motivation factor was significantly different for disconnected tasks than for interconnected tasks, with the sense of control being higher for disconnected tasks in the experiential motivation condition but lower in the goal-directed motivation

	SS	df	MS	F	Sig.
Within-subjects					
task	.531	1	.531	1.117	.298
task×motivation	2.236	1	2.236	4.701	.037*
task×artifact	1.413	1	1.413	2.971	.093
task×motivation×artifact	1.970	1	1.970	4.140	.049*
Error (tasks)	17.128	36	.476		
Between-subjects					
motivation	6.612	1	6.612	3.018	.091
artifact	.160	1	.160	.078	.781
motivation×artifact	4.090	1	4.090	2.003	.166
Error	73.492	36	2.041		

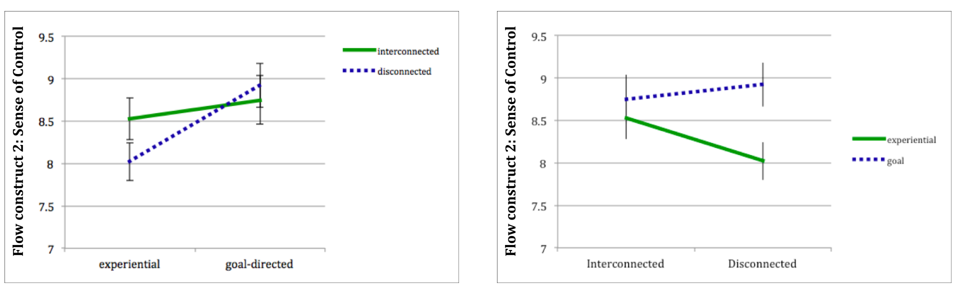
Notes: SS = Type III Sum of Squares, and MS = Mean Square
* $p < .05$

Table 5.6: Sense of Control (DV) RM-ANOVA summary table

setting. The post-hoc decomposition was calculated for significant interactions by interpreting pair-wise comparisons and plots for two-way interaction and three-way interaction in the following sections.

For two-way interaction, motivation levels by task interconnectedness affect sense of control. Specifically, goal-directed motivation setting in disconnected tasks had positive effects on sense of control, S.E. $= .342, p < .05$ (Figure 5.8 (a)). That is, having a clear direction with a pre-arranged layout on a computer helped participants to feel more sense of control when they performed disconnected tasks. For two-way interaction, task connectedness within experiential motivation showed a significant effect on sense of control. Engaging in interconnected tasks in the experiential motivation condition, in which participants coordinated the layout on screen and set task orders by self-inspired means, affected sense of control positively ($S.E. = .204, p < .05$). Whereas, the goal-directed condition did not help sense of control significantly when people performed interconnected tasks. In an interconnected task condition, the experiential condition helped participants feel a higher sense of control than the goal-directed condition. In the disconnected task condition, the goal-directed condition showed a much higher sense of control than in the experiential condition. Specifically, performing disconnected tasks resulted in a higher sense of control than interconnected tasks in goal-directed environments (Figure 5.8 (a) and (b)). The interconnected task condition resulted in a higher sense of control than undergoing disconnected tasks in an experiential condition.

For three-way interaction, performing disconnected tasks within non-modal conditions, motivation levels significantly affected sense of control. The interaction of task, motivation, and technology affordance type factors significantly affect sense of control, $F(1, 36) = 4.701; p < .05$.



(a) Motivation by task interaction in non modal condition - sense of control ($p < .05$)

(b) Task by motivation in non-modal condition - sense of control ($p < .05$)

Figure 5.8: Sense of control by two way interaction

In Figure 5.9, the plot illustrates that the technology affordance type, whether there is a modal notification window played an important role when it comes to sense of control in multitasking conditions. When tasks are disconnected from each other, disabling the notification window is helpful in a goal-directed condition (Figure 5.9). That is, people experience a higher sense of control when there is a goal-directed instruction available on the screen in pre-arranged windows while they are engaged in disconnected tasks without push notifications.

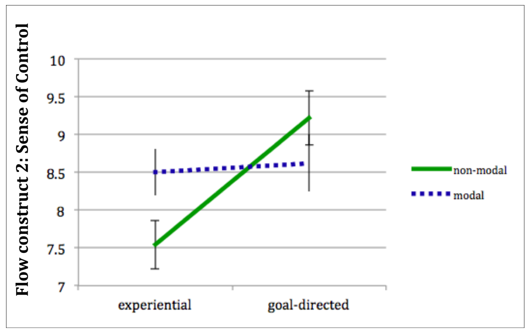


Figure 5.9: Motivation by technology affordance types in disconnected task condition - Sense of control ($p < .05$)

That is, people experience a higher sense of control when there is a goal-directed instruction available on the screen in pre-arranged windows while they are engaged in disconnected tasks without push notifications. Within an experiential motivation condition having non-modal, task interconnectedness affected sense of control significantly (performing connected tasks positively affected sense of control (S.E. = .481, $p < .005$). The graph in Figure 5.9 also shows that sense of control is much higher when there is no modal notification within the goal-directed condition than in performing disconnected tasks within the experiential motivation condition without modal notification.

In Figure 5.10, the plot illustrates that performing disconnected tasks within the experiential motivation condition, technology affordance types significantly affected sense of control. That is, having a modal factor positively affected sense of control (S.E. = .446, $p < .05$).

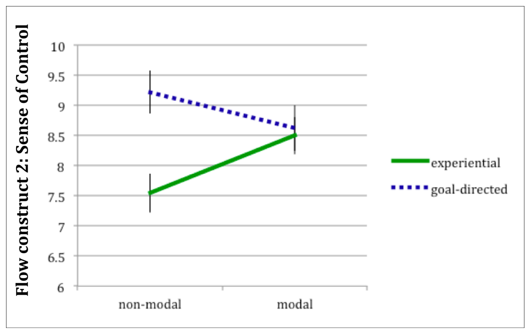


Figure 5.10: Technology affordance types by motivation in disconnected task (sense of control) ($p < .05$)

For three-way interaction, within the experiential motivation condition having non-modal, task interconnectedness levels affect sense of control significantly (performing interconnected tasks positively affected sense of control (S.E. = .294, $p < .005$) (Figure 5.11).

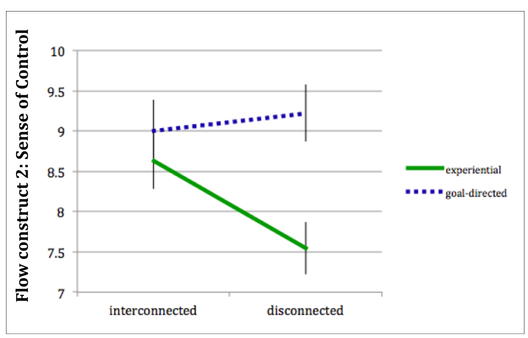
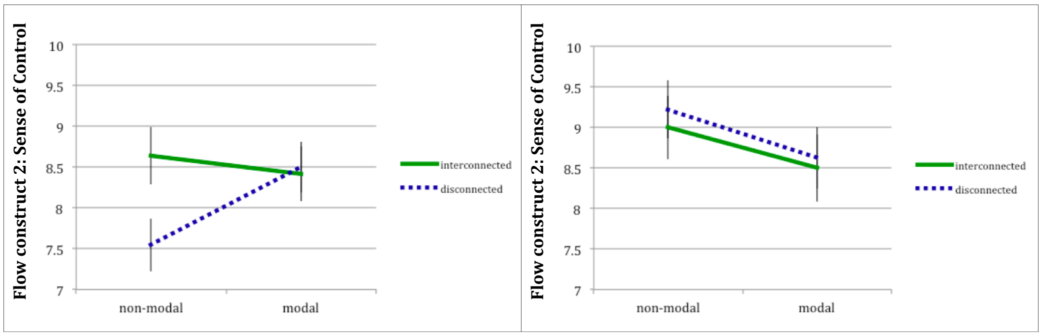


Figure 5.11: The effect of technology affordance types by motivation in interconnected task on sense of control , $p < .005$.

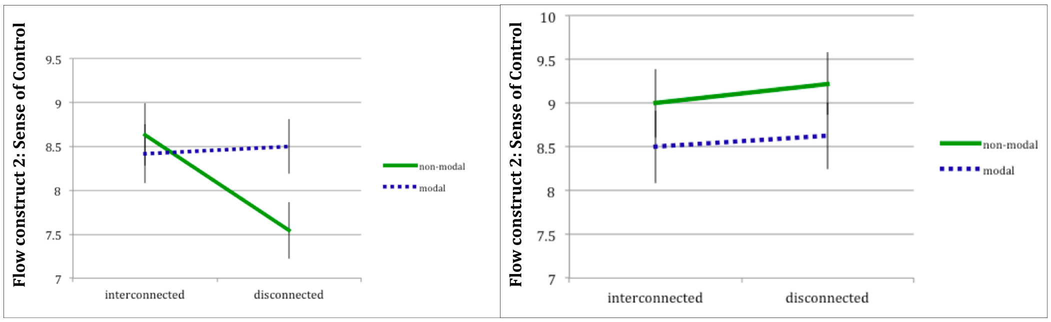
For three-way interaction, the experiential and goal-directed condition effect users' sense of control significantly with 2 (technology affordance type) × 2 (task interconnectedness) interactions as shown in Figure 5.12 (a) and (b).



(a) experiental (b) goal-directed

Figure 5.12: Sense of control in (a) experiential and (b) goal-directed motivation condition (technology affordance type by task interconnectedness interaction), $p < .05$.

In the experiential motivation condition, the non-modal factor helps participants to feel a higher sense of control than having a modal notification when participants perform interconnected tasks; enabling a modal condition provides a much higher sense of control than without the modal condition when participants perform disconnected tasks (Figure 5.13 (a)). In the goal-directed condition in which a pre-arranged layout was provided with having specific task orders to follow, the non-modal condition shows a higher sense of control than having modal notification in both interconnected and disconnected task situations (Figure 5.13 (b)). Participants experienced a slightly elevated sense of control in disconnected task situations than performing interconnected tasks with a goal-directed interface with both modal conditions.



(a) experiental (b) goal-directed

Figure 5.13: Significant effect of the interplay of task connectedness by technology affordance types in (a) experiential and (b) goal-directed motivation condition on sense of control.

5.3.2 Flow Construct 2: Focused Attention

The experiment results found that the interaction between the task interconnectedness and motivation factor significantly affected focused attention, $F(1,36) = 10.821, p < .05$. In addition, the interaction between the motivation and technology affordance type factor also significantly affected focused attention, $F(1,36) = 6.011, p < .05$. The descriptive statistics table of focused attention is reported in Table 5.7.

A three-way - 2 (motivation) $\times$ 2 (technology affordance technology) $\times$ 2 (task interconnectedness) - analysis of variance (ANOVA) was calculated on participants' focused attention, however there was no significant effect of three-way interactions for focused attention, $F(1,36) = .112, p = .740$. Besides, there was no significant main effect for the motivation factor, $F(1,36) = .196, p = .661$, the technology affordance type factor, $F(1,36) = 1.038, p = .315$, and the task interconnectedness factor, $F(1,36) = .358, p = .553$ (Table 5.8).

Focused Attention	Interconnected Tasks		Disconnected Tasks	
	Non-modal	Modal	Non-modal	Modal
Experiential motivation				
N	11	12	11	12
Mean	20.818	17.500	19.546	15.500
S.D.	3.371	3.920	3.857	3.530
Goal-directed motivation				
N	9	8	9	8
Mean	16.222	18.388	18.000	18.875
S.D.	1.922	4.462	2.236	4.421
Total				
N	40		40	
Mean	18.303		17.850	
S.D.	3.816		3.820	

Table 5.7: Descriptive statistics table of Participants' Focused Attention

For interconnected task environments, the goal-directed motivation condition having pre-arranged screen layout and instruction significantly affected focused attention (S.E. = .548, $p < .05$). As can be seen in Figure 5.14, in an interconnected condition, the experiential motivation condition showed higher focused attention than the goal-directed motivation condition. When participants performed disconnected tasks, the goal-directed condition showed higher focused attention than performing tasks in the experiential condition.

	SS	df	MS	F	Sig.
Within-subjects					
task	1.237	1	1.237	.358	.553
task×motivation	37.367	1	37.367	10.821	.002**
task×artifact	4.961	1	4.961	1.436	.239
task×motivation×artifact	.386	1	.386	.112	.740
Error (tasks)	124.316	36	3.453		
Between-subjects					
motivation	4.301	1	4.301	.196	.661
artifact	22.773	1	22.773	1.038	.315
motivation×artifact	131.892	1	131.892	6.011	.019*
Error	789.881	36	21.941		

Notes: SS = Type III Sum of Squares, and MS = Mean Square
* $p < .05$
** $p < .005$

Table 5.8: Focused Attention (DV) RM-ANOVA summary table

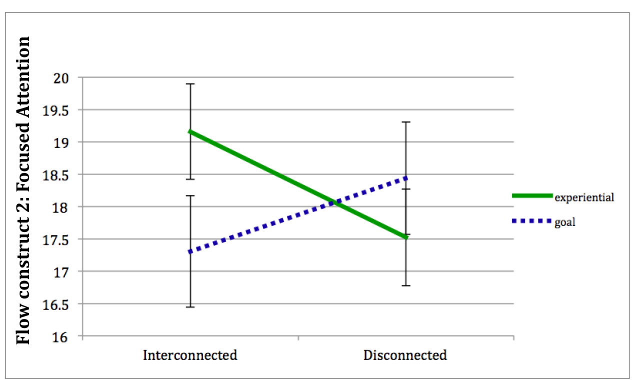


Figure 5.14: Focused attention in the interactions of task interconnectedness by motivation levels, $p < .05$.

