# SUPPORTING WORKING TIME INTERRUPTION MANAGEMENT THROUGH PERSUASIVE DESIGN

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Knowledge workers often suffer productivity loss because of unsuccessful interruption handling, which can lead to even more detrimental behaviors like "cyber-slacking" and procrastination. Many of the interruption management techniques proposed in the research literature focus on minimizing interruption occurrences. However, given the inevitability of internal and external interruptions in everyday life, it may be more practical to help people regulate how they respond to interruptions using persuasive technologies. The aim of this dissertation is to explore and evaluate the design of persuasive computer agents that encourage information workers to resume interrupted work. Based on a systematic review of interruptions in the workplace, theories of self-regulation, and theories guiding the design of persuasive technologies, this dissertation describes the creation of a prototype research platform, WiredIn. WiredIn enables researchers to explore a variety of interruption resumption support strategies on desktop computers. Two empirical studies that investigate the efficacy, attributes, and consequences of applying the paradigms embodied in WiredIn in controlled and real-life working environments are presented here. Both studies validate the effect of persuasive interventions on improving interruption management behaviors; the second study also provides design suggestions that can inform future work in supporting interruption management and multitasking.

Stephen Voida, Ph.D. Chair

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# Chapter 1. Introduction

Using computers at work has become an integral part of modern working environments. For information workers, the dependence on computers for daily work cannot be overstated (Spitz, 2004). While computing has multiplied hundreds of times the productivity and work efficiency for information workers, it also brings new challenges for regulating computer-related work behaviors.

There is a list of detrimental effects that computer use can bring to knowledge workers: constant interruptions (O'Conaill & Frohlich, 1995; Wajcman & Rose, 2011), disruptive workflow (Bondarenko, 2006; Cades, Werner, Boehm-Davis, & Arshad, 2010), non-work-related computing (Pee, Woon, & Kankanhalli, 2008), cyber-slacking (Vitak, Crouse, & LaRose, 2011), procrastination (Lavoie & Pychyl, 2001; Woods, 2014), and even health-related issues (Green, 2008; IJmker et al., 2006). While this list is not exhaustive, it is not hard to see that apart from sedentary work style causing health-related problems, all other issues have connections to interruptions at work. To illustrate, the disruptive workflow starts with continuous interruption to primary workflow, making task resumption and goal-recovery difficult (Monk, Trafton, & Boehm-Davis, 2008). In terms of cyberslacking and procrastination, although they are related to low work morale and poor work ethic (Kidwell, 2010), they are often manifested as depleted cognitive resources and consequently insufficient motivation. Both of these psychological states can be induced by interruptions (Freeman & Muraven, 2010). While appearing to be benign and trivial, interruptions could lead to other types of compulsive behaviors discussed above.

This research thus focuses on how computer interventions can be designed to mitigate the adverse effects of weak interruption handling at work. This dissertation empirically validates the proposal of bringing persuasive computing designs into working environments while also producing design suggestions for similar persuasive design contexts.

## Definition and Scope

This section will describe the scope of this dissertation work and introduce definitions for terms employed in the document.

### Interruption

Interruptions discussed in this document refer to the discontinuity of information worker's workflow when performing a computer-dependent task. While interruptions at workplaces can be of many different forms with distinct characteristics, they share similar common attributes:

**Length**: The time people spend on handling interruptions.

**Initializer/Trigger**: Interruption triggers or initializers are events that happen either externally in the environment or internally in the individual's mind that start the interruption behavior. In the realm of external interruptions, the term "Interrupter" refers to the people that initialize an external interruption to the workflow, and the term "interruptee" refers to the subject of such interruption. Upon being interrupted, the interruptee is expected to interrupt his/her primary tasks to attend to the demand of interrupter.

**Primary task and interruption task**: Primary tasks refer to the tasks that the person was performing before he/she is interrupted. In some scenarios, this document will

also use the term “suspended tasks” to refer to primary tasks. Interruption tasks refer to the target tasks that the person attempts to perform to complete the demand of the interruption.

**Work-related and non-work-related interruptions**

For information workers, interruptions can be significant, work-related and legitimate. Alternatively, they can be non-work-related, time-wasting and unnecessary. Work-related interruptions are task-switching between different types of tasks that are job-related, such as replying business emails. An example of non-work-related interruptions will be watching YouTube videos. In this document, the term unnecessary interruptions will be interchangeable with the term “non-work-related” interruptions. Non-work-related tasks will also be referred as “Off-tasks”.

**Interruption management and SPT**

The phrase “interruption management” in the document refers to the process of shortening unnecessary interruptions and returning to primary tasks sooner. It is also about the self-control process to avoid unnecessary interruptions. Overall this behavior is also referred as “Stay on Primary Tasks” (SPT). SPT is the target behavior that the persuasion is attempting to invoke and foster. The goal of the persuasive design is to use computer agents to persuade users to steer away from unnecessary interruptions and stay on primary tasks.

**Secondary switches**

Later in the discussion, the behavior of “secondary switches” is put under the microscope. Secondary switches refer to the task switching that happens after an initial interruption from primary tasks, and this switching is unrelated to the interruption tasks.

These are the switches of attention toward non-primary tasks that do little service to either primary tasks or interruption tasks. They come from voluntary intentions. For example, a person writing a Word document is interrupted by a legitimate interruption of an email. While he is reading the email, he has the idea to browse an e-commerce site, he then abandons both Word document and the email to start browsing an e-commerce website. The act of switching to the e-commerce site will be counted as a secondary visit.

**Intervention.**

The intervention mentioned in the document refers to the persuasive computer agents that intervene with users' SPT behavior and try to influence users to change their behaviors at the moment. The intervention will use a computer program that shows different images depending on the performance of the user on SPT.

## Overview

The remaining content of this dissertation consists of three major parts.

The first part will involve a review of current literature on three topics: Interruptions at work; self-regulation theories; and persuasive design principles. The purpose of the literature review is to examine the current status-quo of interruption management and suggest design guidelines for intervention. The reason for delving into self-regulation theories is because the current work primary focuses on boosting motivation issues in SPT management, and SPT is one instance of failed self-regulation. Lastly, persuasive technology is the academic realm that focuses on designing computer-enabled agents in behavior/attitude change, which fits the purpose of this presented work.

The second part will entail two empirical studies that investigate the validity of introducing persuasive agents in computer working context, including a study on the environmental and individual factors that influence the effect of such intervention.

The third part will be discussions about the results of the two studies and implications for intervention design and future work.

## Chapter 2. Literature Review on Work-Related Interruption

### Interruption while Working

Jett and George (2003) defines interruption as "incidents or occurrences that impede or delay organizational members as they attempt to make progress on work tasks" (Jett & George, 2003). Speier, Valacich, and Vessey (1999) defines interruptions in the cognitive sense as "externally or internally generated, randomly occurring, discrete events that break the continuity of cognitive focus". Interruptions typically "requires immediate attention and action" and usually happen at "timing beyond the control of the individual" (Speier et al., 1999). A direct result of interruption is demanding of subject to perform a "cessation and postponement of ongoing activities" and divert attention to interruption tasks (O'Conaill & Frohlich, 1995; Zijlstra, Roe, Leonora, & Krediet, 1999).

When it comes to information workers, working environments are becoming more and more interruptive (Garrett & Danziger, 2007; Haynes, 2007; O'Conaill & Frohlich, 1995; Woods, 2014). Haynes (2008) finds disruptions to workflow to be the largest negative predictor for productivity in offices. Quantitatively, O'Conaill and Frohlich (1995) find that interruptions can be as frequent as 4 interruptions per hour and as long as 10 minutes per hour. In total, a portion of 43% of worker's daily working time can be taken by dealing with interruptions. Results from Sykes (2011) report an average of 121 interruptions from an 8-hour business day, taking up to 5.7 hours per week in total for technical professionals in a medium-sized software company. Although in Sykes counting, the exchange between colleagues about company business, other than the subject's primary task at hand, is also counted as an interruption. On a micro-scale, Czerwinski, Horvitz, and Wilhite (2004) report that office workers have up to 0.7

interruptions per primary task. A portion of 40% of interruptions is self-initiated. In monetized terms, interruptions are estimated to consume about 28% of each work day and mount to $588 billion a year for US companies (Spira & Goldes, 2007).

New patterns of office structure and the emergence of new technologies also have created new challenges for office workers in containing the negative effect of interruptions (Karr-Wisniewski & Lu, 2010). A phenomenon known as information overload or "techno stress" is observed and discussed in recent years (Ragu-Nathan, Tarafdar, Ragu-Nathan, & Tu, 2008). Even traditional face-to-face interruption is also under scrutiny with the rise of open-office environments (Dabbish, Mark, & González, 2011; Evans & Johnson, 2000). These studies suggest that the open environment promotes unnecessary interruptions between employees. Also, the emergence of mobile technology produces new problems for dealing with interruptions (Yun, Kettinger, & Lee, 2012). For example, Leiva, Böhmer, Gehring, and Krüger (2012) report that mobile phone interruptions can lead to as much as four times longer resumption lags compared to other interruptions.

Working environments nowadays increasingly enable self-indulgence, which also does a disservice to self-regulation. Part of the reason primary tasks are hard to resume can be attributed to the principles of modern information system design, which emphasize capturing user attention and indulging continuous browsing (Nieson, 2010). Techniques like push notifications, shortcuts, and related links all try to encourage frequent visits and extended stays on these information services, which in many cases are entirely off-task. Group working environments such as open cubicles also result in a higher interruption rate (Dabbish et al., 2011).

**Interruption Anatomy**

An interruption is divided into four major components in temporal dimension (Trafton, Altmann, Brock, & Mintz, 2003), as shown in Figure 1. The four events are alert for secondary (interruption) task, the initialization of the interruption task, the ending secondary task and the resumption of the primary task. The time between the alert and actual onset of an interruption task is coined **as interruption lag** while the time between the conclusions of the interruption task the complete resumption of the primary task is called interruption. The resumption lag is one of the most heavily studied topics in interruption literature because it entails additional cognitive lag for a person to recognize the problem state of the primary task before he/she can resume a full working rate.

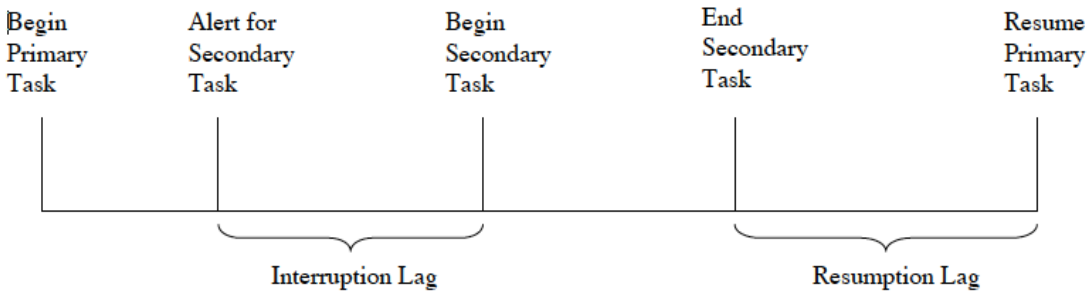


Figure 1 Interruption Anatomy (Extracted from Trafton et al. (2003))

**External interruptions.**

It is reported that around 50% of the interruptions experienced in an office environment are external interruptions (González & Mark, 2004). Those external interruptions usually come from computers (an error message), another person (a coworker pat on one's shoulder to start a conversation), or from other extraneous sources (a phone ring).

**Interruption coordination methods.**

McFarlane (2002) proposes four primary design solutions to coordinate user interruption, as shown in Table 1. The four types of coordination methods are: (a) immediate interruption, (b) negotiated interruption, (c) mediated interruption and (d) scheduled interruption. These four coordination methods

Table 1. Interruption Coordination Methods

| Method | Example | Control over Interruption | Flexibility | System simplicity |
|---|---|---|---|---|
| Negotiated | The user works on a text-editing task, the phone rings, the user decides whether and when to pick up the phone. | High/ Medium | High | Medium |
| Immediate | User talks on the phone while driving the car. The system announces its route directions immediately, interrupting the ongoing conversation. | Low | Low | High |
| Scheduled | Professor schedules interruptions from students' requests by assigning office hours. | High | Low | Low |
| Mediated | Before any incoming call, a PDA checks whether the person can be interrupted or not (given his schedule), and mediates interruptions when possible. | Medium | Low | High |

**Self-Interruptions**

The discussion about interruptions so far is about externally initialized interruptions. The term "external" simply means the source of the interruption is from entities or events that outside the control of the person being interrupted. However, the other half of the story comprises interruptions that are initiated by people themselves (González & Mark, 2004). This self-interruption can happen over varying spans of time. A person can interrupt him/herself for a very short period of time to check email, Facebook wall (Spink, Park, et al. 2006). The same person can interrupt their workflow

for a long time, e.g., a student suddenly remembers tomorrow's paper deadline and dropping everything to work on the paper.