5.3.3 Flow constructs 3: Curiosity

The descriptive statistics table of Curiosity is reported in Table 5.9.

Curiosity	Interconnected Tasks		Disconnected Tasks	
	Non-modal	Modal	Non-modal	Modal
Experiential motivation				
N	11	12	11	12
Mean	10.00	10.917	10.00	10.250
S.D.	2.190	1.782	1.732	2.261
Goal-directed motivation				
N	9	8	9	8
Mean	11.889	10.625	12.111	10.500
S.D.	1.364	2.925	1.616	2.507
Total				
N	40		40	
Mean	10.825		10.650	
S.D.	2.122		2.130	

Table 5.9: Descriptive statistics table of Participants' Curiosity

The results of the experiment show that there was no significant effects of main factors found, $F(1,36) = .271, p > .05$ (Table 5.10). In addition, no significant the effect the three-way interaction on Curiosity was shown, $F(1,36) = .085, p > .05$. The multitasking PAT factors do not affect participants' curiosity.

	SS	df	MS	F	Sig.
Between-subjects					
motivation	19.091	1	19.091	2.682	.110
artifact	3.556	1	3.556	.500	.484
motivation×artifact	19.904	1	19.904	2.796	.103
Error	256.271	36	7.119		
Within-subjects					
task	.395	1	.395	.271	.606
task×motivation	.711	1	.711	.487	.490
task×artifact	1.253	1	1.253	.858	.360
task×motivation×artifact	.124	1	.124	.085	.772
Error (tasks)	52.549	36	1.460		

Notes: SS = Type III Sum of Squares, and MS = Mean Square

Table 5.10: Curiosity (DV) RM-ANOVA summary table.

5.3.4 Flow constructs 4: Intrinsic Interest

The descriptive statistics table of intrinsic interest is reported in Table 5.11. The experiment results revealed that intrinsic interest is not affected by the interactions of multitasking factors.

Intrinsic Interest	Interconnected Tasks		Disconnected Tasks	
	Non-modal	Modal	Non-modal	Modal
Experiential motivation				
N	11	12	11	12
Mean	15.182	15.417	15.000	15.419
S.D.	1.722	2.109	1.844	1.506
Goal-directed motivation				
N	9	8	9	8
Mean	16.111	14.750	16.444	15.000
S.D.	2.421	3.412	1.944	3.024
Total				
N	40		40	
Mean	15.375		15.451	
S.D.	2.350		2.063	

Table 5.11: Descriptive statistics table of Participants' Intrinsic Interest

There was no significant effects of the interplay of motivation, task interconnectedness and technology affordance type factors on intrinsic interest, $F(1,36) = .43, p > .05$ (Table 5.12).

	SS	df	MS	F	Sig.
Within-subjects					
task	.199	1	.199	.097	.757
task×motivation	.709	1	.709	.347	.560
task×artifact	.012	1	.012	.006	.939
task×motivation×artifact	.087	1	.087	.043	.838
Error (tasks)	73.644	36	2.046		
Between-subjects					
motivation	2.022	1	2.022	.254	.617
artifact	5.642	1	5.642	.709	.405
motivation×artifact	14.580	1	14.580	1.832	.184
Error	286.467	36	7.957		

Notes: SS = Type III Sum of Squares, and MS = Mean Square

Table 5.12: Intrinsic Interest (DV) RM-ANOVA summary table

5.3.5 Flow constructs 5: Interactivity

The descriptive statistics table of interactivity is described in Table 5.13. The experiment results show that there was no significant effects of main factors ($F(1,36) = 3.17, p > .05$) and the interplay of motivation, task interconnectedness and technology affordance type factors on interactivity, $F(1,36) = 1.849, p > .05$ (Table 5.14).

Interactivity	Interconnected Tasks		Disconnected Tasks	
	Non-modal	Modal	Non-modal	Modal
Experiential motivation				
N	11	12	11	12
Mean	13.909	15.333	14.818	14.667
S.D.	4.158	1.557	3.945	2.933
Goal-directed motivation				
N	9	8	9	8
Mean	16.111	13.375	17.000	14.125
S.D.	1.054	4.955	2.000	4.155
Total				
N	40		40	
Mean	14.725		15.125	
S.D.	3.297		3.383	

Table 5.13: Descriptive statistics table of Participants' Interactivity

	SS	df	MS	F	Sig.
Within-subjects					
task	4.313	1	4.313	3.170	.083
task×motivation	2.376	1	2.376	1.746	.195
task×artifact	3.582	1	3.582	2.633	.113
task×motivation×artifact	2.516	1	2.516	1.849	.182
Error (tasks)	48.982	36	1.361		
Between-subjects					
motivation	4.324	1	4.324	.212	.648
artifact	22.933	1	22.933	1.124	.296
motivation×artifact	57.740	1	57.740	2.830	.101
Error	734.535	36	734.535		

Notes: SS = Type III Sum of Squares, and MS = Mean Square

Table 5.14: Interactivity (DV) RM-ANOVA summary table

5.4 Findings from Post-test Interview

The interview was a follow-up based on observation of the participants' screens. The researcher asked questions regarding why they use a certain strategy and if the situation is different or similar to their computing environments in their daily life. The observation from participants' screen during experiments and post-test interview results provided valuable findings. First, participants set aside a specific chunk of time to check emails when there was no notification shown. Participants divided the task into chunks to check emails while they were involved in primary tasks. Second, participants arranged the windows to shorten the distance of the cursor movement from one window to another. Third, there were participants who were familiar with using short-cut keys for repetitive tasks. Forth, participants displayed their own habits and strategies to complete the tasks in multitasking conditions. Fifth, participants stated that email notifications (the modal technology affordance type) helped remind them of the arrival of emails. Interestingly, participants rarely noticed e-mail notification windows when they fully focused on the main tasks. The drawback of modal notification was that when participants missed the notification, they had to double-check whether they responded to all of the prompted emails after completing the main tasks.

5.5 Findings from Video-Captured Screens

While conducting the experiment, participants' screens were video captured. The data provided the movement of mouse cursors, time on task, and time on switch. In addition, the screens illustrated how people employ their own strategies to optimize their computing environments and how people coordinate multiple tasks and windows, such as when people pause one task once the secondary task is requested, what strategies they employ to switch from one task to another, and how often they resize the windows. The screen data exhibited that even though they were asked to complete the same tasks as if it happened in the same condition, participants employed their own habits and showed different ways of optimizing the multitasking environments. The screen captured data in an experiment setting provides meaningful insights and potential benefits of the method, which could corroborate participants' post-test questionnaire data. Since there is a limitation to interpret the screen captured data without knowing participants' intentions behind their strategies, Study II (participatory design) is designed to support the part that could explain what kinds of multitasking strategies in computer-mediated environments people employ and understand the reasons why people think that certain strategies help in optimizing multitasking environments.

5.6 Study I: Summary

According to the experiment result analysis, depending on task connectedness and motivation levels, it is important to set the technology affordance types differently to yield a higher sense of control and focused attention, which affect flow experience. The results showed that the given goal-directed motivation supports keeping participants focused while participants perform disconnected tasks. The goal-directed motivation setting with a clear direction and pre-arranged setting helped people stay on the original task and routine towards separate goals while they are engaged in disconnected tasks (Table 5.15).

The Study I results provided information on what kinds of strategies

Finding summary: PAT Combination 1		
Goal-directed motivation	Non-modal	Disconnected tasks
• When tasks are disconnected from each other, disabling the notification window is helpful in a goal-directed condition. • In the disconnected task condition, the goal-directed condition showed a much higher sense of control than in the experiential condition.		
Finding summary: PAT Combination 2		
Experiential motivation	Modal	Interconnected tasks
• In an interconnected task condition, the experiential condition with a modal notification helped participants feel a higher sense of control than the goal-directed condition.		

Table 5.15: Recommended PAT factor combinations based on experiment findings

participants employed in multitasking contexts in addition to examining the interplay of multitasking factors–motivation, artifacts, and task interconnectedness. Based on the Study I results, which focused on understanding how people experience flow depending on different combinations of person, artifact, and task factors, Study II (participatory design) is designed to understand how people actually interact with artifacts while performing multiple tasks. Details of Study II will be described in the next chapter.

Chapter 6

Study II - Participatory Design

6.1 Participatory Design Method

To come up with design guidelines and implications, the participatory design method was employed for the second part of this dissertation study. Participatory design refers to a design method that invites non-designers into the design process to understand current users' experiences and to generate ideas for better design solutions and scenarios. Workers and design professionals are two primary audience groups for participatory design (Kensing & Blomberg, 1998). Predominantly, design professionals and CSCW researchers employ participatory design to understand collaborative interactions in work environments, such as the relationship between workers and systems (Schmit & Bannon, 1992). Unlike a situation where each person is assigned a classical separate role in the design process, participatory design supports a way of understanding as to how designers and non-designers (users) can incorporate participants' thoughts and ideas in the design process (Figure 6.1).

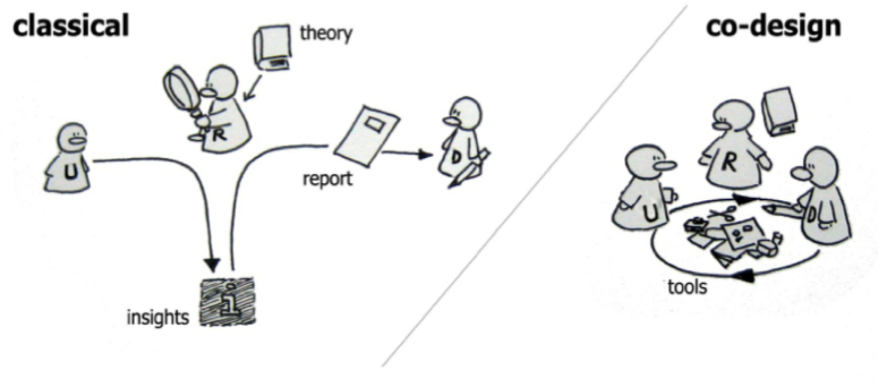


Figure 6.1: Classical design process (left) and co-design process (right). Adopted from Sanders & Stappers (2008)

The purpose of participatory design is to integrate users' perspectives and needs to ensure that technology supports the ways people perform tasks efficiently (Kensing & Blomberg ,1998). Therefore, participatory design is a suitable method to communicate with people to understand users' behaviors and feelings in computer-mediate multitasking environments to develop design guidelines. Sanders et al. (2010) developed a particular framework, which draws on an overview of participatory design tools and techniques to engage non-designers in the design process and design activities. The framework provides three dimensions to help researchers choose proper tools and techniques accordingly for participatory design sessions: form, purpose and context (Table 6.1).

The researchers emphasize that it is crucial to customize the tools and techniques based on an understanding of the purpose and context for the participatory design session (Table 6.2).

The 2-D mapping technique refers to mapping patterns using visual and

Form	From refers to activities : making, telling and/or enacting
Purpose	Purpose has four dimensions : 1) for probing participants, 2) for priming participants in order to immerse them in the domain of interest, 3) to get a better understanding of their current experience or, 4) for generating ideas or design concepts for the future, for instance by creating and exploring future scenarios.
Context	Context refers to "where and how the tools and techniques used and along these four dimensions: group size and composition, face-to-face vs. on-line, venue, as well as stakeholder relationships".

Table 6.1: Definitions of Form, Purpose and Context (Adopted from Sanders et al., 2010)

Form (Tools & Techniques)	Purpose				Context			
	Probe	Prime	Understand	Generate	Individual	Group	Fact-to-face	Online
Making tangible things								
2D collages	O	O	O	O	O	O	O	O
2D mappings		O	O	O	O	O	O	
3D mock-ups			O	O	O	O	O	
Talking, Telling, and Explaining								
Stories and Storyboarding	O	O	O	O	O	O	O	O
Diaries	O	O	O		O		O	O
Cards			O	O	O	O	O	
Participating, Enacting, and Playing								
Game boards and game pieces and rules for playing		O	O	O	O	O	O	
Props and block boxes			O	O	O	O	O	
Participatory envisioning and enactment				O	O	O	O	
Improvisation				O	O	O	O	

Table 6.2: The tools and techniques of Participatory Design organized by three dimensions (Adopted and modified from Sanders et al., 2010)

verbal components. The Cards technique refers to the way of organizing, categorizing and prioritizing ideas based on participants' discussions and thoughts (Sanders et al., 2010). Since the purpose of the participatory design method for this dissertation study is to understand users' needs and generate ideas, 2-D collages, 2-D mapping, and Cards tools and techniques will be used and customized in participatory design sessions. Specifically, the 2-D collages technique refers to using visual probes and verbal triggers in the background. In other words, visual probes refers to the craft materials, which help participants express their ideas with visual aids. Also understand the thought process is also important during the course of arranging and making the 2-D collages in participatory design. Thus, each participant was asked to present their ideas and thought process regarding their collages to the group members.

6.2 Study II : Data Collection

The aim of the participatory design (Study II) is to understand approaches and strategies in multitasking environments through a participatory design session and come up with ideas based on the study I results. This section provides a participatory design overview including participants and procedure.

6.2.1 Participants

A total of 10 participants took part in the participatory design session balanced between genders, and aged 18-40 (Table 6.3). Sleeslijk (2005) found that four to six people are the most effective number of participants in a single group participatory design session. Thus, this study recruited ten participants to conduct two group sessions with five people for each session. Another important consideration in terms of participant requirements was recruiting non-designers (Stappers and Sanders, 2003). The reason for this is that designers are particularly disciplined to a problem-solving approach when they confront any situations thus it is hard to gather explicit personal experience data from designers.

No.	Gender	Session group number
P1	M	Group 1
P2	M	Group 1
P3	F	Group 1
P4	M	Group 1
P5	M	Group 1
P6	M	Group 2
P7	M	Group 2
P8	F	Group 2
P9	F	Group 2
P10	M	Group 2

Table 6.3: Participants' gender and groups

6.2.2 Procedure

Each participatory design session lasted for about an hour. The study held two group sessions separately with five participants for each session in two different locations—a software development company and a public community center in California. First, the researcher explained the study and provided a consent form for the participants to read. The participatory design session consisted of three parts (Figure 6.2).

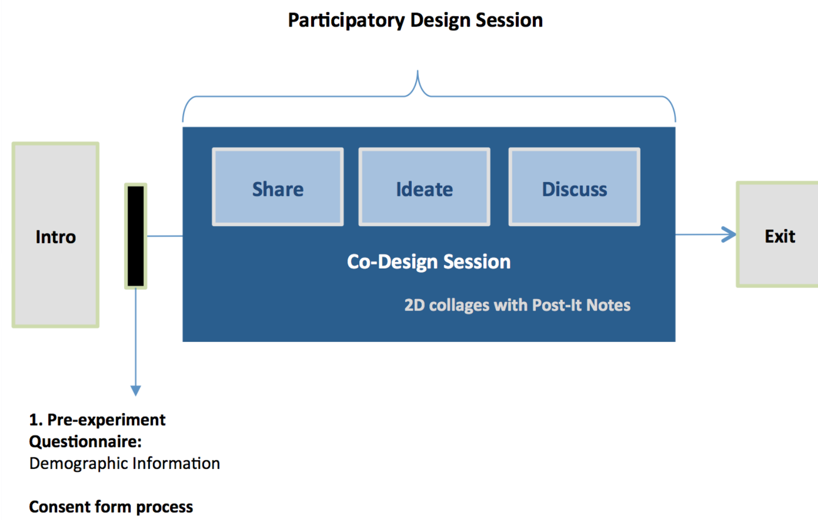


Figure 6.2: Participatory design procedure

For the first part, participants were asked to share their strategies in regards to how to interact and manage tasks in computing environments particularly when there are multiple tasks that require simultaneous attention. The second part - a brainstorming session - followed. In the second part of the participatory design session, the participants came up with ideas and sketches based on desires and multitasking needs. Third, participants were asked to discuss factors and share ideas for creating a desired online-course environment to enable better coordination of multiple tasks that would help users feel more focused. For the action scenarios, five tasks were provided in the context of online course environments. To design tasks that reflect natural settings in computer-mediated multitasking in the real world, this study extracts five tasks: 1) document-editing (reading and writing); 2) Web-browsing; 3) media watching; 4) communicating in a discussion room; and 5) a secondary task - prompted e-mail task. Those five tasks were selected based on previous multitasking studies (Admaczyk et al, 2004; Bailey and Iqbal, 2008; and Cutrell et al., 2000). The data collection aimed to understand how people perceive and characterize the multitasking experiences. With that in mind, this study used action scenarios and a collage in the participatory design session. Participants were assigned an online-learning environment as an action scenario for the participatory design session. The combination of interconnected tasks with the experiential motivation condition setting and disconnected tasks with modal-notification situations were specified for the design session. Specifically, participants were asked to compose the given Post-it notes on a piece of paper to exhibit their desired ideas on creating online-learning environments.

6.2.3 Action Scenarios and Collage Exercise

Action scenarios were designed based on results from Study I (experiment), which showed that: 1) the participants who performed disconnected multiple tasks in a pre-set setting experience more flow - sense of control and focused attention; and 2) participants experience more flow when tasks are interconnected and flexibility for the computing layout setting is provided. Therefore, Study II session aimed to identify factors for a better pre-setting mode and to see how people manipulated the elements to optimize the multitasking setting. I anticipated that by customizing the participatory design tools by combining action scenarios and a collage, the participants would be able to express their thoughts freely to provide a rich and explicit description of their multitasking interactions with low-tech aids (Post-it notes) (Mattelmäki, 2006). All participants were actively involved in the design session and described their personal experience with the screen composition practice using a collage method.

For the participatory design process, participants received a stack of Post-it notes, a pen, and paper. Next, the participants were asked to write down actions on the Post-it notes and arrange them on a white blank piece of paper, which the participants treated as a 13-inch monitor screen. Each participant arranged the Post-it notes on the paper as if they were performing multitasking in computing environments. I asked the participants to share their thought process after they tried out different compositions with the Post-it notes on paper. The advantages of using the Post-it notes are: 1) since the participants are not designers, they may not be familiar with expressing and suggesting their thoughts and ideas by drawing. Therefore, drawing on Post-it notes helps the participants feel less intimidated to suggest their thoughts and exhibit their ideas visually, and 2) Post-it notes encourage the participants to increase their confidence with expressing their creativity (Kelly & Kelly 2013), which helps them express their ideas as much as they can during the limited time.

Mattelmaki (2006; 2007) reports that a collage exercise in association with an interview encourages participants to offer information that they have not previously expressed. It also helps participants to visualize their thought process. The design exercise for the given scenarios with simple physical objects such as cards or basic paper has long been employed and has helped participants transform their thoughts into open questions and better articulate their feedback and ideas (Muller, 1992). The action scenarios and collage exercise worked successfully for enabling participants to express their thoughts and share their multitasking strategies by drawing and showing them on visual aids - Post-it notes (Figure 6.3).

Figure 6.3: Participatory design session sketches (collages with action scenarios)

Participants were less intimidated to provide a rich description in terms of the pros and cons of certain strategies and they discussed each other's options that group members introduced at the discussion table one person at a time. All in all, after participants presented their experiences, an in-depth discussion and brainstorming session followed in which they shared stories and built ideas on top of each other's suggestions and discussions in regards to multitasking environments. During the overall participatory design session, a key approach is to treat participants as creative people who can be directly involved in the design process when their confidence in creativity is encouraged (Mattelmäki, 2006).

6.3 Study II : Data Analysis

6.3.1 Context Mapping Method

To analyze the data from the participatory design session, the *ContextMapping* method was employed to interpret and synthesize the participants' collages with stories that participants described for how they usually compose task windows on a screen while multitasking. The *ContextMapping* analysis method was developed by Sleeswijk Visser et al. (2005), and is a Grounded-Theory-based (Strauss & Corbin, 1990) based design session interpretation method. The process of the *ContextMapping* consists of three phases - *fixate on the data, search and be surprised, and find patterns and create an overall view* - which provide a direction to explore and find patterns from the data from the participatory design session. The focus of the participatory design analysis is placed not only on understanding users' context and behaviors but also on extracting insights from findings that came from patterns shown in the participants' design session outcomes on the artifact outcomes (collages) and interview data.

6.3.1.1 Analysis Phase 1 : Sorting results

Based on the *ContextMapping* method phase 1, *Fixate on the data*, observing the participatory design session itself provides significant information such as how people compose Post-it notes (multiple windows) by certain criteria and the reasons for this during the course of the design session by taking action and presenting participants' thoughts. As Sleeswijk Visser et al. (2005) suggested, the findings from the participatory design session were written down right after the session was finished before the researcher's memory faded. Since there was no video or audio recording used, everything heard and observed was annotated during and right after the session. Based on the documentations (different configurations of Post-it notes on paper and annotations), results were sorted by themes.

6.3.1.2 Analysis Phase 2 : Mapping key themes

Through sorting the results from the analysis phase 1, key themes and their relationships were captured. In this second phase, created artifacts such as collages and drawings were the key materials to assist in finding interesting indicators. Sleeswijk Visser et al. (2005) found that an effective way of communicating the data from the participatory design session, which includes collages and discussion results, is to sort key themes and their relations by means of interpretation. The researchers claimed that visualizations such as showing a map or images that represent the findings could be vehicles to convey the identified patterns through data analysis.

6.3.1.3 Analysis Phase 3 : Grouping insights

Grouping insights is one of frequently applied ways of analyzing the materials from design sessions (Mattemäki, 2006). The process of grouping insights started from emerging design session materials (physical outcomes such as collages) and specifying individual insights and groups them by association with content such as ideas and themes. The key themes from the analysis phase 2 are transformed into design insights and ideas by grouping the key themes and visualizing them as to how certain features can be turned into design implications.

6.4 Study II : Results and Analysis

The aim of the second study is to explore more in-depth understanding of participants' thought process and strategies to assess how they actually coordinate multitasking environments and also discuss the experiment results and which design considerations should be take into account for design implications for the online-learning environment situations as a specific example scenario.

Based on the analysis of participants' data with the *ContextMapping* method, the findings were grouped into five themes:

1. Primary task screen location

2. Task characteristics: passive or active

3. Primary (fixed) and secondary (floating) area, flexibility

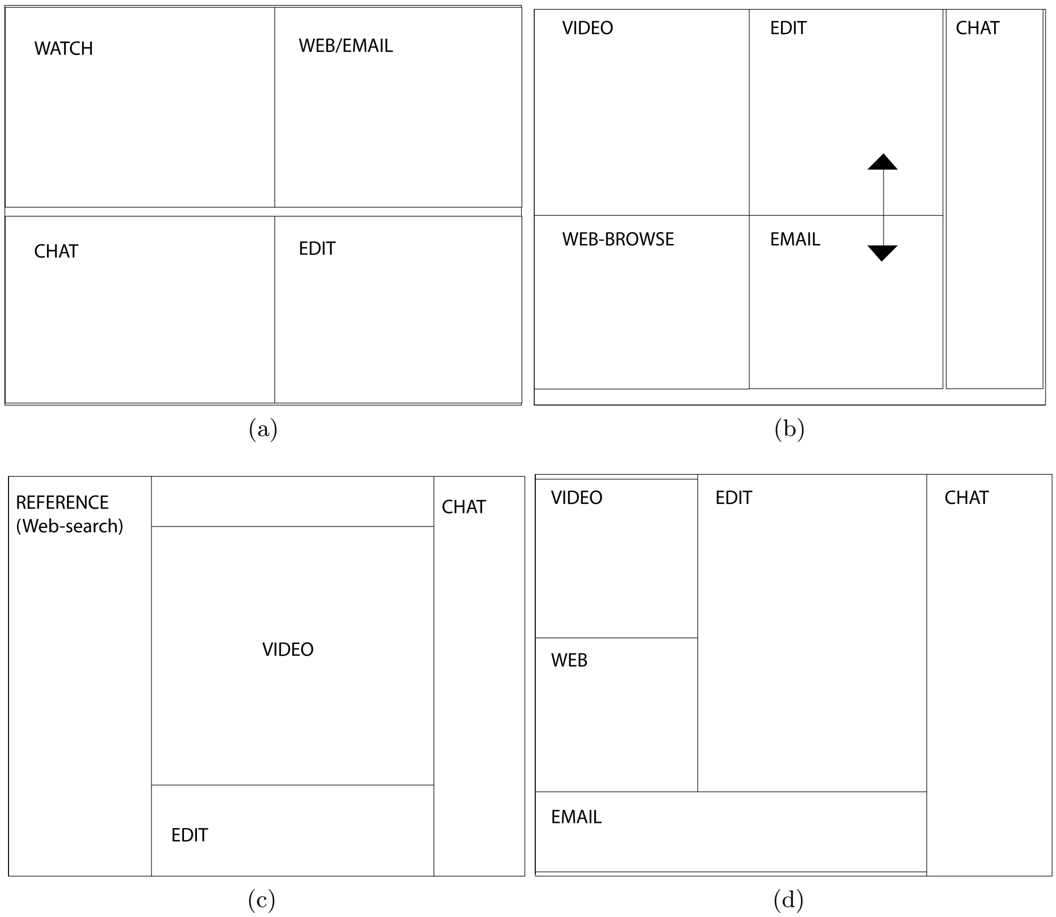
4. Context transition option (context aware) and glimpsing

5. Minimizing distractions

At first, when the participatory design session began, participants identified the primary task and its context and they recalled their own multitasking strategies and composed multiple tasks with Post-it notes on a paper individually. When an online learning environment context was given as an action scenario, watching a video lecture was assumed as a primary task. All ten participants from the two group sessions have attended an online-learning class or a workshop at least once in the past.

6.4.1 Theme 1: Identifying a Primary Task

The first thing that the participants focused on was identifying the location of the primary task (Figure 6.4 (a)). Mainly, participants discussed the location of a primary task whether it should be centered or floating or located on the left or right side (Figure 6.4 (b)). Second, specific features of primary tasks were discussed. For example, if it was a media task, whether the video may only be heard, but not watched. Participants agreed that if the video has visual reference material and they have to fully focus and watch the video thoroughly, then they would put the video at the center or arrange it on the left side instead of right side. There might be a cultural difference if a culture reads from right-to-left. Since the participants were recruited from the U.S., where people read from left-to-right, this result might be applied to that particular culture, which reads from left-to-right.