Self-interruptions share many similarities with external interruptions in terms of basic cognitive processes involved. However, one aspect of self-interruption is very different from external interruptions, and that is the reason behind a person's switching tasks. Jin and Dabbish (2009) identified seven categories of self-interruption regarding computer activities. These categories are: changing the environment (adjustment) or seeking information (inquiry) to facilitate the primary task; temporarily switching to alleviate fatigue or frustration (break); remembering an unrelated task (recollection) or perceiving a cue to a related task (trigger); performing a task out of habit (routine); or filling idle time (wait). Among all the seven categories, break, recollection and routine come from a users' internal cognitive state while the other four types have some link to external and environment factors.

Dabbish et al. (2011) discussed the self-interruption as a function of organizational environment and individual differences as well as previous external interruptions experienced. Their results indicated that an open office environment (compared to enclosed offices), later time of the day, and previous surges of external interruption could lead to a higher rate of self-interruption behavior.

**Effects of Interruption**

Much efforts has been devoted to understand the structure of interruptions in order understand its impact on task performances. The study of interruptions include topics such as the nature of interruptions, disruptiveness of computer introduced interruptions, alleviation, handling of interruptions and so forth (Czerwinski, Horvitz, &

Wilhite, 2004; Mark, Gudith, & Klocke, 2008). Not only do interruptions create difficulties for maintaining task flow, they also cause stress and frustration (Mark et al., 2008). Constant interruptions often lead to discontinuity of primary tasks (O'Conaill & Frohlich, 1995) and procrastination (Jin & Dabbish, 2009).

**Effects of Interruption Timing**

To understand the nature of interruptions, researchers start on the timing of interruptions with respect to the primary tasks. It is generally acknowledged that interruptions occurring at a higher mental workload are more disruptive than at points of lower workload (Adamczyk & Bailey, 2004; Bailey & Iqbal, 2008; Cutrell, Czerwinski, & Horvitz, 2000; Iqbal & Bailey, 2005; Monk, Boehm-Davis, Mason, & Trafton, 2004). Monk et al. (2004) demonstrated that the interruptions that occur during a subtask produces longer resumption lag than interruptions that occur between subtasks. This phenomenon can be explained by problem state maintained during interruptions. Interruptions during a subtask disrupt the problem state for conducting the primary task, thus when resuming the task, the person needs to reconstruct the problem state in order to successfully resume to primary tasks. Interruptions happening between subtasks are free of problem state maintenance. Problem state is one of the major reasons why interruptions are disruptive.

Iqbal and Bailey (2005) investigated the interruption timing with longer and more taxing secondary tasks and found similar conclusions with Monk et al. (2004). They also found correlations between the resumption lag and self-reported ratings of annoyance and frustration.

### Effects of Interruption Types

Whether or not the secondary tasks require maintenance of a problem state can contribute to the interruption disruptiveness. If a secondary task that does not require a maintenance of a problem state, such as looking at a letter and typing it on keyboard, and then it does not replace the problem state buffer of primary task thus has minimal effect of delaying the resumption (Borst, Taatgen, & Van Rijn, 2010).

Cutrell et al. (2000) looked at whether the interruptions' relevance to the primary tasks can have any effect on people's behavior of handling the interruption. Their results indicated that interruptions related to primary tasks will lead to improvement in both processing the interruption and resuming the primary task.

### Length of Interruptions

Quite a few studies have looked into whether the duration of an interruption task increases the disruptiveness (Gillie & Broadbent, 1989; Monk et al., 2004). Specifically, the subject under discussion was whether or not information stored about a primary task is subject to decay during the interruption task (Gillie & Broadbent, 1989). Also, the duration and load of the primary task have been varied in experiments, i.e. with respect to how long the task lasted and how many documents were needed for its completion (Czerwinski et al., 2004).

### Frequency of Interruptions and Repetition of Primary Task

Frequency of interruption is a widely tested variable among attention researchers (Cellier & Eyrolle, 1992; Monk et al., 2004; Speier et al., 1999; Zijlstra et al., 1999). Frequent interruptions result in processing a greater number of information cues and hence increase processing load (Casey, 1980; O'Reilly, 1980). Moreover, each

interruption induces a necessity for reprocessing of some of the primary task's information, which consumes extra effort every time (Speier et al., 1999). Repetition of a primary task is a similar concept to frequency; it is important to know how often the same primary task was resumed during an experiment with the same participants. Repetition causes a learning process, and hence might change the effects of interruption at later sessions (Trafton et al., 2003).

**Interruptions in Cognitive Engineering**

Generally speaking, the study of interruption can be categorized as a subset of task switching and executive control. Thus the first and majority of theoretical accounts for explaining interruption comes from this approach. In particular, derived from activation-based memory accounts such as ACT-R (Anderson et al., 2004), Altmann and Trafton (2002) developed a model called "memory for goals" and applied to the study of interruption. The model describes the disruptiveness of interruptions in terms of decaying of goals. For remedies, the model predicted that there are two primary methods of reducing or slowing down the decay of goal: rehearsal and using environmental cues.

Another theoretical approach comes from prospective memory theories (Brandimonte, Einstein, & McDaniel, 1996). Based on this theory, the major prediction is that providing a reminder will facilitate the resumption of primary tasks. Empirical evidence to support this claim is also provided by Dodhia and Dismukes (2009) and McDaniel, Einstein, Graham, and Rall (2004).

A third approach is based on long-term working memory (LTWM). The LTWM model suggests that experts are able to store and retrieve extremely large amounts of data quickly and accurately (Ericsson & Kintsch, 1995; Ericsson, Krampe, & Tesch-Roemer,

1993). Critical for the study of interruptions, experts are able to remember information over very long periods of time and across interruptions. For experts, once information has entered LTWM, it can be retrieved at a later time regardless of interruptions. For all users, information can enter LTWM if there is enough encoding time; the amount of encoding time needed for information to enter LTWM varies depending on the task, but it is typically no more than a few seconds per object or visual chunk (Oulasvirta & Saariluoma, 2006).

Dodhia and Dismukes (2009) argues that interruptions are in fact prospective memory tasks. Prospective memory (PM) tasks entail a person remembering to perform tasks in the future. They argue that based on prospective memory theory there are three main reasons why interruptions are difficult to handle: 1) The intention of returning to the primary task is poorly encoded, 2) The ending of the interruption fails to work as the target cue in normal PM tasks, and 3) The offset of an interruption usually entails further attention diversions that compete with cognitive resources with the intention of returning.

**Non-work-related Computing**

A more severe problem of interruption is the deteriorated behavior of non-work-related computing, which includes cyberslacking and procrastination. Non-work-related computing (NWRC) thus is a composite term that includes several types of delinquency of self-discipline at workplaces in terms of computer use. The first category is called "junk computer" that points to the use of computer IT resources for personal uses such as browsing e-commerce websites or internet gaming (Vitak et al., 2011), while the other type is use of computer as a way of slacking off and not attending to work-related tasks (Venegas, 2009).

The other description about cyber-slacking emphasizes the autonomy of the person. It involves “any voluntary act of employees using their companies Internet access during office hours to surf non-work related websites for non-work purposes” (Mahatanankoon, 2014).

Apart from taking advantage of company resources, more fundamental causes of such behavior are boredom (van der Heijden, Schepers, & Nijssen, 2012) and disengagement from tasks at hand (Murdvee, 2013). There is an ongoing epidemic from how technologies are enabling procrastinations at an unprecedented level (Yan & Yang, 2014). There are obvious organizational reasons for these delinquencies, but more importantly, the ability of self-regulation is facing great challenging from technological advances.

## Current Interventions

To counter different aspect of the negative effect of interruptions, numerous types of interventions have been proposed and studies over the years. The following discussion of these interventions will be categorized by the problems they want to tackle.

### To minimize interruptions from the source

Existing intervention methods in group work contexts include minimizing occurrences of interruptions by either controlling notifications (Iqbal & Bailey, 2005) or broadcasting the individual's availability in order to regulate mutual interruptions between group members (Dabbish & Kraut, 2003). However, filtering or delaying the arrival of interruptions could result in missing important messages and losing the optimal timing for dealing with the interruptions.

Dabbish and Kraut (2004) demonstrated that using only an abstract information display such as the current busyness of the interruption target, can sufficiently help the interrupter to coordinate his/her interruption timing. Providing a full display of information can only result in the further consumption of the interrupter's attentional resources. One aspect of the work of Dabbish and Kraut (2004) is their introduction of team identity and social motivation. By teaming up the interrupter and interruptee and building a synergistic relationship between the two, the design also improved participants' motivation to use an awareness display and better coordinate interruptions.

In another study regarding working alone and working in pairs, Chong and Siino (2006) compared interruption and interruption handling behaviors between two groups of computer programmers. One group of programmers worked in pairs (Team Pair) and the other group work in solo (Team Solo). Team Pair worked side by side, sharing one station and worked on one task together. Typically one programmer types on the keyboard and the other one directs the task and contemplates the problem space. Team Solo consists of programmers who work on a shared task in cubicles alone. The results suggest that interruption time is significantly shorter for Team Pair than Team Solo. Existing research has shown that social exchanges and relational contracts can develop between individuals who work closely and create a sense of mutual obligation. The authors further suggest that in self-initiated interruptions, both the sense of **accountability** and the **visibility** of their actions to the entire team kept programmers from adopting secondary (unrelated) tasks or taking long breaks, while for solo workers they lack immediate accountability to other members of the team.

However, these practices do not recognize the problem of self-initialized interruptions as they are not triggered by any salient physical entity. It will be difficult to suppress these kinds of interruption from happening by blocking or weakening the source. Also, these interventions serve more of the purpose of coordination rather than self-regulating and are mainly targeted at external interruptions from co-workers. For problems such as non-work-related computing, they are futile. Thus a tool that cultivates self-control and self-discipline would be more universally applicable since it depends on the person himself to control his own behaviors.

**To manage tasks**

There are numerous studies and applications that aim to improve task management at workplaces. Most prominently, task manage applications are widely used in office settings to boost productivity and keep track of the tasks at hands.

When computer-assisted work first become the norm, calendars were the first option workers have to manage or prioritize their work (Palen, 1999; Payne, 1993). Later productivity tools go “paperless” (Lackey et al., 2014). With the “Get Things Done” (GTD) strategies put forward by (Allen, 2002), numerous GTD tools are emerging in the market.

However, many of the tools take effort to manage and the real challenge is not so much about listing, recording or prioritizing to-do items, rather it’s the different extra steps needed to make the important tasks are taken care of (Bellotti et al., 2004a). These extra steps include small details like communicating with people, follow up with previous actions or planning. GTD tools are valuable and useful for visualizing the tasks, but it

can't get into the fine details of the minute-to-minute management of task handling, especially resumptions.

**To counter non-work-related interruptions**

The current intervention is usually updating organizational policies (Ragu-Nathan et al., 2008; Simon, 1996) when companies try to limit non-work-related interruptions. Typical interventions are fostering employee's sense of responsibility (McManus, 1999) and company-wise monitoring (Porter, 2003). There are also ways of psychological training and consulting to ease the addiction to internet use (Mills, Hu, Beldona, & Clay, 2001).

These methods do not solve personal and individual struggles with these compulsive behaviors and facing the new challenges of "working remotely" (O'Neill, Hambley, & Bercovich, 2014). Remote working allows an employee to work from home with Internet access to company resources. This trend is especially prevalent for information workers as the technology and culture are ripe for working away from offices. However, it is problematic for remote workers to maintain high-level productivity (O'Neill et al., 2014).

**Looking for New Interventions**

Most of the previously listed interventions focus on minimizing less important work interruptions. However, the problem goes beyond organizational structure and is also about behavior regulation failures.

The problem is not so much about reducing interruption frequencies; it is more about shortening the interruption time. Even for reducing frequencies, the goal is to reduce specifically **unnecessary, task-irrelevant** interruptions.

Firstly, one reason people suffer from poor SPT is because the opportune timing of returning to primary tasks is usually not well defined. For example, a person browsing Facebook feeds does not have a clear cue signaling the proper end of the activity. On the other hand, ending a conversation and hanging up the phone clearly signals the end of a phone call interruption. In cases like Facebook browsing, it often depends on the person to be aware of the time to finish that task. Different people have different ways of defining how much time is too much for deferring task resumption. In other cases, interruptions are cascaded in such a way that resumption cues for previous interruptions are shadowed by new interruptions and old interruptions are never returned to (Mark, Gonzalez, & Harris, 2005).