(a) (b) (c) (d)

Figure 6.4: Patterns of composing primary and secondary task windows: (a) and (b) locate the primary task in the left. (c) and (d) locate secondary tasks around the primary task window.

On the other hand, if the lecture has a static image with audio, then they preferred to listen rather than watch the video, in which case they would perform secondary tasks simultaneously. Therefore, the lecture video type was the most important factor for users as to whether they wanted to place the video in the center or not (Figure 6.4 (c)). P2 described that he put his primary content on the left, and the right bottom side is the area least focused on. For P6, the left top corner was the primary spot, the top right corner was second, and the bottom right was used for the third task. For his usual work, he put his email on the top left, which provides instruction, and browsing and search for information on the top right, and he put the writing task on the bottom right so the participant arranged two windows side-by-side to compare contents. The least important task was put at the center of the bottom (Figure 6.4 (d)). P7 also shared his strategy that he put the video in the left corner and he shared his specific approach that the size of the window should not take up more than one-fourth of the full screen size. P8 described that she placed the Web-browsing window (upper) and the edit window (lower) on the right side vertically. The rationale the participant (P8) made was that information should be located on the upper side and the editing task (writing) should be right below the Web-browsing window.

> "The left side of the monitor screen is particularly utilized for watching video material, whereas the right side is usually saved for secondary tasks" Put the most passive task on the left side and the primary task sits in the middle, finally tasks that need frequent attention sets in the right side" (P1)

> "For using a Word program, since I start writing from the left to the right side, I put the Word program on the left side" (P3)

P9 shared his thoughts that he placed the writing task window on the right side and arranged the reading task on the left side because he reads information on the screen from the left side to the right. P6 and P7 agreed that the priority and importance of tasks are more important factors for determination of where they locate those task windows rather than the relevance among tasks. P6 and P7 arranged the primary task on the upper left corner and the secondary task on the right side and the rest of the windows were put on the bottom right corner or the center. The discussion between P6 and P7 yielded an insight that given the direction of how we perceive information such as we write a sentence from left to the right, users feel more natural when reference information is located on the opposite side of the primary task.

When participants described their strategies on how to deal with a primary task and secondary task on screen arrangement, the consideration they have taken was the location, specifically whether it should be placed on the left or right side; or upper side or down in the corner or center. A majority of the participants found that the left side is reserved more for a primary task than a secondary task. When there is enough space to arrange two windows vertically on the screen, the upper side is more useful to place the primary task window.

6.4.2 Theme 2: Passive or Active Action

The ways participants arranged screen layouts were based upon whether the task was passive or active action was required and how much interaction was involved to complete the tasks in terms of physical input interactions rather than content-wise relations. Passive interaction refers to the interaction in which users' physical input action such as clicking on a link on the Web-browser or typing on a

Word document is not required on a task (e.g., watching a video, listening to audio, reading an article). P6 mentioned that he used to have a video task for his work and he described that he usually put the video window in the top left corner. In addition, P6 illustrated his strategy that he placed visual and audio (watching and listening) tasks always on the left side that require passive interactions from the participant. One of the findings showed that participants considered the traits of task itself whether it requires participants' passive or active involvement. A specific example was that depending on whether the video lecture showed visual material, which requires participants' constant attention rather than containing only an audio lecture, participants arrange the video window differently such as the participants locate the window as a background audio or arrange the window at the center of the screen (Figure 6.5).

> "If the real-time (Webcast) lecture video provides lecture slides showing a professor lecturing, then the user's focus should be on the video. If the video is not a main task, the location of editing and Web-browsing windows can be swiped" (P2).

When it comes to active interaction, in fact, the participants claimed that physical distance to provide input, for example moving a mouse cursor from one point to another, is a determination point how they arrange the windows on the screen. Since P2 uses his right hand to operate a mouse, the participant positioned the active task window on the right side so he can reduce the distance from the original cursor location and the task window on the same side. For Web-browsing,

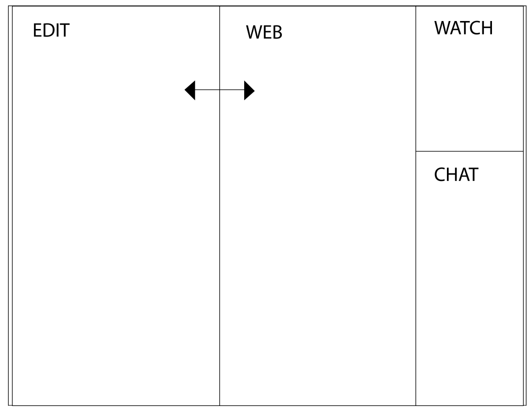


Figure 6.5: The pattern of adjusting two primary task windows horizontally.

P3 likes to operate the tabs. Usually the tabs are located on the top of a window. Thus, P3 mentioned that she tends to have multiple windows and tabs opened and tried to minimize the distance between the primary task window and the tabs on the top of the Web browser window. With this strategy, she mentioned that she can switch between multiple task windows easily by clicking opened tabs or windows. The results showed that participants adapted strategies to minimize the distance between active regions from the starting and ending point of a cursor. For example, if the participants had to switch tasks one from another that also means that they needed to move a mouse cursor from the left to the right or in an opposite direction. Therefore, participants considered the specific region inside of the main task window where they paid attention.

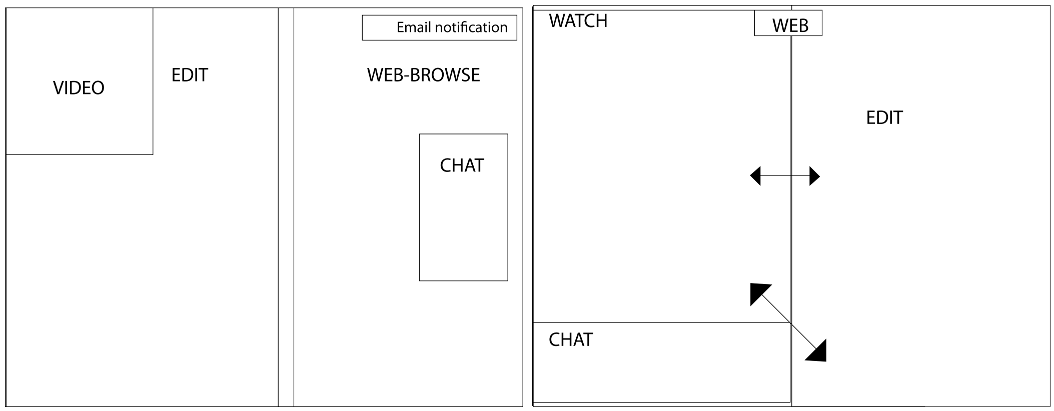
The participatory design session results showed that the window layout arrangement varied depending on whether passive or active interaction was required. Besides, the findings provide an insight that the distance between active areas on a screen is a crucial factor to minimize the extra work switching from one point to another point on the screen. Designers and developers should consider how to treat the passive and active task screen differently to augment users? flow experience. Particularly if there is a constraint such as monitor screen size, overlapping active task screens does not help users to reduce the redundant actions; rather they can consider overlapping passive screens.

6.4.3 Theme 3: Flexibility Matters

As the experiment results demonstrate, having some extent of flexibility helps to yield a sense of control when people perform interconnected tasks with a clear direction. The results imply that the setting of flexibility should be carefully made based on the contexts. During the participatory design session, the discussion results were also aligned with Study I (experiment) results that participants preferred to have flexibility to move windows around instead of having a fixed pre-arranged setting. Participants set the secondary tasks such as chatting or social media to be floating instead of fixed on a certain location (Figure 6.6 (a) and (b)). Floating refers to the state in which the location of a screen is not fixed; rather it can be moved flexibly when users wanted. As for fixed parts, tabs on the top of the window were the things that participants preferred to have fixed.

> "If I write a thesis on the left and (put the reference page on the right). Depending on the location of the contents, I change the window accordingly. I usually put two displays" (P3).

The discussion revealed that having a pre-arranged layout with flexibility helps people ease complicated environments and maintain the same direction



(a) (b)

Figure 6.6: Strategy and insight for adjusting fixed and floating task windows: (a) minimizing the distance between the primary task window (fixed) and the secondary task (floating) window, and (b) adjusting the proportion of multiple task windows in a flexible way.

towards competing tasks. Participants shared their thoughts on situations where pre-arranged settings help them manage multiple tasks with less complexity. Participants discussed if they lost their sense of control over how to coordinate the windows both fixed and floating in terms of functionality, they feel that the multitasking environments are more complicated and distracting. One of participants stated, “Pre-set window is always difficult.” P1 claimed that users’ familiar contexts might vary depending on their preferences and strategies. He suggested that users might figure out how to optimize their settings as time goes by. Then, providing freedom would be useful. Having enough time for customizing the multitasking environments aligned with their preferences would be a better way, however there is a drawback in that it takes time until the users can come up with their specific preferences for the multitasking environment customization. P5 illustrated his multitasking pattern and strategy with a diagram (Figure 6.7). The participant (P5) designated four corners on a screen based on task priority: 1) primary corner, 2) secondary, 3) and 4) are the least focused area. He described that the empty space between those four corners is the flexible (floating screen) area for miscellaneous tasks.

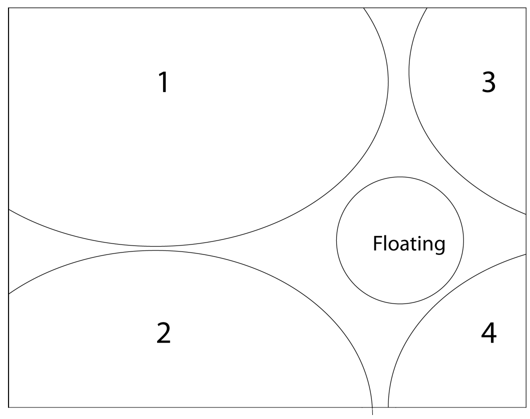


Figure 6.7: Multitasking strategy with designating four primary corners with a floating window in the middle.

Depending on the task priority, the state of windows whether it is a floating window, which has a flexibility to move on the screen, or a fixed window, which has to be placed in a specific location on the screen, is important in the multitasking environments.

6.4.4 Theme 4: Context-Aware Mode

One of the multitasking strategies found from the participatory design session was arranging all of the task windows to be overlapped along the boundary of the primary task window so that the participant could see every task at a glance

(Figure 6.8). The participants expressed a concern that if there were something they could miss if their attention was focused on a certain task.

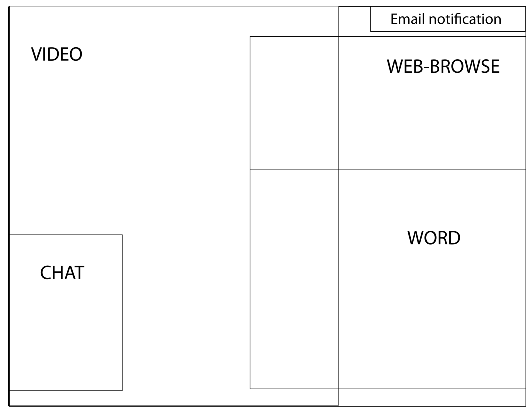


Figure 6.8: Pattern for glimpse of all tasks at once

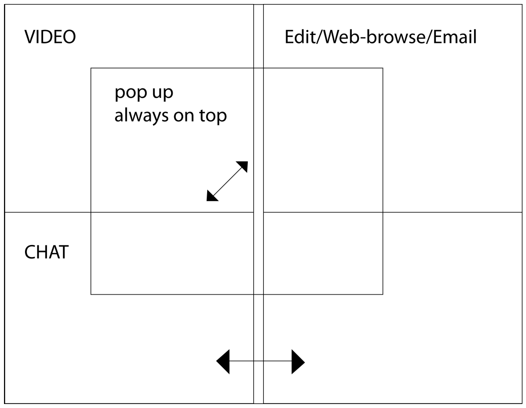
Even a small window helps users to be aware of the context. Also, the monitor screen size was another factor that participants frequently mentioned, such as if the monitor screen is big enough, participants can apply different multitasking strategies such as displaying windows side-by-side. The P3 participant mentioned that even having a small window available without taking any action to see the content in the window helps to be aware of the context such as number of tasks and keeping track of engaged tasks. On the other hand, P9 took a different strategy for managing an email or Web-browsing task. The participant said that she would use tabs for checking a new email or use a Web browser because those layouts provide a consistent experience. Providing a consistent experience is important, such as the location of menus and visual cues (e.g., color of buttons and font types) to reduce redundant effort and time on repetitive tasks (e.g., opening an inbox menu, clicking on a message from the list, and clicking on the send button).

The findings provide insights that the computing system should provide a context-switch mode, which is an easier way to switch the environments based on a customized context. That is, the system helps users to change the computing environment quickly by a simple action based on customized settings such as the size of the windows and the layout arrangement for a primary and secondary task for a particular situation. A simple context transition button would be useful. P4 suggested that having all active and passive tasks overlapped and being able to show the preview or visual cue of the contents from each window, would help the participant easily be notified and make them aware of the overall context. P4 illustrated that he usually puts a main task at the center on the screen, and places the secondary task on the right side. The participant described his multitasking strategy that even if the secondary task windows around the boundary of the primary task window keep changing, the primary task window would stay in the same location. P4 found that if a bigger screen were given, his thought process to divide and arrange the screens for primary and secondary tasks would be basically the same. P5 suggested a context switch feature that allows users a quick transition from one task to another. The key factors to consider when the customization options are provided for context transition are enabling users to adjust the proportion of the window size, and providing easier ways for switching from a small screen to a full screen. In addition, placing a simple button for an option to place a primary task at the center of the screen and putting secondary tasks on the boundary of the primary task window is another insight from the findings. To reduce distractions caused by checking secondary task screens over time, displaying the secondary tasks around the primary task setting might help users to keep an eye on secondary tasks while focusing on a primary task without switching multiple task screens back and forth.