Common to both external and self-interruptions, a critical moment in an interruption cycle is when the interrupting task is completed, or its urgency has been contained. This crucial moment is the time that the person is supposed to return to primary tasks. Ideally if an individual always resumes the suspended task at this moment, staying on primary tasks will not be a problem.

Thus, it is proposed that a more practical approach is to help task resumption regardless of its source. Previous designs in supporting task resumption focus on preserving and resuming the context of the original task to enhance goal retrieval from memory (Daniels, Regli, & Franke, 2002; Franke, Daniels, & McFarlane, 2002). These attempts try to ease the transition by providing some memory aid. Though it is important to support goal retrieval, it neglects to address other relevant problems behind failed resumption: missing the resumption cues and the lack of motivation for resumption. These issues apply equally to external and self-interruptions.

In order to design such interventions, two prominent sources of knowledge is needed: the theories on self-regulation failures and the current understanding of persuasive design. The next two chapters will review both knowledge domains to arrive at design principles for the behavioral regulation of interruption management.

## Chapter 3. Literature Review on Self-Regulation

This chapter will delve into the cognitive and psychological background of self-regulation. Its purpose is to find breakpoints that allow us to design effective interventions for failed task management. At the end of each major theory, there will be section summarizing and linking to the design of interventions.

There are many theoretical angles one can take in analyzing the causes of attention lapses and failed task resumption behaviors. From a cognitive engineering perspective, one general approach is to categorize it as an instance of failed self-regulation (Carver & Scheier, 2001).

The literature of self-regulation has progressed tremendously over the years. To serve the purpose of designing interventions, the following discussions will be conducted using two main frameworks in self-regulation: the mechanical model of Carver and Scheier's feedback loop (Carver & Scheier, 1981) and the resource-based model by Baumeister, Bratslavsky, Muraven, and Tice (1998a). These two models have different views in analyzing the self-regulation phenomenon but are complementary to each other.

Compared to cybernetics' feedback control, self-regulation is described as a "continual process of moving forward, and away from, various kinds of mental goal representation" (Carver & Scheier, 2001). On the other hand, Baumeister and colleagues define self-regulation as a process of "inhibiting habitual innate responses" in order to arrive at a "standard-conforming state." While both definitions capture the process of control-to-conform, Carver and Scheier are concerned more about the mechanical process of the phenomenon while Baumeister and colleagues emphasize the importance of resistance to innate responses to regulate behavior.

**Carver and Scheier's Feedback Loop Model**

Much of this dissertation's design for intervention encompasses Carver and & Scheier's model of "Discrepancy-Reducing Feedback." In their model, self-regulation is described as a process of comparison-conform-comparison. Similar to the negative-feedback system in engineering, as an individual is regulating his behavior, he constantly draws a comparison between self and an explicit or implicit standard. He then moves in the direction of reducing the difference (Figure 2). Notice the circular formation of the information flow in the scheme. The comparator stand as the core component of the system. The job of the comparator is to take in the information for "standard" and the current status. Then it produces a signal to guide behavior based on the difference between the two. The term "negative" refers to the fact that the valence of the output signal of the comparator is always the opposite of the difference. If the difference between standard and status is positive, the behavior is guided to increase the intensity of effort to catch up with the goal. If the difference between standard and status is negative, the comparator will generate signals to "turn down" the effort. In another word, the comparator always generates signals that try to **reduce** the discrepancies.

In most cases of self-regulation, one can argue that the standard is always too ideal to be attainable. Therefore, the comparator is always trying to get closer to the goal, but rarely does it exceed the standard. There are certain scenarios in which an individual might tune down effort in order to conform to social norms (De Beuckelaer, 2002).

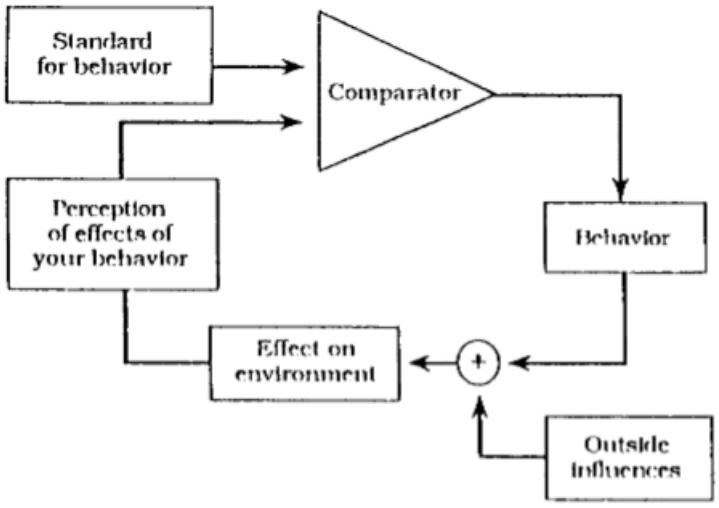


Figure 2 Schematic of feedback loop in self-regulation process (Carver & Scheier, 1981)

The overall recognition is that self-regulation is a complex cognitive activity that encompasses various aspects of human cognition. On that front, Bandura (1991) point out that self-regulation is an intricate combination of various sub-systems. Early studies demonstrate that individual intention alone does not drive regulation behavior in the absence of people's capabilities to influence their motivation (Bandura & Simon, 1977). In general Bandura (1991) divides the process into three subsystems: self-observing, judgment process, and self-reactive process. These three systems creates a sequence of information processing when self-regulation activates.


Figure 3. Subsystems for self-regulation information process

Firstly, it is crucial that the standard and the implications of the standard are clear to the individual. The standard, or reference value, refers to the goal of behaving in line with personal/social expectations. However, it is not always clear to the behavior activator what reference value is under different circumstances. In Bandura's model, this "self-observing" process constantly involves monitoring "quality" of behavior. In another word, an individual needs to be sufficiently *self-aware* to be able to carry out behavioral regulation successfully.

The second subsystem, coined as "judgment process" by Bandura, is a process of establishing standards and comparing it with behavior. This process is about making the discrepancy and its implications salient and fully interpreted by the individual. This subsystem relates closely to individuals ability to find their reference value and interpret it.

The third "self-reactive" process is to generate enough influence to drive a course of action. This drive is based on the discrepancy, and it motivates an individual to change the behavior. Just like physical systems that rely on mechanical motors to activate the movement, behavioral feedback system relies on motivation to generate the behavior change.

The following sections will expand the details on each of three points with emphasis on their relation to designing intervention methods.

**Self-Awareness**

The first stage of self-regulation dictates that a person should be highly self-aware. This stage relates to the "perception" part of Carver and Scheier's model. The premise is that for comparators to work, an individual should be fully aware of the

standard and the current state. It demands that individuals have the cognitive resources to guide their attention toward themselves.

First proposed by Duval and Wicklund (1972), self-awareness is the process of raising self-knowledge through inwardly-directed attention. Heightened self-awareness is suggested by various studies to increase awareness about personal attitude, emotional states, and enhanced the ability to perform causal judgment (Gibbons, 1990). Self-awareness is a critical component in behavior regulation presumably because focusing attention on the self makes the attribution of performance result more apparent (Pryor & Kriss, 1977). With high self-awareness, people are found to attribute failure more to external factors to avoid negative affect (Federoff & Harvey, 1976). This attribution process is described by Duval and Wicklund (1972) as the process of objectifying one's own consciousness. Thus, objective self-awareness leads to high levels of being self-critical (Silvia, 2001). An individual with strong self-awareness is like a distinct object being observed and judged by an imaginary and abstract "other". In reality, this "other" is simultaneously the person himself (Baldwin & Holmes, 1987).

Forking from Duval and Wicklund's objective self-awareness theory, Carver and Scheier (Carver & Scheier, 1981) incorporated self-awareness in their model of a negative feedback loop on self-regulation. Although both theories agree on the premise that self-awareness leads to behavior regulation, conflicts exist on the mechanism that make the regulation happen (Carver, 1979). Objective self-awareness posits that aversive affect will inevitably arise from the discrepancy between actual behavior and ideal standard, which leads to behavior conformity. Carver and Scheier, on the other hand, argue that self-focus simply produces the "realization" of the existence of a standard in

the current context. But the actual drive depends on various aspects of the psychological system within the negative feedback loop. Carver's standpoint even argues against the existence of aversive affects in some circumstances (Carver, 1979). Details on how to drive courses of action in the face of salient discrepancy will be presented in later sections on motivation.

***Inward-directed attention***

One aspect of the self-awareness that is worth expanding upon is the process of attention. Since theories point to the idea of raising awareness to produce conformity to standards, it is interesting to know how to guide attention inward. There is evidence that self-directed attention occurs when people are confronted with demands for an immediate decision (Norman & Shallice, 1986), or when the result of behavior contradicts with one's expectation (Norman, 1981). Emotional states can also draw attention toward the self. Negative emotion has a better reliability of doing so (Carr, Teasdale, & Broadbent, 1991; Salovey, Rothman, Detweiler, & Steward, 2000; Wood, Saltzberg, & Goldsamt, 1990). These results indicate that invoking emotions could raise awareness of the self. However, care must be taken so that the effect should not be too large to trigger task disengagement (Klinger, 1975).

There are also circumstances where attention shifts away from the self. Empirical evidence shows constant Web browsing promotes low self-awareness during Web interaction (Huang, Chiu, Sung, & Farn, 2011). This experience of "loss of self" is a well demonstrated and documented effect in various studies relates to flow experience (Csikszentmihalyi, 1991). It is thus profitable to design interventions that bring attention toward the examination of the difference between behavior and standards.

Attention is also a valuable cognitive resource that needs budgeting and restoring. Details about this topic will be covered in the section regarding "resource-based self-regulation."

**Comparison to Standards**

The second stage in self-regulation is the establishing of goals or standards and making the comparison between behavior and the standard. The first thing to understand about goal setting theories is that goals are hierarchical (Miller, Galanter, & Pribram, 1986). Goals can be high level and abstract e.g. "to be a good person" or low level and concrete, e.g. "stay focused for half an hour." In the research presented here, goals refer to short-term objectives that an individual attempts to achieve during working hours. These goals have a narrow scope and often are very task-specific (Elliot, Elliot, & Dweck, 2005). Downgrading of goals from a higher level to a lower level will occur if people find themselves unable to attain higher and more abstract level of goals (Carver, Lawrence, & Scheier, 1999). For example, a person might disengage from the goal of building up a healthy figure but might still pursue the concrete goal of eating a salad instead of a burger. In their research, Dweck et al discover that their subjects (children) who have set short-term goals as a way of demonstrating their competence and **verifying** their skills are more prone to slacking off their efforts to keep up with the goal, while subjects who set goals as a way of **learning** skills had longer period of sustained effort (Dweck & Leggett, 1988). As the target audience of this present study is adults, who mostly approach their goals as a way of self-verification of competence, they could fall into the first category in goal setting.

Goal setting is relevant in the present study also because it tightly relates to the concept of the "standard" or the "reference value" in feedback loop system. The goal determines at each iteration of the feedback test whether there is a discrepancy between the benchmark and the actual behavioral performance and determines how large the discrepancy is. Different properties of the goal thus directly influence the quality of feedback control. An essential result in goal-setting literature is that setting higher goals have better effects on mobilizing cognitive resources to take on the task than lower goals (Locke & Latham, 2002). For information workers involved in the present research, who tackle everyday familiar yet mundane work, deliberate and well-thought-out goal setting is not always a priority.

***Public and private self***

An important contribution of Carver and Scheier's interpretation on self-awareness is the distinction between public and private self (Carver et al., 1999). Generally speaking, private self concerns the inner well-being of the subjective self and empathizes the personal desires, needs and goals while the public self is about the personal image projected onto others. It is the self that expects interaction with others in order to maintain self-esteem (James, 1892). This distinction helps outline the structure of goal setting in the context of self-regulation. Scheier (1980) further categorizes goals into four types based on the self that the person is pursuing and the nature of the action the person is taking.

Table 2. Self and actions on self-awareness

| | Self-determined actions | Controlled action, satisfying conditions of worth |
|---|---|---|
| Consider others: No | Individual, Personal | Self-image management |
| Consider others: Yes | Communal, collective, interdependent | Impression-management, self-presentational |

If a goal does not concern others, it is private and only relates to personal values. However, some of these goals are about producing results that fulfill personal goals and are purely intrinsic (Deci, Koestner, & Ryan, 1999; Ryan, Sheldon, Kasser, & Deci, 1996). These goals are usually of high level and are hard to fulfill. "Self-image management" goals are about building defensive mechanisms to maintain self-esteem (Ryan, Koestner, & Deci, 1991).

While considering others, goals can be either self-initiated that support group goal-striving (Fiske, 1992) or goals can be more controlled by external pressure to maintain impressions on others (Enzle & Anderson, 1993). The emphasis a person puts on either personal or social goals can vary by personality (Cheek & Briggs, 1982) or by cultural differences (Brewer, 1991; Landrine, 1992).

The difference between personal and social self further influences the process of forming the goals (Fishbein & Ajzen, 2005). When establishing willpower to perform certain actions, a person will generate two kinds of sources for intention: personal attitude and social pressure. Personal attitudes arise from intrinsic desires to strive for outcomes that cater to personal needs. While social pressures are social norms that expect an individual to carry out certain actions and the outcomes are often desired by other people and not intrinsically desired by the person himself. The difference between private and public self thus could play a vital role when the two types of sources for intention

forming conflicts. Previous studies show that individuals with a higher sense of social contingency form goals that favor social benefit while people who have an inclination for the private self will form goals that cater to personal attitudes and needs. (Trafimow & Finlay, 1996).

**Motivation and Conforming to Standard**

The third stage in self-awareness is the process of summoning sufficient motivation and taking discrepancy-reducing actions. A critical component in generating motivation is the expectancy management. The expectancy of success to large degree dictates a persons' willingness to exert effort to achieve the expected goal (Carver & Scheier, 1990). If the expected success is highly likely, a person will summon more effort to get close to the goal. But if the outlook for expected success is becoming increasingly unlikely, the person will instead tend to disengage from the task or even give up. Two prominent constructs that pertain to this topic are self-efficacy (Bandura, 1977, 1982) and sense of control.

Bandura (1977)'s view on self-efficacy describes the level of a person's confidence in his ability to perform actions to change status. Evidence shows that individuals with high level of self-efficacy generate more sustained effort in keeping up with goals, while people confronted with seemingly impossible tasks often lose the tendency to try (Bandura, 1982). Self-efficacy does not only rely on the pure belief that the person can or cannot do certain things, it also can be boosted based on new information or their accomplishment in previous successful attempts or in tasks that do not relate to the current task (Zimmerman, 2000).

The construct of a sense of control is about the perception that an individual can decide the course of actions. Studies show that sense of control boosts confidence in dealing with tricky and stressful events (Aldwin, 2007; Taylor, 1983, 1991). Other studies suggest that it is the expected result from the control that matters rather than the fact of owning control. For example, studies done by Burger (1989) and Miller and Norman (1979) found people relinquishing their right to control the process if they knew that they would not produce good results if they were in control. Both theories suggest that for motivation to alter the course of action, what mostly matters is the sense that the outcome is desirable and the perceived high possibility of success.

***Affect and Motivation***

At each comparison, the result of comparison produces affect and it also influences the motivation generated (Higgins, 1987; Simon, 1967). Positive affect is demonstrated to help individuals perform better on self-controlling tasks while negative affect has detrimental effects on self-regulation. It is hard to narrow down where affect originates. However, studies within the feedback loop model find that it is the rate at which the discrepancy is reducing that influences the affect invoked by the comparison, not the degree of discrepancy itself (Carver & Scheier, 1990). In Carver and Scheier's model, there exists a secondary monitoring process (apart from the one that monitors the discrepancy) that oversees the rate at which the discrepancy is reducing. This process will register an affect (positive or negative) based on the comparison of rate of reduction and expected rate of progressing. Several supporting studies confirm Carver and Scheier's position on the rate of reduction (Hsee, Abelson, & Salovey, 1991; Lawrence, Carver, & Scheier, 2002).

It is also argued by other studies that the positive/negative affect is produced because people achieve or fail to achieve sub-goals (Wyer Jr, Srull, & Wyer Jr, 2014). This position is a discretized version of Carver and Scheier's model of continuous monitoring of discrepancy-reduction rate.

***Influence of the social dimension***

As predicted by private and public self theory, people tend to serve two purposes during behavior regulation: one is to serve intrinsic goals and the other is to satisfy group/social demands so as to win approval from others. The relative weight of the two purposes make a difference when people are deciding which standard to conform to. A privately-oriented person will tend to ignore the social norm and pick the path of satisfying personal needs while a publically-oriented person will choose to go along with the group (Bond & Smith, 1996).

Higgins (1987) extends the "two-self" model and argues that any behavior regulation is to fulfill two discrepancies simultaneously: one between actual state and an "ideal" self, and the other between the actual state and "ought" self or social self. The ideal self refers to the ideal standard set out by the individual's intrinsic goals and the "ought" self refers to demand to avoid being disapproved by group/society. These two discrepancies can overlap, or they can be vastly different from each other. Empirical studies show that failing to reduce the "ideal" self leads to negative affect similar to rejection and even depression, while failing to meet "ought" self goals leads to agitated feelings such as frustration and anxiety (Finlay-Jones & Brown, 1981).

In searching for interventions for self-regulation tasks such as health management, more and more approaches are leaning toward social support (Ellis,

Bernichon, Yu, Roberts, & Herrell, 2004). This trend emerges due to the realization that sometimes the self alone cannot cope with the immensity of self-regulation task, especially when it is related to addiction. Studies have shown the evident effect of social relationships on helping people to regulate their behaviors (Vohs & Finkel, 2006). For example studies show role models in a close relationship has the effect of increasing an individual's motivation (Lockwood, Jordan, & Kunda, 2002).

The need for acceptance by others can trace to evolution for adaptive benefits. Only when accepted by others can we rely on group members' support when in danger or threat (Baumeister & Leary, 1995). Leary (2002) proposed this adaptive view as the center of his "sociometer" theory. The hypothesis posits that given the vital importance of social support in evolution and survival, human beings develop a monitoring system that keeps tabs on environmental cues that relate to interpersonal relationships. This tracking system generates positive or negative affect that corresponds to either acceptance or rejection signals from others. These affective states then motivate the individual to take actions to restore an ideal state of social acceptance and maintain self-esteem. The motivation generated by the sociometer depends on various factors including the initial self-esteem set by the person (Leary, 2005) or an individual's sensibility toward cues (Kernis & Goldman, 2006).

***Disengagement***

At times when the goal of regulation overwhelms the person's perceived ability, it is predicted that the urge for disengagement will emerge (Carver & Scheier, 1990; Klinger, 1975). As discussed earlier, disengagement is usually attributed to the lack of

confidence of goal attainment, although it could also be caused by extreme affect such as fear (Carver, Blaney, & Scheier, 1979).

A special form of disengagement is worth discussing as it relates to attention lapse in the presented study: mental disengagement. Mental disengagement happens when it is not possible to for people to withdraw from tasks, often due to social reasons. In such cases, people demonstrate cognitive behaviors such as off-task thinking, mind wandering (Smallwood & Schooler, 2006), or day-dreaming (Diener & Dweck, 1980). Mental disengagement may give brief moments of relief and relaxation and can also renew a period of new effort, but it usually does not last long. Instead, after repetition of disengagement and brief effort, people might experience negative feelings about their ability and frustration (McIntosh & Martin, 1992; Wigfield & Eccles, 1989).

Overall the cybernetic model of self-regulation outlines information flow in a mechanical way. Self-awareness, goal-setting, and motivation are key components in the model whose effectiveness directly relate to the success of regulation. The next section will introduce another influential theory in self-regulation that uses the analogy of human muscle and views self-regulation ability as a form of limited resource.

**Relation to Intervention Design**

The primary takeaway from feedback theories is that feedback is a necessary prerequisite component in the success of self-regulation process. To raise self-awareness, the feedback needs to bring attention to stimuli that trigger comparison between current state and set goals. Both attention and comparison can be performed by people internally in their mind, but externalizing the process produces a higher possibility of motivating them to perform the behavior change.

In the context of SPT, raising self-awareness can be achieved by using visual feedback stimuli. To invoke a comparison between state and goal, the visual stimuli can tie the change of the appearance of the stimuli to the semantic persuasion meaning.Given the pre-knowledge about the semantic meaning, the receiver of these stimuli will register the persuasion and bring their attention to the state and goal.

There have been similar designs in previous years. Consolvo et al. (2008) designed Ubifit Garden, an animated mobile game promoting fitness activeness. The growth of virtual flowers and plants is linked to the physical activeness data from the mobile application. Fish'n'Steps (Lin, Mamykina, Lindtner, Delajoux, & Strub, 2006) is another similar game promoting physical activity. It ties the level of activeness tied to the growth of animated fish in a virtual tank.

The design of "likable" agents, such as flowers and small animals in the previous two examples, can be supported by the discussion about using affect as a way of motivation in preceding sections. As people are innately pursuing positive affect and avoiding negative ones, linking the positive behavior change with positive outcomes for agents adds motivation to do so.

In addition, based on the theories of task disengagement, it is suggested that persuasive design for SPT should help people gain confidence and a sense of accomplishment. Visual feedback could be designed overcome the thought of disengagement by explicitly highlighting the accomplished behavior change and rewarding the subject with a sense of success.

Lastly, apart from using emotionally likable objects, the theories on social motivation points to the direction of adding social dimension. Involving agents that

represent social goals in the working environment could be one of the powerful means of motivating behavior change.

**Baumeister's Resource Model**

In self-regulation, an individual cognitive capacity for exerting effort is limited, thus over time it is predictable that regulation performance will deteriorate. This view of limited resource model forms the consensus of resource-based regulation (Baumeister et al., 1998a). In the scope of the present work, knowledge workers need to refrain from being disrupted to fight external distractions and internal noises. In another word, they need to constantly exert cognitive efforts to dispel the temptation for leaving primary tasks. One would think exerting cognitive effort to self-regulate behaviors could help people resist those distractions and maintain attentional focus, but it is only true when attentional resources are abundant. When they are scarce, self-regulation is counterproductive. The more effort they put into controlling themselves, the more attention resources will drain, and their executive functions will suffer. This competition between self-regulation and executive function, studied extensively by Baumeister and colleagues (Baumeister, Bratslavsky, Muraven, & Tice, 1998b), is called "ego depletion." They found evidence to support the argument that mobilizing limited cognitive effort for self-regulation will in the end hurt directed attention tasks, such as solving puzzles and arithmetic calculations (Baumeister et al., 1998b; Schmeichel, Vohs, & Baumeister, 2003; Tice, Baumeister, Shmueli, & Muraven, 2007). Correlating studies from executive functioning and self-regulation indicates the proposition that both processes share the same bucket of limited attentional resources (Kaplan & Berman, 2010).

In Baumeister's model, self-regulation is defined as the constant struggle to override innate or automatic desires and tendencies in order to achieve personal or social norms. A general construct called "self-regulation strength" is used by Baumeister to include all the possible cognitive resources needed to fight these intrinsic tendencies (Schmeichel & Baumeister, 2004). Baumeister integrates this self-regulation strength in the scope of the cognitive executive system and argues that it is an underlying resource for various types of volitional capabilities such as planning, calculation, and goal-directed behavior as well as decision-making. Depletion of this resource will weaken a person's ability to inhibit innate thought and thus give way to more automatic processes such as task disengagement.

**Resisting Temptation**

One direct result of depleted resources is the failure to resist temptation. Numerous studies indicate that people who depleted their regulatory strength will fail to resist temptation (Muraven & Slessareva, 2003; Vohs & Heatherton, 2000).

***Delayed Gratification***

The ability to resist temptation is demonstrated as the capacity to accept delayed gratification (Mischel & Baker, 1975). It is the ability to resist successfully temptation in order to receive larger and better benefits later in time. In his famous "Marshmallow Experiment," Mischel asks a group of children to resist the temptation to eat one small marshmallow in exchange for two marshmallows after they wait for a period of time. During the waiting period, the experimenter leaves the room (Mischel, Ebbesen, & Raskoff Zeiss, 1972). The result shows that children waited longer achieve better academic performance. In the scope of task resumption, it is the ability of the information

worker to delay the relaxation of diverting to or continuing doing unrelated tasks and get on the difficult tasks at hand. Delayed gratification can be viewed from economic or evaluation point of view as temporal discounting (Ainslie, 2001; Loewenstein, Read, & Baumeister, 2003). Generally speaking, according to temporal discounting theory, people tend to satisfy immediate gratification because human cognition devalues the benefits in the distant future while over-valuing benefits that can be immediately attained. This relation of failed resistance to temptation and temporal discounting is demonstrated in studies where the delay interval was manipulated (Mischel & Metzner, 1962; Wulfert, Block, Santa Ana, Rodriguez, & Colsman, 2002).