6.4.5 Theme 5: Efforts on Minimizing Distractions

There were also findings that participants tend to minimize distracting factors in multitasking environments. P10 put chat and email on the left bottom, because he thought that they distract him from his main tasks. Also, P3 mentioned that if there were many tabs, she would tab it because displaying many available windows on a screen would be a distraction.

P4 claimed that even if a larger screen was provided for the design session scenario, he would leave some empty (unused) space and still overlap secondary tasks, not showing all the contents, since having multiple windows with the same proportion side by side might distract him from the primary task. P3 claimed that she would be more flexible depending on the task. If she has to really focus on something, she would center the primary task and enlarge it to fill out the whole screen (Figure 6.9 (a)). P1 also added on a full-screen transition button at the corner of the screen so that any screen that the participant who desires to enlarge the screen can find the button easily. P4 shared his strategy that he would set a secondary section as small as possible and overlap them so that the secondary tasks become less visible than a primary task (Figure 6.9 (b)). He claimed, “the more you see, you more you will be distracted.”



(a)

(b)

Figure 6.9: Strategy for minimizing distractions: (a) add an easy transition button to full screen mode, and (b) locate the prompted message (email) task window in the background.

6.5 Study II: Summary

The participatory design session (Study II) focused on deriving guidelines as to how multitasking environments should be designed to better coordinate them to allow users to feel more focused and have a better sense of control, using various ideas for multitasking environments based on the experiment (Study I) results. Those five themes from the findings provide insights as to how designers and researchers can manipulate multitasking environments and how to adapt the results to the actual design guideline for the online environment. The findings from the quantitative and qualitative research provide a richer understanding of humans' multitasking behaviors and interaction patterns. There was a limitation that the sample size of participatory design session was ten people, which might make it unwise to generalize the findings. However, since the original purpose of the participatory design session was to interpret findings and convert those into insights and design implications, thus the design session outcomes provide enough evidence to answer the research question. Based on the participatory design data analysis, this study developed design guidelines to help designers and developers create systems that support flow experience in multitasking environments. Specifically, the implications were derived from the participants' multitasking strategies and ideas for desired multitasking environments with a consideration of person, artifact, and task factor combinations, which came from the Study I (experiment) results. Detailed design guidelines will follow in the next chapter.

Chapter 7

Design Guidelines

Based upon the findings from Study I (experiment) and Study II (participatory design session), six recommendations were created as overarching design guidelines to help designers to create a better support interaction design for multitasking computing environments. Baker and Lund (1997) found that specific design guidelines help in designing a structured and efficient multitasking interaction as 'preferred collaborative interaction patterns' (p. 177). In this dissertation study, design guidelines were created based on considerations of the interplay of motivation, artifacts, and task interconnectedness factors from Study I (experiment) results and insights from participants' multitasking strategies from Study II (participatory) design session.

7.1 Design Guidelines for Multitasking Environments

7.1.1 Design Guideline 1

: Provide flexibility to customize the layouts and size of windows particularly for multitasking with interconnected tasks.

Allowance of flexibility in multitasking environments helps users feel more sense of control and helps them to be focused specifically when tasks are interconnected and users know the clear direction in terms of task orders step-by-step. For example, online-learning contexts basically require users, particularly students, to perform multiple interconnected tasks simultaneously such as watching a video lecture and taking notes. Online learning system design features can provide benefits or obstacles to users who are multitasking, depending on how much flexibility users can have. Therefore, with a consideration of the relationships among tasks, providing users flexibility to adjust layouts of screens reduces the restrictions to customize the computing environment to better fit to the users' preferences.

7.1.2 Design Guideline 2

: Provide a clear indication of status progress information and the direction for multitasking environments when users are engaged in disconnected tasks.

As opposed to interconnected tasks, when users are engaged in performing disconnected tasks, a pre-arranged layout setting helps the users feel more flow experience particularly a sense of control and focused attention. In addition, providing a clear direction amplifies the benefits of multitasking, which is flow, while performing disconnected tasks.

7.1.3 Design Guideline 3

: Customize proper technology affordance types depending on task interconnectedness.

The technology affordance feedback such as different types of notifications should be able to be turned on and off easily. Specifically, depending on the motivation of users, whether they are amidst experiential or goal-directed contexts, designers should let users select different options. The recommendation from the findings of this dissertation study is enabling a pop-up notification (modal condition) for situations in which people perform disconnected tasks and disabling the pop-up notification (non-modal condition) when tasks are interconnected.

7.1.4 Design Guideline 4

: Support identifying a primary task and secondary task in the system.

Participants exhibited that the main factor for deciding their multitasking strategies was setting up the primary task first, and then the secondary tasks were accordingly arranged. Therefore, providing a convenient system to identify the task hierarchy and priorities is a crucial part of users' starting point of configuring multitasking environments. For example, the patterns observed from the participatory design is that participants set up the location and the size of the primary task window first and then they arranged the secondary tasks based on considerations of how to minimize the distance between the primary task and the secondary task windows.

7.1.5 Design Guideline 5

: Consider the passive and active interactions and their relation to the task hierarchy.

Identifying active and passive tasks and areas on the screen is another important design factor. Designers should provide different multitasking environments for active tasks and passive tasks. In addition to the consideration of task priority, the computing system should be designed taking into consideration whether the interaction requires users' passive or active involvement. There are pairs of interaction scenarios that have to be taken into consideration: a primary-passive, primary-active, secondary-passive, and secondary-active interaction.

7.1.6 Design Guideline 6

: Provide a fixed and floating option.

Once users identify the task priority, the next thing they consider is whether they prefer to have a fixed or floating window. This consideration is also related to flexibility. Seven out of ten participants in the participatory design session mentioned that having windows floating is useful to have when secondary tasks demand frequent attention from the participants.

7.2 Summary

The overarching design guidelines that designers need to consider in the design process will help designers take a better approach to consider the multitasking contexts of users. Specifically, the design guidelines for multitasking environments will allow users to have more predictable, focused experiences with a greater sense of control so as to reduce the negative effects such as complexity, uncertainty, and distractions. Second, the design guidelines will help designers support users by enabling a better coordination strategy and system through providing directions and reducing complicated and repetitive efforts such as switching tabs, arranging windows, applications, and screens so that users feel more flow experience.

Next, a concluding chapter explores future work and design implications on how researchers and designers should take into consideration contextual factors for more efficient multitasking in computer-mediated environments in future research.

Chapter 8

Conclusions

The ultimate goal of this dissertation study was: 1) to explore how designers can develop a better coordinating system for multitasking environments to help users experience more flow, and 2) to determine which constructs consist of a sense of control, focused attention, curiosity, intrinsic interest, and interactivity. In order to achieve this goal, this dissertation research developed a synthesis framework with layers of multitasking factors and their relationships to understand the context of the multitasking sphere. This dissertation found that the integrated human multitasking perspective is situated within the Information Studies field as an interdisciplinary practice. With that in mind, this dissertation focused on three multitasking factors - person, artifact, and task. Eight different combinations of motivation, artifact, and task factors were examined through an experiment. The results found that the interplay of the multitasking factors significantly affect the participants' sense of control and focused attention. The results revealed that people actually feel less distracted and more sense of control and focused attention in one environment than another depending on which combination of multitasking factors was treated and supported users' multitasking performance. Through the experiment, we could understand multitasking contexts from a human perspective because Study I (experiment) focused on which factors and interactions actually affect humans' flow experience. For Study II (participatory design session), our focus shifted more towards how people interact with artifacts such as computing system elements and how they facilitate their own strategies to optimize the multitasking environments. As one of the participants mentioned in the design session - "multitasking is inevitable," people develop their own strategies to make the best suitable environments for themselves. The findings from the design session yielded findings and insights associated with eight themes and allowed the development of design guidelines with six design recommendations for multitasking environments. Employing a combination of these two methods - an experiment and participatory design - provided benefits to better understand the multitasking context and factors from various perspectives.

For future work, there still remain under-examined factors of human multitasking behaviors in contexts. As an extension of this dissertation study, examining the multitasking factors - motivation, artifacts, and task interconnectedness - in multitasking contexts where people use multiple displays (monitor screens) and devices (laptops, tablets, and smart phones) would provide a different perspective for design considerations. As Ophir et al. (2009) pointed out, the changes of the media environment affect the expectations of certain human behaviors. The increasing tendency of interacting with social media channels and multiple devices (Robertson et al., 2004) can be a specific multitasking context for future research to examine the effects of the multitasking factors on humans' flow experience. When it comes to research methods of multitasking, the mixed methods of an experiment and a participatory design session can be applied to different contexts of multitasking environments not just for online learning environments but also health-informatics system environments for future research.

As multitasking becomes prevalent in computing environments, multitasking researchers need to investigate the potential positive effects more to better understand factors that can amplify the benefits of multitasking (Salvucci & Taatgen, 2011) such as flow experience. There are four contributions of this dissertation study. First, this dissertation research is the first study focusing on flow experience in multitasking environments. Second, the mixed method with an experiment and participatory design method provides not only the way of thinking about users' experiences but also the design process of computing systems from a holistic viewpoint. Third, the holistic perspective helps to understand multitasking factors and users' flow experience in multitasking. Fourth, deriving practical design guidelines based on empirical research helps designers and developers to apply specific implications in their design processes.

Appendices

Appendix A

Task Instructions for the Experiential Motivation Condition

- Interconnected Tasks Condition

  You will be given 20 minutes to finish these tasks below. There is no specific task order to follow.

  Task 1. Please open the Part 1 excel file on the desktop. Next, fill out information in the spreadsheet (white blank boxes) by searching for relevant information on the Web.

  Task 2. Please watch the video and list movie titles you have seen from the 85th academy awards (Oscar awards) 2013 Winners List. You can create a new document either Word or Textedit program to list the movies. Below this movie clips will show you the full list of the winners. Feel free to pause and replay the video clip, as you need. `http://www.youtube.com/watch?v=cc10n7Iunvg`

  Task 3. You will receive three emails during the session. You can check and respond to the emails any time you want. However, you will be asked to respond those three emails before finishing the session.

- Disconnected Tasks Condition

You will be given 20 minutes to finish these tasks below. There is no specific task order to follow.

Task 1. Please open the Part2 word file on the desktop. Next, please complete two subtasks.

Task 2. Please watch the video and list fruits that the researcher tested. `http://www.youtube.com/watch?v=3Qg80qTfzgU`.

Task 3. You will receive three emails during the session. You can check and respond to the emails any time you want. However, you will be asked to respond those three emails before finishing the session.

Appendix B

Task Instruction for the Goal-directed Motivation Condition

- Interconnected Tasks Condition

  You will be given 20 minutes to finish these tasks below. Please complete Task 1 first and Task 2 respectively and use the pre-arranged screen setting.

  Task 1. Please open the Part 1 excel file on the desktop. Next, fill out information in the spreadsheet (white blank boxes) by searching for relevant information on the Web.

  Task 2. Please watch the video and list movie titles you have seen from the 85th academy awards (Oscar awards) 2013 Winners List. You can create a new document either Word or Textedit program to list the movies. Below this movie clips will show you the full list of the winners. Feel free to pause and replay the video clip, as you need. `http://www.youtube.com/watch?v=cc1On7Iunvg`

  Task 3. You will receive three emails during the session. You will receive email notifications. Please check and respond to the emails as soon as you notice that the new email is received.

- Disconnected Tasks Condition

You will be given 20 minutes to finish these tasks below. Please complete Task 1 first and Task 2 respectively and use the pre-arranged screen setting.

Task 1. Please open the Part2 word file on the desktop. Next, please complete two subtasks.

Task 2. Please watch the video and list fruits that the researcher tested. `http://www.youtube.com/watch?v=3Qg80qTfzgU`.

Task 3. You will receive three emails during the session. You will receive email notifications. Please check and respond to the emails as soon as you notice that the new email is received.