Another process-related model in describing delayed gratification is the "Hot/Cold system" theory. The "cold system" refers to the emotionless "know" system that is involved in the slow calculation, logical deduction, and contemplation. The "hot system" is a "go" system that responds to emotional stimuli and processes information in a fast and direct way (Lieberman, Gaunt, Gilbert, & Trope, 2002). The "hot" system involves emotion and produces quick and impulsive responses when faced with approaching or avoidance dilemmas. The theory holds that the interaction between the two systems determines the process of self-regulation.

Other factors can also influence the struggle between the two systems in making decisions on self-regulation. In particular, stress level is found to have a moderating effect on which system has the upper hand (Metcalfe & Mischel, 1999): when stress level is low, the cold system is more alert and activated, while on a high stress level, the hot system gets heightened.

To understand the mechanism of delayed gratification, researchers find that directing attention to the salience of reward worsens the self-control of children and makes them demand the gratification even sooner (Mischel et al., 1972). Predictably, removing the reward away from attention makes children less susceptible to temptation (Mischel, Shoda, & Rodriguez, 1989). Presumably this is due to weakening the mental representation of the reward (Mischel et al., 1972). Following this line of thought, studies have shown that manipulation of the attributes of mental representation can also play a role in delayed gratification. For example, by focusing on a reward's arousing and sensory attributes promote children to decrease the delay. While making the reward "cold" or abstract (by displaying a picture of reward instead of the actual reward) has the effect of extending the delay (Mischel & Moore, 1980).

**Resource Restoration**

In light of the limited resource model, some studies have been conducted in the search for ways to offset or replenish the resource depletion. Firstly it is demonstrated that human cognition will budget the utilization of limited self-regulation strength in the face of an anticipated self-control task (Muraven, Shmueli, & Burkley, 2006). While conservation might work in some circumstances, high-demanding scenarios require regulation strength to be restored. To that end, Tice et al. (2007) found that depleted individuals who go through positive mood moderation performed as well as people whose regulation resources were not depleted. This result indicates the restoring effect of positive affect. Further, Schmeichel and Vohs (2009) showed that re-affirming personal values (by writing it down on a piece of paper and talking about it) also has the effect of replenishing depleted self-regulation strength. Other replenishing approaches include:

taking breaks and relaxation (Tyler & Burns, 2008), mild distracting (Alberts, Martijn, Nievelstein, Jansen, & De Vries, 2008), priming with concept of persistence (Alberts, Martijn, Greb, Merckelbach, & Vries, 2007) and raising self-awareness (Alberts, Martijn, & de Vries, 2011).

### *Attention Restoration Theory*

Based on James's categorization of voluntary and involuntary attention (James, 1892), Kaplan and Berman (2010) proposed Attention Restoration Theory (ART) for resource restoration. ART advocates the use of involuntary attention capture for attention restoration. Involuntary attention is attention that does not require effort. One example would be when something exciting or interesting occurs, people's attention will be easily captured. Involuntary attention is more bottom-up and automatic than directed attention (Moors & De Houwer, 2006). One notable effect of activating involuntary attention is that it can replenish limited attention resources by freeing one's mind from processes that involve effortful attention (Bargh & Chartrand, 1999). That is, when involuntary attention captures environmental changes, people do not utilize directed attention, which provides them with temporary refreshment. ART posits that as long as the external objects are "sufficiently gentle," they can capture involuntary attention without interfering with fixated thoughts (Kaplan, 1995). Kaplan (1995) categories these objects as "soft fascination." On the other hand, "hard fascination" refers to objects that occupy the cognitive system entirely and disallow other thoughts. One "hard fascination" example listed by Kaplan is television watching. Kaplan (1995) argues that instead of being "recreational," TV watching increases "mental fatigue rather than reducing it" (Kaplan & Berman, 2010). With respect to candidates for "soft fascination," ART recommends

natural environments such as gardens or lakes. These are ideal environments for capturing involuntary attention and thus restoring attention resources. With the limitation of working environments, it is not practical to decorate every office to be as natural as a garden. However, it is worth investigating the effect of using ambient virtual environment elements based on this design suggestion.

A related theory that supports the use of ART comes from Wickens' Multiple Resource Model. Wickens (2008) provides a coherent four-dimensional model for interpreting resource competition between processes. The model is shown schematically in Figure 4 below. The four categorical dimensions are stage of processing (perception, cognition, or responding), codes of processing (spatial or verbal), modalities (auditory or visual) and visual channels (focal or ambient). According to the model, most of the time, any two simultaneously executed tasks that occupy different levels along each of the dimensions will work better than tasks that share the same levels. Depends on their work context, knowledge-intensive tasks can occupy perception, cognition, and response stages, with visual or auditory modalities, while both are performing manual and verbal processing. However, it is not common for knowledge workers to use both their focal and ambient visual channels for information processing. Based on this model, it is possible to take advantage of this visual channel to signal performance feedback.

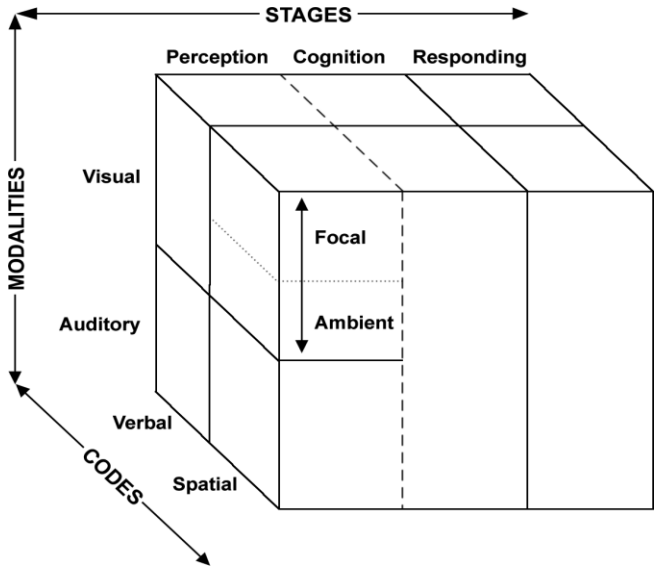


Figure 4. Wickens's 4-D Multiple Resource Model (Wickens, 2008)

**Relation to Design**

The resource model of self-regulation highlights the competition between self-control effort and executive functioning in cognitive mind. It points out two important features of self-regulating behaviors: 1) regulating behaviors consumes cognitive resources and 2) the resources need to be restored, or the regulation ability will decay. It leads to an important aspect of the design that the intervention has to be subtle and peripheral. Besides, attentional restoration theory suggests the use of environmental friendly visual elements as ways of attention restoration. Work by Wickens (2008) also provides a guideline for sending the feedback on secondary channels.

Based on the discussion about delayed gratification and temporal discounting, another important design suggestion is to reward subjects whenever possible. Constant rewarding is an attempt to counter the discounting of the reward of self-regulation by providing immediate gratification of other forms, such as badges, scores or success/encouragement notes.

**Summary**

In sum, both cybernetic model and resource-based model on self-regulation recognize the importance of motivation. According to the cybernetic model, the motivation for behavior change is spurred by the inevitable discrepancy between current state and the goal established by self or by social expectation. The cybernetic model highlights the key influence of negative affect aversion on behavior change. On the other hand, the resource-based model also focuses on the role played by motivation in the success of self-regulation but puts more emphasis on the importance of budgeting cognitive resource, such as attention, allocation. The resource-based model advocates the use of attentional restoration techniques to contain the depletion of regulation resources, such as using "soft fascination" objects (Kaplan & Berman, 2010).

# Chapter 4. Persuasive Technology

This section organizes and expands upon previous work in the field of persuasive technology. The discussion will focus on theoretical models and design principles.

Persuasive technology is proposed by Fogg (1998b) as "interactive systems that designed for attitude and/or behavior change". The computers are designed in "an attempt to shape, reinforce, or change behaviors, feelings, or thoughts about an issue, object, or action" (Fogg, 1998b, 2002).

Because of this, persuasive systems thus are not neutral. They are assigned an intention, and the purpose of the system is to convey the intention to the users (Fogg, 2002). Besides being intentional, persuasive systems also need to adopt strategies in persuasive messaging and consider the context at which the system will be utilized (Oinas-Kukkonen & Harjumaa, 2009).

In order to obtain a better taxonomy, Oinas-Kukkonen (2013) suggests categorizing persuasive systems in terms of intention. Systems can be **initializing**, **changing** or **consolidating** attitudes and behaviors

## Psychological Theories of Persuasion

### The Elaboration Likelihood Model

An influential model in the realm of persuasion psychology is the Elaboration Likelihood Model (ELM) proposed by Cacioppo and Petty (1984). The model is built upon the multi-channel theory on information processing. It recognizes the phenomenon that people process important and less important information simultaneously and heuristically. The Elaboration Likelihood Model posits that persuasion should take both central and peripheral channels for transmitting persuasive messages. The premise is that

when a person pays attention to a message and uses the core channel for information processing, the person will mobilize cognitive resource to digest and judge the intention of the message. On the other hand, if the individual is using the peripheral information channel, he is using certain attributes of the message rather than the actual content of the message to judge the authenticity and value of the message. Such attributes could be the source of the message and the trustworthiness of the source. In that case, the likelihood of a person receiving and accepting the message is not so much dependent upon the content of the message, but rather on the presentation.

The key element in the Elaboration Likelihood Model is the concept of the likelihood a person would make cognitive efforts to digest and check the content of the message. The model further argues that two constructs determine the level of probability that a person will "elaborate" the message, namely the **ability** and **motivation.**

Ability concerns the amount of usable cognitive and physical resources that the subject can mobilize to digest the message. Such resources could be attention and memory. The word "ability" refers to the fact that cognitive and physical resources are fundamental requirements that a person will use to check the persuasive message.

Motivation pertains to the level of relevance of the message to the receiver. This relevance to a large extent determines the level of motivation a person has to act according to the message. Motivation could also involve personal values and opinions about certain issues not necessarily relevant to the person, but issues that reflect a person's personal values and outlook that could also spur motivation for behavior change.

The Elaboration Likelihood Model also predicts that short-term persuasion is best suited with the peripheral channel while the long-term change of attitude and behavior

depends on central channel processing. In addition, high-level and value-based attitudes will be more stable and resistant to change if they are established through deliberate and rational processing. Low-level behavior changes are more direct and easier to establish with the right type of presentation and right persuasive message (Cacioppo & Petty, 1984).

### Cialdini's Principles of Influence

Cialdini listed and elaborated the six principles of influencing other people to carry out desired behaviors in his book (Cialdini, 1993). These principles have been implemented and validated by many studies and applications over the years (Bunce, Flens, & Neiles, 2010; Evans & Johnson, 2000; Shinar, Schechtman, & Compton, 2001; Wilson & Korn, 2007). Although this research is primarily done with human-human interaction, and the principles are derived from mainly persuading people to agree on purchasing items or services, the principles are still relevant and useful in persuading people to change their behavior, such as designing persuasive robots (Siegel, Breazeal, & Norton, 2009). These six principles are consistency, reciprocity, liking, authority, scarcity, and consensus.

**Consistency** is the idea that a pre-commitment, though small and insignificant, could lead to larger and more profound behavior change because people want to keep doing what they have committed to do, or even on larger scale. For example, it is much more likely that homeowners will be willing to erect a sign in their front yard to promote safe driving if they were previously given a small sticker with the same message. This desire to retain the original behavior could be used to magnify existing commitments and elevate the level of behavior change to a higher standard.

Secondly, the principle of **reciprocity** says that people will be more likely to repay a favor from others. Sales professionals often use this technique to persuade and land contracts. Studies have shown that by giving small gifts at the end of a meal in a restaurant will see the waiters gaining larger tips from diners (Bacon & Egeth, 1994).

The third principle is **liking**. A person will be more likely to be persuaded by people that they know and like. Liking can take many forms. It could be someone that they are close to or someone that is similar to them professionally or personality-wise. It could also be someone that they trust and respect.

The fourth principle is **authority.** The rule of authority says that people are more likely to be influenced to make decisions by people who present themselves with authority and expertise. It is empirically studied that by presenting job titles, uniforms or certificates will see a higher rate of persuasion success (Cialdini, 1993).

The fifth element in successful persuasion is **scarcity**. People will be more likely to perform a behavior to attain benefits that are scarce. By manipulating the perceived availability of certain resources, people tend to act in order to get possession of it even though none of the endogenous properties of the resource has changed.

The sixth principle is **Consensus**: it is the theory that people will conform to norms of the majority to satisfy consensus. Thus, it is more likely for a person to change his/her behavior if it is made clear that majority of his/her social group is doing the same thing.

These six elements are not mutually exclusive and can be combined and utilized to maximize the persuasion strength.

### Captology

Captology refers to "Computer as Persuasive Technology." It was conceived in a special interest group by B. J. Fogg (Fogg, 1998b). Captology is about the concept of using computers as a persuasive medium and changing people's attitudes and behaviors in an interactive way.

Fogg has gone to great lengths explaining and expanding theories of persuasion through many of his publications (Fogg & Tseng, 1999; Fogg, 1998b, 2002; Fogg, 2009c). The most salient concept on Fogg's computer intervention for behavior change is the proposition of Types of Intent and Functional Triad.

#### *Types of Intent*

Fogg's types of intent categorize the type of intent embedded in persuasive designs and systems. Based on the source of intention, persuasive technology's persuasive messages can be classified as endogenous, exogenous, or autogenous. The endogenous intent is the intent of developers of the system; exogenous intent is the intent from distributors while autogenous systems are systems satisfying the intention of the person him/herself and for the users' own good. Often a system can carry intentions from any combinations of the three intents.

#### *Functional Triads*

Fogg also categorizes persuasive systems by the role played in the persuasion process: as a **tool**, a **medium,** or a **social actor** (Fogg, Cuellar, & Danielson, 2009).

*As a Tool*

If persuasive technologies are treated as **tools**, they are believed to alter a person's attitude and behavior by improving an individual's ability while making the target

behavior easier to do (Oinas-Kukkonen & Harjumaa, 2009). According to Fogg, persuasion happens when technology as tool is able to achieve any of the following goals: 1) Increasing a person's self-efficacy, 2) providing personalized information, 3) triggering decision making, and 4) simplifying or guiding users through a process (Fogg et al., 2009).

Self-efficacy is achieved when computers are used to increase the possibility that a person will be able to perceive the effect of the personal effort. By raising the mere belief that an individual is able to control his/her own behavior and make efforts toward goals, the possibility that the person will carry out the action will be more likely (Fogg, 2009b).

The second function of persuasive technology as a tool is to provide sufficient and accurate information that caters to a person's needs. During persuasion, general and unfiltered information will obscure the significant and right-in-moment information that a person needs to make decisions about changing behavior. Computers are able to provide the tailoring and personalization (Garrett & Danziger, 2007; Jimison, 1997).

The third function of persuasive technology as a tool is the convenience to provide triggers for behavioral change. Computers, as they become more ubiquitous and easier to use, are able to provide cues that signal the decision-making process. Cues can be designed to interrupt current mental processes by utilizing the central processing channel, but they can also use the peripheral channel and feed the cues subconsciously.

The fourth function of the computer as a persuasive tool is the ability to make the decision-making process easier and smoother. By providing content information and guiding the user through a complicated and convoluted process using a simpler and

intuitive interaction, computers persuade people to make a decision faster and easier. The primary target of this function is to remove roadblocks for a desired behavior to happen (Spitz, 2004). Changing the environment and process is seen to be a good facilitator to promote personal behavioral change (Woods, 2014).

*As a medium*

The computer as a medium could also play a role in behavior change. Fogg focused on using computer simulations to promote attitude and behavior change. Recent developments in health games and serious gaming fall into this category (Wajcman & Rose, 2011). Using a simulation, a computer can convey key aspects of the problem and situation such that the user of the simulation will have a better understanding of the problem and the persuasive message.

In particular, the computer can simulate the **cause and effect** of behavior so that it is possible for the person to comprehend the "what-if" scenario. By shortening and simplifying the causal relationship, a person will be exposed to the benefit of improved behavior and the detrimental effect of inappropriate behavior (Bondarenko, 2006; Cades et al., 2010; Green, 2008; IJmker et al., 2006; Pee et al., 2008).

Computers as a medium can also simulate an **environment** to put users in context with a high-fidelity virtual simulation. By becoming immersed in the environment, a person will have a heightened experience that encourages him/her to make decisions as if he/she is in the real situation (Freeman & Muraven, 2010; Haynes, 2007; Kidwell, 2010; Monk et al., 2008; Ragu-Nathan et al., 2008). Computers can also be used in physical object simulations such that physical objects are equipped with the programmed logic that simulates certain behavior under different context.

*As social actors*

Computers can also act as **social actors** to provide support and emotional dependence for individuals. In this category, computers are used as a surrogate of a human in psychological and emotional care (Haynes, 2008; Karr-Wisniewski & Lu, 2010; Sykes, 2011). In addition, computers can be used to model attitudes and behaviors in social interaction in order to promote healthy behavior (Spira & Goldes, 2007). Finally, computers can be used to mimic human social dynamic and cultural rules to encourage appropriate behaviors and attitudes (Dabbish et al., 2011).

***Macrosuasion and Microsuasion***

According to Fogg (Fogg et al., 2009), analysis and appraisal of a persuasive system can be conducted in a two-level structure. From the perspective of the overall persuasion target, a product/system can be seen as "macrosuasion" if persuasion and behavior change is its primary goal. Examples are health-promoting systems or commerce websites like Amazon.com. On the other hand, there are also systems whose primary goal is not persuasion, but over the course of user experience, persuasion is used in a micro-level to change the user's behavior so that a better user experience can be achieved. These systems are called "microsuasion." Microsuasion is regarded as small steps that a system designer could use to promote bigger and more desired behaviors. Examples of "microsuasion" are techniques web sites use to make users stay longer on pages and make more clicks.

In case of interruption management, the persuasion is categorized as macrosuasion. The goal is to change behavior for task management, and it is the primary objective of persuasion.

**Persuasive System Design Model**

The Persuasive System Design (PSD) Model developed by Oinas-Kukkonen and Harjumaa (2009) is a heuristic model that provide steps and suggestions in designing persuasive systems. The model consists of two sets of toolkits: One focuses on analyzing the task context while the other set focuses on design techniques for persuasion.

The persuasion context concerns the source, target, and means of persuasion. It prompts the designers to ask three key questions: 1) **the intent:** what is the goal of persuasion? What is it that the persuader wants to convey and convince the subject to do? It also pertains to the nature of the persuader as to who is the source of the persuasion. 2) **The event**: this element in the PSD model asks the designers to find the event that could trigger the persuasion. 3) **The strategy**: this component in the PSD model describes the way a user interacts with the persuasive source. In particular, it asks: a) what is the message contained in the interaction and b) which cognitive route does the message transmit (central or peripheral).

The persuasion technique is a bag of suggestions on how persuasion could be more successful using proper techniques. There are four categories of techniques the tailored to four different aspects of user tasks:

**Primary tasks**: this category contains methods to make primary tasks easier for users. It contains the following techniques:

Table 3. Design Methods for making primary tasks easier

| Technique | Purpose | Example |
|---|---|---|
| Reduction | Making the task easier for the user to complete | Using social network login authentication to avoid long process of registering new user |
| Tunneling | Guiding the user through a process | Installation wizard |
| Tailoring | Adjusting offered information for a certain user group. | "Basic" and "Advanced" view for new and advanced users. |
| Personalization | Adjusting offered information to specific users | Item recommendations on Amazon |
| Self-monitoring | Allowing the user to track his/her own progress | Progress data visualization for continuous use. |
| Simulation | Provide the user with a way to discern the link between cause and effect | Show correlation between healthy habits and improved health status. |
| Rehearsal | Provide the user with a means to rehearse a target behavior | Flight simulation |

**Dialog**: this category concerns techniques to enhance the rhetorical interaction between the persuasive system and user in order to strengthen the persuasion effect.

Table 4. Rhetorical Techniques

| Technique | Purpose | Example |
|---|---|---|
| Praise | Compliment the user when it performs target behaviors | Encouragement when a user is doing the right action. |
| Rewards | Reward the user when it performs target behaviors. | Virtual achievements and awards |
| Reminders | The system reminds the user to perform a target behavior | Email reminders to ask users to revisit the system |
| Suggestion | The system suggests an appropriate course of action | Anti-virus software gives suggestions on how to handle suspicious files. |
| Similarity | The system tries to imitate the users in some way. | Avatars and virtual characters. |
| Liking | A system is visually attractive to the user. | Aesthetically designed websites |
| Social Role | The system adopts the role of a social actor. | Virtual counselors |

Credibility Support: these are techniques that enhance the credibility of a system so as to make the persuasion stronger. The techniques include raising trustworthiness, expertise, surface credibility, real world feel, and authority. It also includes techniques such as using third-party endorsement and making the system verifiable.

Finally, the last category of persuasive techniques includes means of persuasion in the form of social support. These techniques leverage social dynamics to create additional dimensions in increasing persuasion's success. It contains methods such as: social learning (simulate target behaviors for subjects to learn), social facilitation (create group effects by broadcasting the number or trend of people doing the same target behavior), social comparison (make the comparison between users salient and easy to comprehend), and normative influence (create direct and typical instances of good and bad results of

behavior). Moreover, systems can also be designed using social dynamics such as cooperating (helping people cooperate), competition (promote healthy completion between users) and recognition (deliberately and publicly recognize a user's effort in changing behaviors).

**Peripheral Display**

Another related field to persuasion technology is the use of peripheral displays for informational conveyance. In order to provide sufficient feedback of a worker's level of attendance to the task without causing too much distraction to his main focus, the visualization feedback needs to be placed in a peripheral and unobtrusive manner.

Matthews, Rattenbury, and Carter (2007) classified several important concepts in peripheral display research and defined peripheral display as an important class of ubiquitous computing applications that can allow a person to be aware of information without being overly burdened by it. One of the interesting outcomes of this paper is a summary of evaluation metrics for peripheral display designs. They include appeal (usefulness and aesthetics), learnability, awareness, effects of breakdown, and distraction.

Plaue and Stasko (2007) addressed the distraction issue by experimenting with their design of displaying an RSS feed on a peripheral display. The experiment manipulated two main independent variables: 1) whether or not the participant knows what the secondary display is for, and 2) the placement of primary display and the secondary display. The finding is not surprising that the motivated group (group that knows what the secondary display is for) gathered more information from the screen, but they also argue that by telling them what the secondary display is for makes it possible to

turn the task of awareness task into a “monitoring task”. In terms of desktop configuration, the results indicate the angled display (with the secondary display placed right beside the primary display but slightly tilted at an angle) is most distractive to users. Other configurations do not yield significant differences in terms of distraction, but consequently the information conveyed in those configurations is also small.

McCrickard, Catrambone, and Stasko (2001) on the other hand focused on small animated displays such as stickers and faders in one display. Their results indicate that animated textual peripheral display do not distract too much. An earlier paper done by Maglio and Campbell (2000) discredited the use of continuous display (animation) arguing that discrete displays have less negative impact on the user performance. It seems that the trade-off between distraction and information conveyance is major issue to solve in the design of the peripheral display.

All these studies, however, have an extra criterion in judging the efficacy of using peripheral displays for information conveyance, something that the design in the research presented here is not particularly interested in.

Stasko, McColgin, Miller, Plaue, and Pousman (2005) did a representative longitudinal study on peripheral awareness systems deployed in real-life settings. Their InfoCanvas project uses artistic images with variable image elements embedded in them. Those elements can change their property based on changes in external data, such as weather, stock values, and so on. They recruited eight participants, interviewed them about their information needs, tuned the application to entail their needs, and installed a separate display in their offices positioned according to users’ preferences. Over a month’s time, they visited the participants in the mid-month and at the end of the month.

In both times, they interviewed the participants and surveyed their using experiences with the display. Their main concerns were usefulness, personalization, aesthetics, distraction, novelty, and fun. In terms of distractions, the overall feedback was positive with most of the participants not finding it distracting at all.

**Relation to Intervention Design**

The knowledge gained in the section pertains to the implementation details on intervention. Specifically, the psychological theories of persuasion point out the semantic meanings of visual feedback.

Moreover, both Captology and PSD models generate a blueprint for designing persuasive systems. Peripheral display studies provide examples on how to properly embed messages in a peripheral visual channel. Details on implementing these design principles will be discussed in next chapter.

# Chapter 5. Study Design

## Target Behavior

The persuasive design tries to manage how a person allocates time and attention on various tasks. Since typically a person only has one primary task, the target behavior is how well a person can stay on the primary task in the face of either external or self-initiated interruptions. Therefore, to quantify performance, there are two primary metrics to measure this target behavior:

1) Resumption rate: how soon does a person get back to the primary task once they get away from it?

2) Resistance: how often does a person try to get away from the primary task?

SPT are measured by the two metrics above. A good SPT behavior will entail a person getting back to primary tasks as soon as possible and always stay within the primary tasks. On the other hand, a bad SPT behavior will see the subject prolongs interruption tasks, even goes to "secondary switches" and always tries to leave primary tasks.