Appendix C

Study I Experiment Results - Captured screens

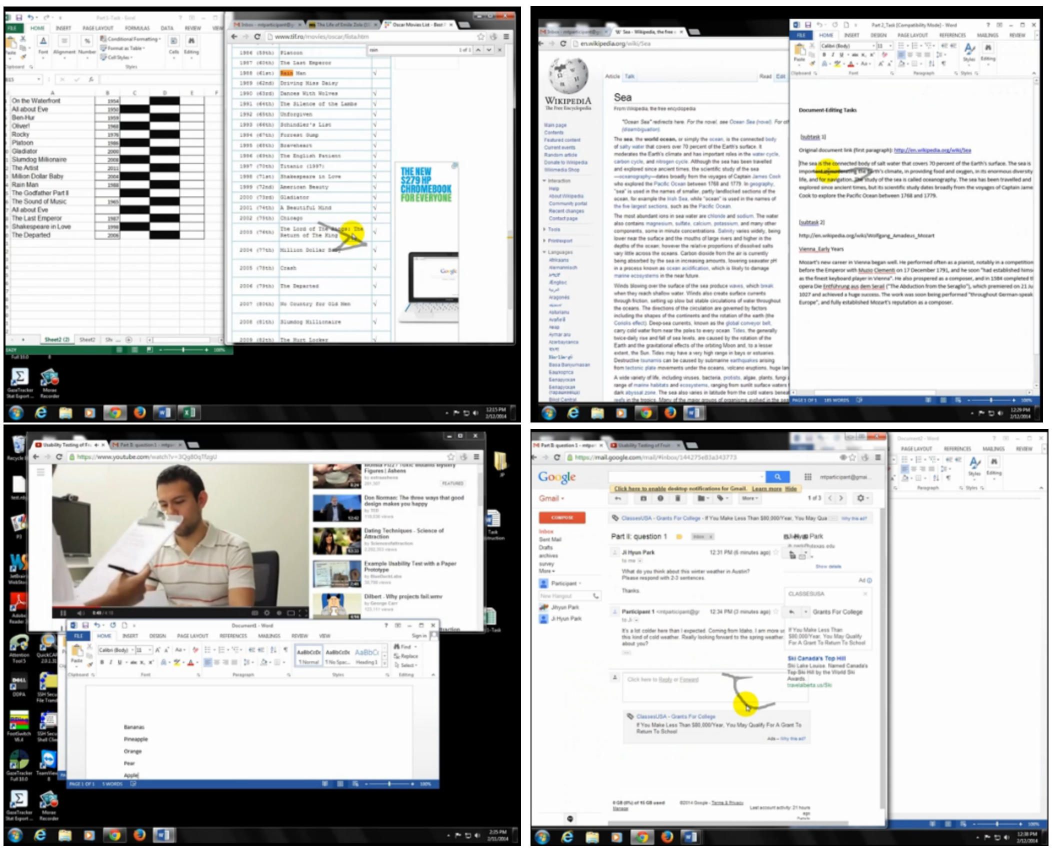


Figure C.1: Experiential motivation condition - participant's captured screen

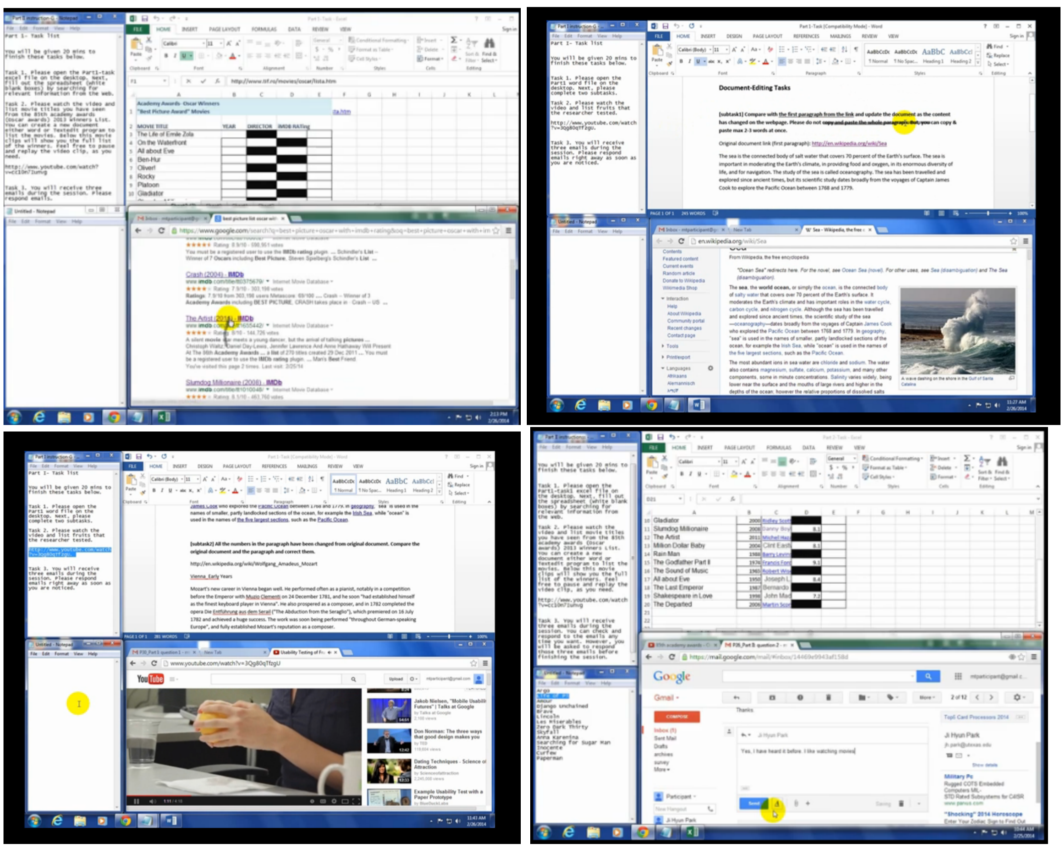


Figure C.2: Goal-directed condition - participant's captured screen

Appendix D

Flow Measuring Instrument

The scale contains a total of 18 items (each rated on a 5-point Likert scale) measuring the following five dimensions: sense of control, focused attention, curiosity, intrinsic interest, and interactivity. This instrument adapted and expanded from research of Ghani and Deshpande (1994), Pearce et al. (2005), Webster et al. (1993), and Novak and Hoffman (1998).

Control (3 items)

- CO1 clearly know the right things to do/ feel confused about what to do
- CO2 feel calm/ feel agitated
- CO3 feel in control/ do not feel in control

Focused Attention (4 items)

- FA1 My attention was: focused / not focused (Reverse-scored)
- FA2 I concentrated fully / did not concentrate fully (Reverse-scored)
- FA3 I thought about other things. (Reverse-scored)
- FA4 I was aware of distractions. (Reverse-scored)

- FA5 I was totally absorbed in what I was doing

Curiosity (3 items)

- CU1 The conditions of the multitasking experiment excited my curiosity
- CU2 Interacting with multiple tasks made me curious about next step
- CU3 The multitasking activities aroused my imagination

Intrinsic Interest (3 items)

- II1 Involving in multiple tasks on the computer system bored me
- II2 Involving in multiple tasks was intrinsically interesting
- II3 Involving in multiple tasks was fun for me to do

Interactivity (5 items)

- IA1 Interacting with the multiple tasks is slow and tedious (R)
- IA2 Navigating multiple tasks with the computer system is not very intuitive (R)
- IA3 The computer system allows me to navigate the multiple tasks in a natural and predictable manner
- IA4 The range of what can be manipulated on the computer screen is narrow
- IA5 At any time, there are many different actions available to me as I use the computer system

Appendix E

Pre-Test Questionnaire

Demographic Information

- In what year were you born?

Web usage tendency

When did you start using the Web?

- Less than 6 months ago
- 6 months - less than 2 years ago
- 2 - 4 years ago
- 5 -10 years ago
- More than 10 years ago

When did you start using a computer?

- Less than 6 months ago
- 6 months - less than 2 years ago
- 2-4 years ago

- 5-10 years ago
- More than 10 years ago

Multitasking preference

: Polychronic-Monochronic Tendency Scale (PMTS)

(5 Likert-Scale: Strongly disagree 1 - Strongly agree 5)

When I use my computer,

- I prefer to do two or more activities at the same time
- I typically do two or more activities at the same time
- Doing two or more activities at the same time is the most efficient way to use my time
- I am comfortable doing more than one activity at the same time
- I like to juggle two or more activities at the same time

Appendix F

Post-Test Questionnaire

Please state whether you agree or disagree with the following statements.

In this exercise,

- I clearly knew the right things to do_______________ feel confused about what to do
- I felt calm _______________ agitated
- I felt in control_______________ did not feel in control
- My attention was: focused _______________ not focused
- I concentrated fully _______________ did not concentrate fully
- I was aware of distractions

  Strongly disagree (1) _______________ Strongly agree (5)
- I thought about other things

  Strongly disagree (1) _______________ Strongly agree (5)
- I was totally absorbed in what I was doing

  Strongly disagree (1) _______________ Strongly agree (5)

- The conditions of the multitasking experiment excited my curiosity.

  Strongly disagree (1) _______________ Strongly agree (5)

- Interacting with multiple tasks made me curious about next step.

  Strongly disagree (1) _______________ Strongly agree (5)

- The multitasking activities evoked my imagination.

  Strongly disagree (1) _______________ Strongly agree (5)

- Involving in multiple tasks on the computer system bored me.

  Strongly disagree (1) _______________ Strongly agree (5)

- Involving in multiple tasks was intrinsically interesting.

  Strongly disagree (1) _______________ Strongly agree (5)

- Involving in multiple tasks was fun for me to do.

  Strongly disagree (1) _______________ Strongly agree (5)

- Interacting with the multiple tasks is slow and tedious.

  Strongly disagree (1) _______________ Strongly agree (5)

- Navigating multiple tasks with the computer system is not very intuitive.

  Strongly disagree (1) _______________ Strongly agree (5)

- The computer system allows me to navigate the multiple tasks in a natural and predictable manner.

  Strongly disagree (1) _______________ Strongly agree (5)

- The range of what can be manipulated on the computer screen is narrow.

  Strongly disagree (1) _______________ Strongly agree (5)

- At any time, there are many different actions available to me as I use the computer system.

  Strongly disagree (1) _______________ Strongly agree (5)

Appendix G

Experiment Participant Informed Consent Form

Title: Flow in Multitasking: The Effects of Motivation, Artifact, and Task Factors.

- Conducted by: Ji Hyun Park, Doctoral candidate (jh.park@utexas.edu)
  School of Information, The University of Texas at Austin, Phone: 512-897-4563

- Faculty Sponsor: Randolph Bias, Professor (rbias@ischool.utexas.edu)
  School of Information, The University of Texas at Austin, Phone: 512-657-3924

The study aims to examine how we can understand and measure the dynamics of multitasking, which result from interactions among multitasking factors - users, artifacts, and tasks. Your participation in the study will contribute to understand the relationship between design features and users' multitasking efficiency, and to develop a user interface design concept for multitasking context based on user experience and usability evaluation. You are free to contact the investigator at the above address and phone number to discuss the study. You must be at least 18 years old to participate in

If you decide to participate in the experiment:

- You will be asked to read a consent form and to fill out pre-test questionnaires about demographic information and multitasking preferences.
- After completing the questionnaire, you will be asked to complete three tasks in multitasking contexts and fill out post-session questionnaires.

Total estimated time to participate in this study is:

- The amount of time to complete the experiment will be approximately 35-45 minutes.

Risks of Participation: The risks of participating in this study are no greater than those of everyday life.

Benefits: There are no direct benefits to you other than what you learn from answering the questions and knowing that you are helping research. This research, however, will provide a guideline for improving design systems for multitasking efficiency in computer-mediated environments such as an e-learning environment.

Compensation: Upon the completion of the experiment, you will be compensated $10

Confidentiality and Privacy Protections:

- For the experiment, the investigators will **not** video record of the subjects (you), but only record monitor screen video-captures, which contain no identifiable information of the subjects.

- Only the investigators will have access to the folder where the data is stored. Any written results will discuss group findings and will not release any information that could possibly identify you as an individual.

- All collected data, including all field notes that contain the assigned pseudonyms, will be kept in a locked box at the investigator's home. The key to the lock box will be separately stored and secured so only the researcher has access.

- The data resulting from your participation may be made available to other researchers in the future for research purposes not detailed within this consent form. In these cases, the data will contain no identifying information that could associate you with it, or with your participation in any study.

- To make possible future analysis, the investigators will retain the recordings from all data for the next 10 years.

Participant Rights: Your participation in this research is voluntary. You may discontinue the experiment at any time without reprisal or penalty. You may also skip questions that you do not wish to answer. Withdrawal will not affect your relationship with The University of Texas at Austin. If you do not want to participate in the study, either stop participating or close the browser window.

Contacts

If you have any questions about the study or need to update your email address, contact the researcher Ji Hyun Park at 512-897-4563 or send an email to jh.park@utexas.edu.

Questions about your rights as a research participant.

If you have questions about your rights or are dissatisfied at any time with any part of this study, you can contact, anonymously if you wish, the Institutional Review Board by phone at (512) 471-8871 or email at orsc@uts.cc.utexas.edu.

Thank you.

You will be given a copy of this information to keep for your records.

Appendix H

Participatory Design Participant Informed Consent Form

Title: Flow in Multitasking: The Effects of Motivation, Artifact, and Task Factors.

- Conducted by: Ji Hyun Park, Doctoral candidate (jh.park@utexas.edu)
  School of Information, The University of Texas at Austin, Phone: 512-897-4563
- Faculty Sponsor: Randolph Bias, Professor (rbias@ischool.utexas.edu)
  School of Information, The University of Texas at Austin, Phone: 512-657-3924

The study aims to examine how we can understand and measure the dynamics of multitasking, which result from interactions among multitasking factors?users, artifacts, and tasks. Your participation in the study will contribute to understand the relationship between design features and users' multitasking efficiency, and to develop a user interface design concept for multitasking context based on user experience and usability evaluation. You are free to contact the investigator at the above address and phone number to discuss the study. You must be at least 18 years old to participate in the study.

If you decide to participate in the experiment:

- You will be asked to read a consent form and to fill out pre-test questionnaires about demographic information and multitasking preferences.

- After completing the questionnaire, you will be asked to evaluate two types of interface prototypes (A & B) and comment on each prototype to make design prototypes based on your preferences and ideas.

Total estimated time to participate in this study is:

- The amount of time to complete the participatory design session will be approximately 30-45 minutes.

Risks of Participation: The risks of participating in this study are no greater than those of everyday life.

Benefits: There are no direct benefits to you other than what you learn from answering the questions and knowing that you are helping research. This research, however, will provide a guideline for improving design systems for multitasking efficiency in computer-mediated environments such as an e-learning environment.

Compensation: Upon the completion of the experiment, you will be compensated $10.

Confidentiality and Privacy Protections:

- For the session, the investigators will not video record of the subjects (you), but only record monitor screen video-captures.

- Only the investigators will have access to the folder where the data is stored. Any written results will discuss group findings and will not release any information that could possibly identify you as an individual.

- All collected data, including all field notes that contain the assigned pseudonyms, will be kept in a locked box at the investigator's home. The key to the lock box will be separately stored and secured so only the researcher has access.

- The data resulting from your participation may be made available to other researchers in the future for research purposes not detailed within this consent form. In these cases, the data will contain no identifying information that could associate you with it, or with your participation in any study.

- To make possible future analysis, the investigators will retain the recordings from all data for the next 10 years.

Participant Rights: Your participation in this research is voluntary. You may discontinue the experiment at any time without reprisal or penalty. You may also skip questions that you do not wish to answer. Withdrawal will not affect your relationship with The University of Texas at Austin. If you do not want to participate in the study, either stop participating or close the browser window.

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If you have any questions about the study or need to update your email address, contact the researcher Ji Hyun Park at 512-897-4563 or send an email to jh.park@utexas.edu.

Questions about your rights as a research participant.

If you have questions about your rights or are dissatisfied at any time with any part of this study, you can contact, anonymously if you wish, the Institutional Review Board by phone at (512) 471-8871 or email at orsc@uts.cc.utexas.edu.

Thank you.

You will be given a copy of this information to keep for your records.

Bibliography

Abaté, C. (2008). You say multitasking like it's a good thing. *Thought and Action, 24*, 7-13.

Adamczyk, P. (2004). If not now, when?: The effects of interruption at different moments within task execution. *CHI '04 Proceedings of the SIGCHI conference on Human factors in computing systems, 6*(1), 271-288.

Adams, A. D., Nelson, R. R., and Todd, A. P. (1992). Perceived usefulness, ease of use, and usage of information technology: A replication. *MIS Quarterly, Vol.16*, No.2 (Jun., 1992). 227-247.

Altmann, E. M. and Gray, W. D. (2008). An integrated model of cognitive control in task switching. *Psychological Review, 115*(3), 602-639.

Anderson, J. R., Bothell, D., Byrne, M. D., Douglass, S., Lebiere, C., and Qin, Y. (2004). An integrated theory of the mind. *Psychological Review, 111*, 1036-1060.

Anderson, J. R. (2007). *How Can the Human Mind Occur in the Physical Universe?* New York: Oxford University Press.

Appelbaum, H. S. and Marchionni, A. (2008). The multi-tasking paradox: perceptions, problems and strategies. *Management Decision, Vol. 46*, No. 9, 1313-1325.

Baker, M. and Lund, K. (2003). Promoting reflective interactions in a CSCL environment. *Journal of Computer Assisted Learning, Vol. 13*, Issue 3, 175-193. DOI: 10.1046/j.1365-2729.1997.00019.x

Bailey, B., Adamczyk, P., Chang, T., and Chilson, N. (2006). A framework for specifying and monitoring user tasks. *Computers in Human Behavior, 22*(4), 709-732.

Ballard, I. D. and Seibold, R. D. (2000). Time orientation and temporal variation across work groups: Implications for group and organizational communication, *Western Journal of Communication, 64*:2, 218-242.

Ballard, I. D. and Seibold, R. D. (2003). Communicating and organizing in time : A meso-level model of organizational temporality, *Management Communication Quarterly, 16*: 380.

Ballard, I. D. and Seibold, R. D. (2004). Organizational members' communication and temporal experience: Scale development and validation, *Communication Research, 31*: 135.

Bargh, J. A. (1997). The automaticity of everyday life. In R. S. Wyer, Jr. (Ed.), The automaticity of everyday life. *Advances in social cognition, Vol.10*, pp. 1-61). Mahwah, NJ: Erlbaum.

Benbunan-Fich, R. and Truman, G. (2009). Multitasking with laptops during meetings. *Communications of the ACM, 52*, 2, February 2009, 139-141.

Benbunan-Fich, R, Adler, F. R, and Mavlanova, T. (2009a). Developing new metrics for computer-based multitasking behavior. *ICIS 2009 Proceedings*. Paper 132. http://aisel.aisnet.org/icis2009/132.

Benbunan-Fich, R., Adler, F. R., and Mavlanova, T. (2009b). Towards new metrics for multi-tasking behavior, *Extended Proceedings of the Conference on Human Factors in Computing Systems CHI '09*, Boston, MA, 4039-4044. New York: ACM Press.

Benbunan-Fich, R., Adler, R. F., and Mavlanova, T. (2011). Measuring multitasking behavior with activity-based metrics. *ACM Transactions on Computer-Human Interaction, 18*(2), 1-22. doi:10.1145/1970378.1970381.

Bendy, G. Z, Seglin, M. H., and Meister, D. (2000). Activity theory: History, research and application. *Theoretical Issues in Ergonomics Science, 1*,2, 168-206.

Bendy, G. Z. and Karwowski, W. (2007). *A Systemic-Structural Theory of Activity: Applications to Human Performance and Work Design.* CRC/Taylor and Francis, Boca Raton, FL.

Bluedorn, A. C. and Denhardt, R. B. (1988). Time and organizations. *Journal of Management, Vol. 14*, No. 2. 299-320.

Bordens, K. S. and Abbott, B. B. (2008). *Research Design and Methods: A Process Approach* (7th ed.). Boston: McGraw-Hill.

Bødker, S. (1989). A human activity approach to user interfaces. *Human-Computer Interaction, 4*, 3, 171-195.

Bødker, S. (1996). Applying activity theory to video analysis: How to make sense of video data in human computer interaction. In *context and consciousness*, Nardi, B.A. Ed., MIT Press, Cambridge, MA, 147-174.

Borst, J. P., Taatgen, N. A., and van Rijn, H. (2010). The problem state: A cognitive bottleneck in multitasking. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 36*(2), 363-382. doi:10.1037/a0018106.

Brumby, D. and Salvucci, D. (2009). Focus on driving: How cognitive constraints shape the adaptation of strategy when dialing while driving. In *Proceedings of the SIGCHI conference on Human factors in computing systems*, 1629-1638. Boston, MA, USA.

Buckland, M. K. (1991). Information as Thing. *Journal of the American Society for Information Science, 42*(5), 351-360.

Burgess, P. W. (2000). Real-world multitasking from a cognitive neuroscience perspective, in Monsel, S. and Driver, J. (Eds), *Control of Cognitive Processes, Attention and Performance*, No. XVIII, MIT Press, Cambridge, MA, 465-72.

Burton-Jones, A. and Straub, D.W. (2006). Reconceptualizing system usage: An approach and empirical test. *Information Systems Research, 17*, 3, 228-246.

Carlson, R. A. and Sohn, M.-Y. (2000). Cognitive control of multistep routines: information processing and conscious intentions, in Monsell, S. and Driver, J. (Eds),*Control of Cognitive Processes, Attention and Performance*, No. XVIII, MIT Press, Cambridge, MA, 443-464.

Carrier, L. M, Cheever, N. A., Rosena, L. D., Beniteza, S., and Changa, J. (2009). Multitasking across generations: Multitasking choices and difficulty ratings in three generations of Americans. *Computers in Human Behavior 25*, (2009) 483-489.

Cozby, P. C. and Bates, S. C. (2012). *Methods in Behavior Research* (11th ed.). Boston: McGraw-Hill.

Csikszentmihalyi, M., and Csikszentmihalyi, I.S. (eds.) (1988). *Optimal Experience: Psychological Studies of Flow in Consciousness.* Cambridge University Press, New York.

Csikszentmihalyi, M. (1990). *Flow: The Psychology of Optimal Experience.* Harpers Perennial, New York.

Csikszentmihalyi, M. (1998). *Finding Flow: The Psychology of Engagement with Everyday Life.* Basic Books, New York.

Czerwinski, M., Cutrell, E and Horvitz, E. (2000). Instant messaging and interruption: influence of task type on performance. *OZCHI 2000*, 356-361.

Czerwinski, M., Cutrell, E and Horvitz, E. (2001). Notification, disruption and memory: Effects of messaging interruptions on memory and performance. *INTERACT* 2001, 263-269.

Davis, F. (1989). Perceived Usefulness, Perceived Ease of Use, and End User Acceptance of Information Technology: A Replication. In: *MIS Quarterly, Vol. 13*, No. 3, 318-339.

Dearman, D. and Pierce, S. J. (2008). "It's on my other computer?": Computing with multiple devices, *Proceedings of the Conference on Human Factors in Computing Systems CHI '08* (Florence, Italy),767-776. New York: ACM Press.

eCrush and OTX (2007). Teens learn about new TV shows from TV, not the Internet, *Hearst Magazine*.

Finneran, M. C and Zhang, P. (2003). A person-artefact-task (PAT) model of flow antecedents in computer-mediated environments. *International Journal of Human-Computer Studies, 59*, 475-496.

Finneran, M. C and Zhang, P. (2005). Flow in computer-mediated environments: promises and challenges. *Communications of the Association for Information Systems, Vol. 15*. 82-101.

Fornell, C. and Larcker, D. F., (1981). Evaluating structural equation models with unobservable variables and measurement error. *Journal of Marketing Research, 18* (1), 39-50.

Fox, S., Zickuhr, K., and Smith, A. (2009). Twitter and Status Updating, Fall 2009. Pew Internet (Pew Internet and American Life Project). Retrieved from http://www.pewinternet.org/Reports/2009/17-Twitter-and-Status-Updating-Fall-2009.aspx

Gagné, M., and Deci, E. L. (2005). Self-determination theory and work motivation. *Journal of Organizational Behavior, 26*, 331?362.

Ghani, A.J and Deshpande, P.S. (1994). Task characteristics and the experience of optimal flow in human-computer interaction. *The Journal of Psychology, 128*(4). 381-391.

Gilbert, S. J. and Shallice, T. (2002). Task switching: a PDP model. *Cognitive Psychology, 44*(3), 297-337.

Gonzlez, V. M. and Mark, G. (2004). "Constant, constant, multi-tasking craziness": managing multiple working spheres. In *proc. of the ACM Conference on Human Factors in Computing Systems. Vol. 6*, p.113-120. ACM Press.

Harvard University. (2012 , May 24). MIT and Harvard announce edX. Harvard Gazette. Retrieved from http://news.harvard.edu/gazette/story/2012/05/mit-and-harvard-announce-edx/

Hoffman, D. L. and Novak, T. P. (1996). Marketing in hypermedia computer-mediated environments: Conceptual foundations. *The Journal of Marketing, Vol. 60*, No.3 (Jul., 1996). 50-68.

Horrigan, J. (2008). *Mobile Access to Data and Information.* Pew Research Center. Retrieved from `http://www.pewinternet.org/Reports/2008/Mobile-Access-to-Data-and-Information.aspx`

Horvitz, E., Kadie, C., Paek, T., and Hovel, D. (2003). Models of attention in computing and communication: from principles to applications. *Communications of the ACM, Vol. 46*(3), March 2003.

Iqbal, S. T. and Bailey, P. B. (2008). Effects of intelligent notification management on users and their tasks, *Proceedings of the Conference on Human Factors in Computing Systems CHI '08* (Florence,Italy), 93-102. New York: ACM Press.

Iqbal, T. S, Ju, Y-C, and Horvitz, E. (2010). Cars, calls and cognition: Investigating driving and divided attention. In *ACM Conference on Human Factors in Computing Systems (CHI 2010)*, Association for Computing Machinery, Inc., 2010.

Jersild, A. T. (1927). Mental set and shift. *Archives Psychology, 89.*

Kaptelinin, V. (1996). Activity theory: Implications for human-computer interaction. In *Context and Consciousness*, Nardi, B.A. Ed., MIT Press, Cambridge, MA, 53-59.

Kaptelinin, V. and Nardi, B. A. (2006). *Acting with technology: activity theory and interaction design*. MIT press, Cambridge, MA.

Kelly, D. (2009). Methods for evaluating interactive information retrieval systems with users. *Foundations and Trends in Information Retrieval, Vol.3*, Nos.1-2.1-224.

Klauer, S. G., Dingus, T. A., Neale, V. L., Sudweeks, J. D., and Ramsey, D. J. (2006). *The impact of drivers inattention on near-crash/crash risk: An Analysis Using the 100-Car Naturalistic Driving Study Data*. Virginia Tech Transportation Institute, National Highway Traffic Safety Administration. April 2006. Retrieved from `http://www.nhtsa.gov/DOT/NHTSA/NRD/Multimedia/PDFs/Crash%20Avoidance/2006/DriverInattention.pdf`

Kleinman, L. (2010). *Physically Present, Mentally Absent? Technology Multitasking in Organizational Meeting.* Ph.D. dissertation, University of Texas at Austin, 2010.

Krippendorff, K. (2004). *Content Analysis: An Introduction to its Methodology.* Thousand Oaks, California: Sage Publication, Inc.