## Research Question

The overall research question thus is how well a person can perform on SPT with the exposure to a persuasive intervention. The first study empirically validates this proposal in a lab setting while the second study tries to understand factors that could influence the SPT behavior and use of persuasive intervention in a natural setting.

## Designing WiredIn

### Design Strategy

Recall previous discussion on why cognitively interruptions are difficult to resume, because interruptions lead to memory loss and difficulty in recovery for goals (Altmann & Trafton, 2002), constant switching between tasks may lead to lowered awareness of the state of the interrupted task or even its existence (Dodhia & Dismukes, 2009). On the other hand, the high demand for cognitive effort on resuming tasks might demoralize people from achieving task resumption.

Thus, the strategies that these two studies are taking is to enhance two critical cognitive processes in SPT behavior regulation: **Awareness** and **Motivation**.

In this context, awareness refers to the understanding and self-evaluation of the current state of interruption management, with the focus on the discrepancies between the state and goal. On the other hand, motivation refers to the will to resume to primary tasks. This "willingness" includes a voluntary desire to abandon current activities, recollect the main task's goal and content to perform the resumption immediately.

Based on the theoretical discussion in the previous chapters, this section is devoted to discussion of how to design a computer-based intervention that aims at improving SPT. This intervention is named "WiredIn".

The following discussion will first describe the design features of WiredIn and trace this design decision back to the literature.

### Feature 1: Meaningful Animation

WiredIn uses series of images as visual stimuli. These pictures were taken from time-lapse videos so that changing images continuously creates an animated sequence of

same object varying its state. In the first study, the experiment uses a sequence of images of same rose changing between blossoms and withered. The second study uses a series moon phrasing images showing the moon changing from new moon to full moon.

The design of choice of both rose and moon is based on the affective theories on motivation (Hsee et al., 1991; Lawrence et al., 2002). Both flower and moon are commonly recognizable objects with two extreme states to represent favorable and unfavorable outcomes. From the discussion about inward-directed attention, it is also predicted that invoking emotions lead to self-reappraisal (Carr et al., 1991; Salovey et al., 2000; Wood et al., 1990).

The use of visually pleasant objects also comply with the recommendations from Attention Restoration Theories of using "Soft fascination" (Berman, Jonides, & Kaplan, 2008). Images such as flowers provide users a brief moment of relaxation and is predicted to restore depleted self-regulation resources.

Another characteristics of using images extracted from time-lapse videos is to minimize the disruption of visual continuity when changing the images, so that changing an image to its neighboring counterpart won't capture subjects' involuntary attention and disrupt his/her primary focus on tasks (St John & Risser, 2009).

**Feature 2: Visualizing SPT Performance**

The second point of the design is assigning a state of the objects to real-life behavior in SPT. The goal is to make subjects register a self-evaluation of their performance on interruption management when they see the state of the visual stimuli.

The mapping of SPT performance to the state of the objects is critical in creating a sense of responsibility and empathy toward virtual agents (Higgins, 1987; Payne, 1993).

Empathy toward virtual agents is one of the reasons to explain high motivation on video games (Allen, 2002) and other persuasive use cases (Bellotti et al., 2004b).

The explicit visualization of an abstract notion of SPT performance also heightens awareness toward the performance of productivity management and serves as a way of reminding people the existence of suspended tasks.

**Feature 3: Images of Self**

This feature will be used an alternative to abstract objects as visual feedback elements in Study II. Participants in Study II will be asked to upload profile images of themselves to WiredIn.

The use of self-portraits is commonplace in self-awareness studies as a venue for enhancing self-directed attention (McManus, 1999; Mills et al., 2001). A static image of self does not explicitly visualize the state of SPT performance but brings attention closer to the goal, which is to manage tasks properly in order to get things done.

**Feature 4: Images of Social Circle**

This feature is also only adopted in Study II as an alternative to emotionally-attachable objects. Users of WiredIn is asked to upload up to 3 images of someone from their social circle. The purpose of bringing the simulated presence of social support is to mobilize the social dimension in self-regulation. Using picture is an easy but effective way of create virtual presence (Porter, 2003). The theory of public self predicts behavior change based on an aversion to social rejection (Enzle & Anderson, 1993). From the point of view of Cialdini's principles of influence, the motivation to conform to goals can be described as pursuing "consensus" from others (Cialdini, 1993). In this context, the

expected “social norm” is establishing himself or herself as a productive worker and being committed to important tasks.

The following table summarizes the design decisions to the theoretical origins.

Table 5. From theories to design decisions

| Design Decision | Self-Regulation Theories | Persuasive Design |
|---|---|---|
| Animation of emotionally-attachable objects | • The “feedback” in negative feedback loop;<br>• Affect-based motivation;<br>• Emotion leads to self-awareness<br>• “Soft fascination” from Attention Restoration Theories; | As **Tool,** provide trigger to persuade a behavior change |
| Linking SPT to objects’ states | • Raise self-awareness;<br>• Instant reward, to avoid disengagement; | • As a **Tool**, this design improves “self-efficacy”;<br>• As **Medium,** highlighting the **causal** relationship |
| Subtle Animation | • Constitute as the “feedback” in control loop<br>• Slow down ego depletion;<br>• Give executive functioning an opportunity to refresh | N/A |
| Images of self | • Raise self-awareness;<br>• Invoke comparison between goal and state; | N/A |
| Images of members of social circle | • Add social dimension to motivation<br>• Conform to social norm and avoid rejection. | • As **Social Actors,** activating social expectations;<br>• **Consensus** principle by Cialdini. |

# Chapter 6. Study I

## Introduction

Study I was designed to investigate the effect of bringing visual feedback into the personal working environment on improving SPT.

## Visual Feedback

Based on the findings from the previously discussed literature, a feedback mechanism is needed to boost self-regulation when self-control strength is low. Visual feedback works as a "discrepancy-reducer" in self-control by decreasing the gap between one's self-control goals and actual behaviors (Botvinick, Braver, Barch, Carter, & Cohen, 2001). In order to detect such discrepancies, a monitoring process is a key to successful control (Carver & Scheier, 1981). Similar to the cybernetic model in engineering (Wiener, 1948), this monitoring process operates on a negative feedback loop in which feedback is given in proportion to the discrepancy. A monitoring lapse of neglecting a goal often leads to failure in self-control (Kane & Engle, 2003). Thus, it is predicted that using the visual feedback that highlights the goal and discrepancy could enhance this monitoring process and improve self-control behaviors.

## Methodology

### Experiment Setting

To test the effect of visual feedback on task resumption, the design process two forms of computer animations as visual stimuli: a dynamically changing flower (rose) and a traditional horizontal progress bar (See Figure 5). With a total of 1024 frames, the flower animation changed from being fully bloomed to withered and dying. The progress bar also updated in 1/1024 increments. Both flower and progress bar started at 2/3 of full

scale. Both visualizations occupied the entire screen on an extended display adjacent to the primary working display. For the control group, the extended display showed an empty black screen. Participants were told only to operate on the primary display, leaving the extended display unoccupied. The display was full screen on the extended monitor in order be consistent across groups.

Figure 5. Sample Flower Frames and Progress Bar

The choice of using a blooming/withering flower was inspired by and partly in accordance with design strategies put forward by Consolvo et al. (Consolvo, McDonald, & Landay, 2009). A blooming/withering flower satisfied most of their design strategies such as aesthetic, unobtrusive, abstract/reflective and controllable. The principle of Positive – provide positive encouragement - was tested as an independent variable (persuasion strategy) while the principles Trending/Historical and Comprehensive were not fully implemented. The deviation from some of these principles is due to the lab-based nature of this study. Moreover, Consolvo et al.'s design strategies were drawn from projects targeted at changing long-time lifestyles, e.g. physical activity while the goal of the WiredIn tool was more interested in correcting short-time interruption management behaviors.

A logging tool using the Windows API was developed to monitor constantly the topmost window in the participant's primary display. This was used as an indication of what the participant was looking at any moment and determined whether the participant was on or off the task at that moment.

With two visualizations (Flower and Progress Bar) and two persuasion strategies (Punishment and Reward), this experiment had a 2x2 factorial design plus the empty condition as a control group, receiving no visual feedback and consequently no persuasion strategies. In the "punishment" condition, the longer a person was deviating from the windows that were related to primary tasks (such as a Microsoft Word document), the more withered the flower appeared, or the less full the progress bar became, depending on the visualization condition. In the reward condition, the longer a user stayed on windows that were related to primary tasks, the more the flower blossomed or the more the progress bar became full. The transition of direction in both visualizations was instantaneous: the moment a user changed the topmost window from primary tasks to work-unrelated task or vice versa, the transition direction changed to reflect this.

The punishment and reward strategies were further manipulated by adjusting the change rate of the visualizations, as described in Table 6. Fast animation changed at the rate of 4 frames per second while slow animation changed at the rate of 2 frames per second.

Table 6. Implementation of Persuasion Strategies

| Visualization | Punishment | Reward |
|---|---|---|
| Flower | Slowly blossom/<br>Fast decay | Fast blossom/<br>Slowly decay |
| Progress Bar | Slowly grow/<br>Fast reduce | Fast grow/<br>Slowly reduce |

**Calibration on the Flower Frames**

The actual difference between two neighboring frames in the flower visualization was almost undetectable to the human eye. However, given the change rate described earlier, over 2~3 seconds the difference should be obvious to participants.

To have at least a roughly linear representation of flower florescence, the flower image frames were calibrated based on florescence ratings from a pilot study. From the image sequences, nine equally-spaced frames were selected from the flower visualization with each representing 10% increment for the whole range of florescence from 10% blossomed to 90% blossomed. These images were put Amazon Mechanical Turk (AMT) along with images representing the two extreme states of flowering: the fully withered and the fully blossomed, labeled with a score of 0 and 10 respectively. The accompany questionnaire asked the participants on AMT to rate the 9 randomly presented frames in terms of their level of florescence in comparison with the two extremes. In return, 52 participants from AMT responded with their ratings. The mean values are shown in Table 7. Though the perceived florescence did not follow the spacing of the frames perfectly, only the midpoint (5/10) was substantially higher than anticipated. These results confirm the validity to compare the sequence of flower florescence with linear progression such as progress bar.

Table 7. Florescence Ratings from AMT Study

| | | | | | |
|---|---|---|---|---|---|
| Actual Frame | 1/10 | 2/10 | 3/10 | 4/10 | 5/10 |
| Mean Ratings | 1.87 | 2.85 | 3.04 | 4.62 | 6.23 |
| Actual Frame | 6/10 | 7/10 | 8/10 | 9/10 | |
| Mean Ratings | 6.65 | 7.58 | 7.88 | 8.56 | |

**Hypotheses**

The set of hypotheses was focused on studying differences caused by visualizations and persuasion strategies on time spent on off-task activities:

H1: Participants with visual feedback (Flower or Progress Bar) will spend shorter off-task time than participants without visualization (control group).

H2: Participants with the Flower will spend shorter off-task time than participants with the Progress Bar visualization.

It was interesting to investigate whether participants would perform more secondary visiting behaviors without visual feedback. Secondary Switches are task switching that are driven by their own volition, including self-interruptions and subsequent voluntary switching after the initial interruption.

H3: Participants with visual feedback (Flower or Progress Bar) will have less Secondary Switches than participants without visual feedback.

In order to observe depletion effects in this study as predicted by resource depletion theory (Baumeister et al., 1998a), H4 was constructed as:

H4: Participants will have slower task resumption in later stages of the experimental session.

Finally, in order to see whether different visualizations or persuasion strategies would cause more psychological effects such as stress, H5 and H6 were constructed as:

H5: Participants with visual feedback (Flower or Progress Bar) will have a higher subjective stress level than participants without visual feedback.

H6: Participants receiving Punishment feedback will have higher subjective stress levels than participants receiving Reward feedback.

**Participants**

30 participants were recruited from a Midwestern university campus via online and in-person solicitation. Participants were randomly assigned to three visualization groups with ten in each group. Each participant in the intervention groups (Flower or Progress Bar) was randomly assigned to either the Punishment or Reward persuasion strategy, resulting in five Punishment recipients and five Reward recipients in each of the intervention groups. This allowed us to compare between five independent groups: Empty, Flower/Punishment, Flower/Reward, Progress Bar/Punishment and Progress Bar/Reward. Each participant was compensated with a $10 Amazon gift card at the end of the study.

**Procedure**

Framing

It is known that people will behave differently when they know they are being tested (Carlopio, 1983). To increase the chances of capturing the behaviors of interest, despite the inherent limitations of a laboratory setting, and to cover the actual intent of studying interruption behaviors, experiment design framed the study as an evaluation of new office working environments, in which the participant would perform a typical office task: editing Microsoft Word documents.