Kuutti, K. (1991). Activity theory and its applications to information systems research and development. In *Information Systems Research*, H-E. Nissen Ed., Elsevier Science Publishers, Amsterdam, 529-549.

Lewin , T. (2012, March 4). Instruction for masses knocks down campus walls. *New York Times.* Retrieved from http://www.nytimes.com/2012/03/05/education/moocs-large-courses-open-to-all-topple-campus-walls.html.

MacKay, B. and Watters, C. (2008). Exploring multi-session web tasks, *Proceedings of the Conference on Human Factors in Computing Systems CHI '08* (Florence, Italy), 1187-1196. New York: ACM Press.

Mahraj, T. (2012). Using information expertise to enhance massive open online courses, *Public Services Quarterly, 8*:4, 359-368, DOI: 10.1080/15228959.2012.730415

Malone, T. W. (1981). Toward a theory of intrinsically motivated instruction. *Cognitive Science, 4*, 333-369.

Markoff, J. (2011, August 15). Virtual and artificial, but 58,000 want course. *New York Times.* Retrieved from http://www.nytimes.com/2011/08/16/science/16stanford.html

Mattelmki, T. (2006). *Design Probes.* Finland: Aalto University Press.

Miyata, Y. and Norman, D. A. (1986). *Psychological issues in support of multiple activities, in User Centered System Design*, D.A. Norman and S.W. Draper (Eds). Lawrence Erlbaum, Hillsdale, N.J., USA (1986), 265-284.

Monsell, S. (2003). Task switching. *Trends in Cognitive Sciences, 7*(3), 134-140.

Nardi, B.A. (1996). Studying context: A comparison of activity theory, situated action models and distributed cognition. In *Context and Consciousness*, Nardi, B.A. Ed., MIT Press, Cambridge, MA, 69-102.

Neale, V. L., Dingus, T. A., Klauer, S. G., Sudweeks, J., and Goodman, M. (2005). An overview of the 100-car naturalistic study and findings. National Highway Traffic Safety Administration. In *Proceedings of the International Technical Conference on Enhanced Safety of Vehicles*, June 6-9, Washington, DC. 2005.

Nel, D., Niekerk, V. R., Berthon, J. P., and Davies, T. (1999). Going with the flow: web sites and customer involvement. *Internet Research: Electronic Networking Applications and Policy, Vol. 9*, No.2. 1999.109-116.

Newell, A. (1990). *Unified Theories of Cognition.* Cambridge, MA: Harvard University Press.

Novak, T. P., Hoffman, D. L., and Yung, Y. F. (2000). Measuring the customer experience in online environments: A structural modeling approach. *Marketing Science, 19*(1), 22-42.

Novak, P. T., Hoffman, L. D. and Duhachek, A. (2003). The influence of goal-directed and experiential activities on online flow experiences. *Journal of Consumer Psychology, 13*(1), 3-16.

Ophir, E., Nass, C., and Wagner, A. D. (2009). Cognitive control in media multitaskers. *Proceedings of the National Academy of Sciences of the United States of America, 106*(37), 15583-15587. National Academy of Sciences.

Park, J. (2011), A synthesis of internal and external factors of users' multitasking contexts. *IA Summit* (Poster). April, 2011. Denver, CO. U.S.A.

Park, J. and Liu, M. (2012). Multitasking in e-learning environments: users' multitasking strategies and design implications. *Proceeding of CHI '12, Extended Abstracts on Human Factors in Computing Systems*. 1991-1996.

Park, J. and Bias, R. G., (2012). Understanding Human Multitasking Behaviors through a lens of Goal-Systems Theory. *ALISE (Association for Library and Information Science Education) Conference* (Presentation), January, 2012. Dallas, TX. U.S.A.

Pashler, H. E. (2000). Task switching and multitask performance. In S. Monsell and J. Driver (Eds.), *Control of Cognitive Processes: Attention and Performance XVIII*, 275-423; Cambridge, MA, The MIT Press, 2000 xvi, 2779.

Parry , M. (2010 , August 29). Online, bigger classes may be better classes. *Chronicle of Higher Education* Retrieved from http://chronicle.com/article/Open-Teaching-When-the/124170

Pashler, H., Johnston. C. J., and Ruthruff, E. (2001). Attention and Performance, *Annual Review of Psychology. 52*:629–51.

Pearce, J., and Howard, S. (2004). Designing for Flow in a Complex Activity. *Paper presented at the 6th Asia-Pacific Conference on Computer-Human Interaction*, New Zealand.

Pilke, M.E. (2004). Flow experiences in information technology use. *International Journal of Human-Computer Studies, 61*. 347-357.

Preece, J., Rogers, Y., Sharp, H., Benyon, D., Holland, S. and Carey, T. (1994). *Human Computer Interaction*. Massachusetts:Addison Wesley.

Reder, S. and Schwab, R. G. (1990). The temporal structure of cooperative activity. In *Proceedings of CSCW'90*, ACM Press, 303-316.

Reeve, J. (2002). Self-determination theory applied to educational settings. In E.L. Deci and R.M. Ryan's (Eds.), *Handbook of self-determination*, 183-203. Rochester, NY: University of Rochester Press.

Reeve, J. (2005). *Understanding Motivation and Emotion*, 4th Edition, Hoboken, NJ: John Wiley and Sons, Inc.

Ricker, J. (2010). Section7: Social Influences on Cognitions, Emotions, and Behavior, *What is psychological process?* (Online Textbook) Retrieved from http://wwwi.scottsdalecc.edu/ricker/psy101/readings/section_7/7-10.html

Ried, J. (2011). The digital millennials: Are you ready? Resource Interactive. Keynote Presentation. Retrieved from
http://www.slideshare.net/ResourceInteractive/dm-webinar-nov08-fina-lfor-slide-share-arial-presentation

Robertson, G., Horvitz, E., Czerwinski, M., Baudisch, P. Hutchings, R. D., Meyers, B., Robbins, D ., and Smith, G. (2004). Scalable Fabric: flexible task management, AVI '04 *Proceedings of the working conference on Advanced Visual Interfaces*, ACM. 85-89.

Rohrer, D. and Pashler, H. E. (2003). Concurrent task effects on memory retrieval. *Psychonomic Bulletin and Review, 10*(1), 96-103.

Rubinstein, J. S., Meyer, D. E., and Evans, J. E. (2001). Executive control of cognitive processes in task switching. *Journal of Experimental Psychology: Human Perception and Performance, 27*(4), 763-797.

Ryan, R. M. and Connell, J. P. (1989). Perceived locus of causality and internalization: Examining reasons for acting in two domains. *Journal of Personality Assessment, 49*, 6-12.

Salvucci, D. D. and Macuga, L. K. (2002). Predicting the effects of cellular-phone dialing on driver performance, *Cognitive Systems Research, 3*, 95-102.

Salvucci, D. D. (2006). Modeling driver behavior in a cognitive architecture. *Human Factors, 48*, 362-380.

Salvucci, D. D. and Taatgen, N. A. (2008). Threaded cognition: An integrated theory of concurrent multitasking. *Psychological Review, 115*(1), 101-130.

Salvucci, D.D., Taatgen, A. N., and Borst, P. J. (2009). Toward a Unified Theory of the Multi-tasking Continuum: From Concurrent Performance to Task Switching, Interruption, and Resumption, *Proceedings of the Conference on Human Factors in Computing Systems CHI '09* (Boston, MA), 1819-1828. New York: ACM Press.

Salvucci, D. D. and Taatgen, N. A. (2011). *The multitasking mind.* New York. Oxford University Press.

Sandelands, L. E., Ashford, S. J., and Dutton, J. E. (1983). Reconceptualizing the over justification effect: A template- matching approach, *Motivation and Emotion, Vol. 7*, Issue 3. pp. 229-255.

Sanders, E. Brandt, E., and Binder, T. (2010). A framework for organizing the tools and techniques of participatory design. *PDC 2010 Proceedings*. Sydney, Australia.

Sanders, E. and Stappers, P. (2008). Co-creation and the new landscapes of design. *CoDesign*, Taylor and Francis. March 2008.

Schenider, W. and Chein, J. M. (2003). Controlled and automatic processing: behavior, theory, and biological mechanisms, *Cognitive Science, 27* (2003) 525-559.

Sleeswijk Visser, F., Stappers, P.J., van der Lugt, R., Sanders, E.B.-N. (2005) Contextmapping: Experiences from practice. *CoDesign, 1*(2), 119-149.

Smith, A. (2010). Mobile Access 2010, *Pew Internet*, Pew Internet and American Life Project, `http://www.pewinternet.org/Reports/2010/Mobile-Access-2010/Summary-of-Findings.aspx`

Schriber, J. B. and Gutek, B. A. (1987). Some time dimensions of work: The measurement of an underlying dimension of organizational culture. *Journal of Applied Psychology, 72*, 642-650.

Shaughnessy, J. J., Zechmeister, E. B., and Zechmeister, J. S. (2012). *Research Methods in Psychology* (9th ed.). Boston: McGraw-Hill.

Skadberg, Y. X. and Kimmel, J. R. (2004). Visitors' flow experience while browsing a Web site: its measurement, contributing factors and consequences. *Computers in Human Behavior, 20*(3), 403-422.

Smith, G., Baudisch, P., Robertson, G., Czerwinski, M., Meyers, B., Robbins, D., and Andrews, D. (2003). Groupbar: The taskbar evolved. OZCHI 03 Proceedings of the *Australasian conference on Computer Human Interaction* (Vol. 3, p. 1-10). Citeseer. Retrieved from `http://patrickbaudisch.com/publications/2003-Smith-OZCHI03-GroupBar.pdf`

Sohn, M.-H. and Anderson, J. R. (2001). Task preparation and task repetition: Two-component model of task switching. *Journal of Experimental Psychology: General, Vol. 130*, No. 4, 764-778.

Spink, A. Ozmutlu, H. C., and Ozmutlu, S. (2002). Multitasking information seeking and searching processes. *Journal of the American Society for Information Science and Technology, 53*(8) 639-652.

Spink, A. (2004). Multitasking information behavior and information task switching: an exploratory study. *Journal of Documentation, 60*(4). 336-351.

Spink, A. and Cole, C. (2005). A multitasking framework for cognitive information retrieval. In Amanda Spink and Charles Cole (Eds.), *New Directions in Cognitive Information Retrieval, Vol. 19.* 99-112.

Spink, A. and Park, M. (2005). Information and non-information multitasking interplay. *Journal of Documentation, 61*(4). 548-554.

Spink, A. and Cole, C. (2008). Multitasking behavior. *Annual Review of Information Science and Technology, 39*(1). 1-118.

Spink, A. (2010) *Information Behavior: An Evolutionary Instinct*, Springer.

Steuer, J. (1992). Defining Virtual Reality: Dimensions Determining Telepresence. *Journal of Communication, 42*(4), 73-93.

Strauss, A. and Corbin, M. J. (1990). *Basics of Qualitative Research: Grounded Theory Procedures and Techniques.* SAGE Publications, Inc.

Strauss, W., Howe, N., and Markiewicz, P. (2006). *Millennials and the pop culture: Strategies for a new generation of consumers in music, movies, television, the Internet, and video games.* Great Falls, VA: Lifecourse Associates.

Su, N. M. and Mark, G. (2008). Communication chains and multitasking. *Proceeding of the 26th Annual CHI conference on Human factors in computing systems CHI 08*, 83. ACM Press.

The National Safety Commission. (2007). The Dangers of Multitasking Retrieved from `http://alerts.nationalsafetycommission.com/2007/10/dangers-of-multitasking.php`

Trevino, L. K. and Webster, J. (1992). Flow in computer-mediated communication - electronic mail and voice mail evaluation and impacts. *Communication Research, 19*(5), 539-573.

Vallerand, R. J., Pelletier, L. G., Blais, M. R., Briere, N. M., Senecal, C., and Vallieres, E. F. (1992). The academic motivation scale: A measure of intrinsic, extrinsic, and amotivation in education. *Educational and Psychological Measurement, 52*, 1003-1017.

Waller, M. J. (1997). Keeping the pins in the air: how work groups juggle multiple tasks, *Advances in Interdisciplinary Studies of Work Teams, Vol. 4*. 217-247.

Wallis, C. (2006, March 27). The multitasking generation: they're e-mailing, IM-ing and downloading while writing the history essay. What is all that digital juggling doing to kids' brains and their family life? *Time, 167*. 48-55.

Webster, J., Trevino, L. K., and Ryan, L. (1993). The dimensionality and correlates of flow in human-computer interactions. *Computers in Human Behavior, 9*(4), 411-426.

Wensveen, A. G. S., Djajadiningrat, P. J., and Oberbeeke, J. C. (2004). Interaction frogger: A design framework to couple action and function through feedback and feedforward. *DIS' 04*, August, 2004. Cambridge, MA. U.S.A.

Wickens, C. D. (2008). Multiple resources and mental workload. *Human Factors The Journal of the Human Factors, 50*(3). 449-455.

Wilson, T. D. (2002). *Strangers to Ourselves: Discovering the Adaptive unconscious.* Cambridge, MA: Belknap Press of Harvard University Press.

Yongxia, X., and Kimmel, J. (2004). Visitors'f flow experience while browsing a Web site: its measurement, contributing factors and consequences. *Computers in Human Behaviour*, 403-422.

Zacarias, M., Pinto, H. S., and Tribolet, J. M. (2007). Discovering multitasking behavior at work: A context-based ontology. *In Proceedings of TA MODIA 2006*, 292-307.