After reading and signing the consent form, participants were asked to fill out a questionnaire collecting their demographic information and social media/computer usage. The facilitator then introduced several "new office setting elements" to the participant, including green plants, a new type of office chair, some newly designed lamps, and a seat beside a large window in order to provide an outdoor view and natural light. Participants

in the intervention groups were also introduced to the visualization intervention (flower or progress bar). The facilitator introduced each of these office setting elements with equal emphasis and in random order. This design intended to minimize participants' suspicion toward the visualization as the tool for evaluation.

The monitoring application detects inputs from the mouse and keyboard and considers any input as legitimate as long as the Microsoft Word windows stay in the topmost position. This knowledge, if shared with participants beforehand, could result in participants abusing the system by just randomly using the keyboard/mouse to fake productivity. Therefore facilitators did not tell them these operational details beforehand, but only told them that the visualization changes based on their progress on the primary task.

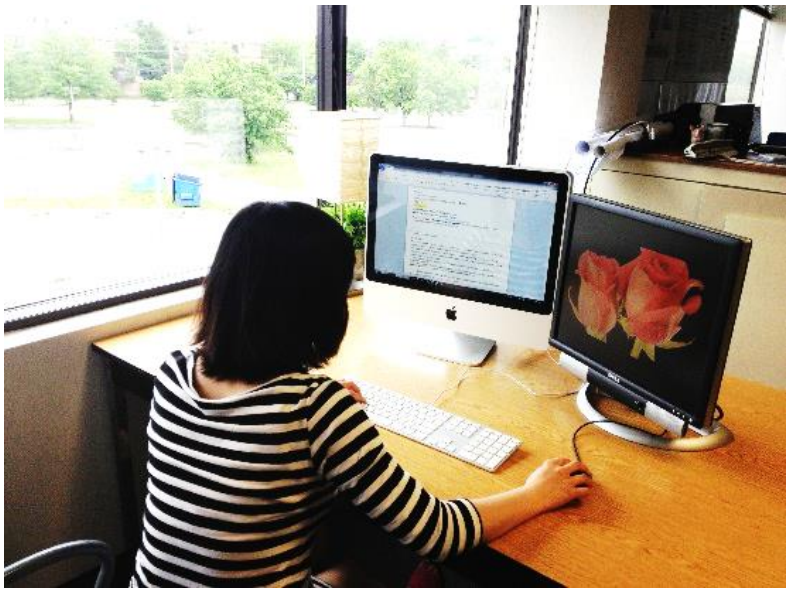

Figure 6. Study I Experiment Setting

***Task***

The primary task was editing a Word document continuously for 40 minutes. The document was ill-formatted with inconsistent fonts, unaligned paragraphs, messy tables

and other features requiring editing. They were given four such documents and asked to fill the time by performing the editing task, but not to be concerned about making a specific amount of progress. Participants were told that this task was of low importance and had no deadline. Each document was at least 20 pages long and they were not expected to finish any of four documents. They were reminded that neither editing quality nor speed was important to the study. They were encouraged to relax and perform the task at the rate and in the way they felt comfortable. They were told that no audio or video recording devices were implemented in the room and that they were allowed to perform any habit they may have when doing computer-based tasks, e.g. listening to music, checking emails, etc. All these instructions are aimed to lower participants' awareness of being in an experiment and encourage spontaneous behaviors. Participants were still reminded that the editing task is the primary goal during the experiment and relinquishing the editing task is not appreciated.

***Interruptions***

Interruptions were sent over Google Chat in the form of task requests. These external interruptions forced a baseline level of interruptions in the task in addition to participants' voluntary interruption behaviors such as self-interruptions and delayed resumptions. Typical requests included "Please go check your Facebook feeds and follow any links or stories for as long as you like" and "Please go check new uploads in your YouTube subscription and watch any video you like." All these interruption destinations (e.g. Facebook and YouTube) were drawn randomly from the participants' answers to the question regarding their most frequently visited websites in the pre-study questionnaire. Participants were told that they did not have to reply to the facilitator upon completing

the requests. All subsequent actions were of their own volition. This was to eliminate the possibility that replying in the chat box would constitute an additional resumption cue for the participants.

The logging program continuously broadcast the participant's window changing activities to a web service by sending out the window titles (not the actual content of the windows). The facilitator in another room then was able to monitor participants' window-switching activities via a browser-based client. Based on moment-by-moment updates, the facilitator decided when to send the next request according to the following rules: 1) if the participant was on the editing task, wait for five minutes and send a request; 2) if the participant was off task, do not send requests; 3) when the participant resumed the editing task, reset the timer and wait for another five minutes to send the next interruption; 4) if the participant self-interrupted and went off task before the five minute timer is up, stop the timer and wait for the participant to resume on his/her own.

Both the logging and monitoring program were not revealed to the participant until the end of the study. At the end of the study, signed consent forms from participants were collected to use log data. No participants requested any deletion of entries from the log files.

***Pre- and post-tests***

Before the editing task, each participant went through a five-minute digit-span test. A digit-span test asks subjects to repeat a sequence of digits immediately after seeing the sequence. The digit-span tests were used to deliberately deplete participants' cognitive resources before entering the actual experiment. As adopted in Ego Depletion

studies (Kaplan & Berman, 2010), this technique is used to make the depletion effect more detectable.

After the editing task, participants were asked to fill out a modified NASA TLX (Hart & Staveland, 1988), with one additional question about self-reported stress level, as used by Mark and colleagues (Mark et al., 2008). Participants also rated how much they liked the visualization after the study. The study concluded with a semi-structured interview about the participant's experience using the tool, their motivations behind interruption behaviors and their general impression toward the visualizations.

**Data Collection**

The logging tool captured all the window switching activities and wrote all activities into a file. Each entry contained the timestamp of the switching as well as the title of the current topmost window. This log file provided the data analysis the ability to determine if a participant was on or off of the editing task at any moment of the study. Two measures were extracted from the log files as dependent variables:

**Average Off-task Time (AOT):** For each participant, the analysis computed the average duration of off-task time as a measure of primary task resumption speed. This quantity was calculated by dividing their total off-task time by the number of window switches away from Microsoft Word to other windows. In some cases, the participant peeked at other windows and switched right back to the editing task within 10 seconds, these incidents were excluded from counting. This was based on the observation from the data that a task deviation that lasts shorter than 10 seconds usually ends at the Google Chat window. This suggested that such deviations were intended at checking for new requests, rather than leaving the editing task. AOT is preferable to using total off-task

time as a measure of resumption speed because the total duration of the experiment varied from participant to participant due to the off-task time being open-ended. The five-minute limit for an on-task time before an interruption created a floor effect where even the most efficient workers suffered a baseline penalty without being rewarded for remaining on-task for the full duration.

**Secondary Switches:** For each participant, data analysis counted the incidents of window switching that were driven by their own volition. Specifically, the counting included the number of different web pages a participant visited other than the websites requested by the facilitator. This includes all the subsequent visited websites after an initial interruption as well as all the target websites visited by self-initiated interruptions.

**Results**

***Task Switching:***

Overall, participants spent on average 45.00% (*SD* = 0.15) of time off tasks which amount to about 18 minutes of off task time if total experiment time is normalized to 40 minutes. The mean AOT across all groups was 169.46 (*SD* = 111.50) seconds. On average, participants made 114.00 (*SD* = 82.37) window switches. Participants made 8.53 (*SD* = 3.55) switches away from the editing task. Of those switches, a mean of 4.86 (*SD* = 2.23) were self-initiated.

***Average Off-task Time (AOT)***

One-way ANOVA on five between-subject groups revealed significant differences of AOT[1] across the groups ($F(4, 20) = 3.21$, $p < 0.05$). Planned contrasts showed the Empty group (*M* = 249.60, *SE* = 43.81) had significant higher AOT than the rest of the

[1] AOT was log10 transformed for a normal distribution.

groups ($t(20) = -2.72$, $p < 0.05$), confirming H1 that providing the visualization significant shortens average off-task time compared to the control. Further, Flower group's AOT ($M = 119.03$, $SE = 15.35$) was also significantly shorter than that of Empty group ($t(20) = -2.64$, $p < 0.05$). Progress Bar ($M = 139.76$, $SE = 27.51$) also produced a significantly shorter AOT than the Empty group ($t(20) = -2.32$, $p < 0.05$), but the Flower and Progress Bar did not have a significantly different AOT ($t(20) = 0.40$, *ns*). This rejects H2 and indicates that the Progress Bar and Flower are not significantly different in term of resumption effectiveness. Figure 7 illustrates AOT among the three groups. The fact that having a visualization produced low AOT is partially supported by interview data. For example, P24 mentioned: "As soon as I see the petals get a little brown edge, I jump back to the Word. I want to keep it normal!"

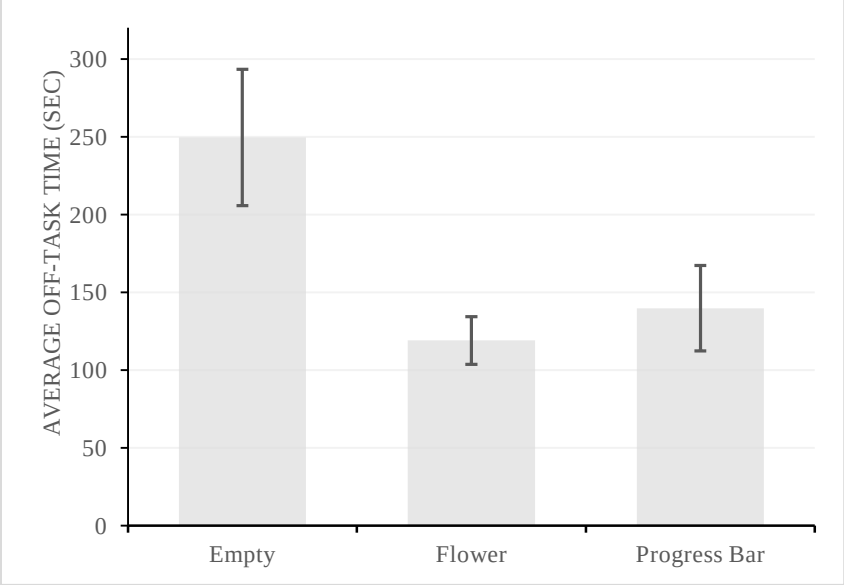


Figure 7. Study I AOT across Visualization Groups

For persuasion strategies in the intervention groups, a two-way Factorial (2x2) ANOVA of both visualizations (excluding Empty) and persuasion strategy revealed a significant main effect of persuasion strategy ($F(2, 16) = 11.04$, $p < 0.05$), but no

significant main effect of visualization and no significant interaction effect between the two. Regardless of visualization, Reward ($M$ = 170.23, $SE$ = 21.07) produced significantly longer AOT than Punishment ($M$ = 88.56, $SE$ = 14.20). Figure 8 shows the AOT between two strategies.

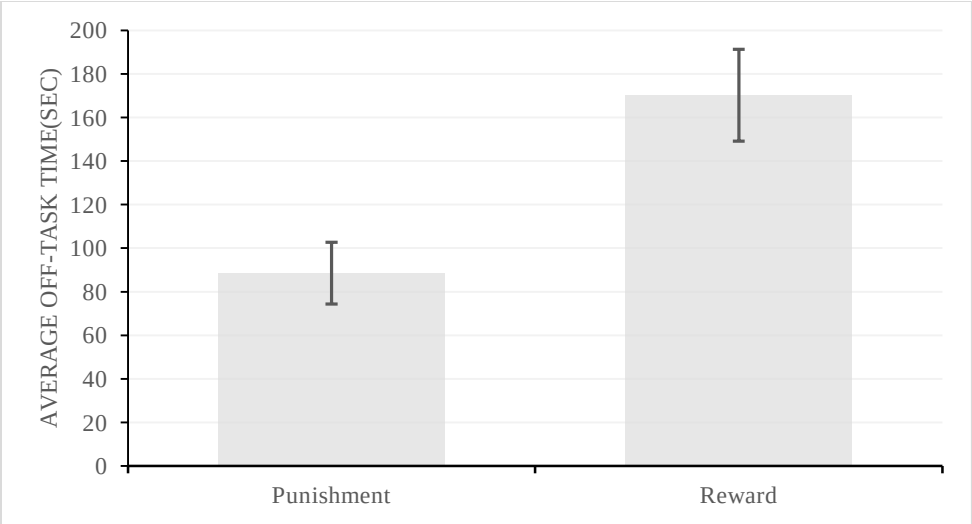


Figure 8. AOT between Persuasion Strategies

Even though there was no significant interaction effect between visualization and persuasion strategy, Figure 9 shows that the Progress Bar is marginally more sensitive to persuasion strategies.

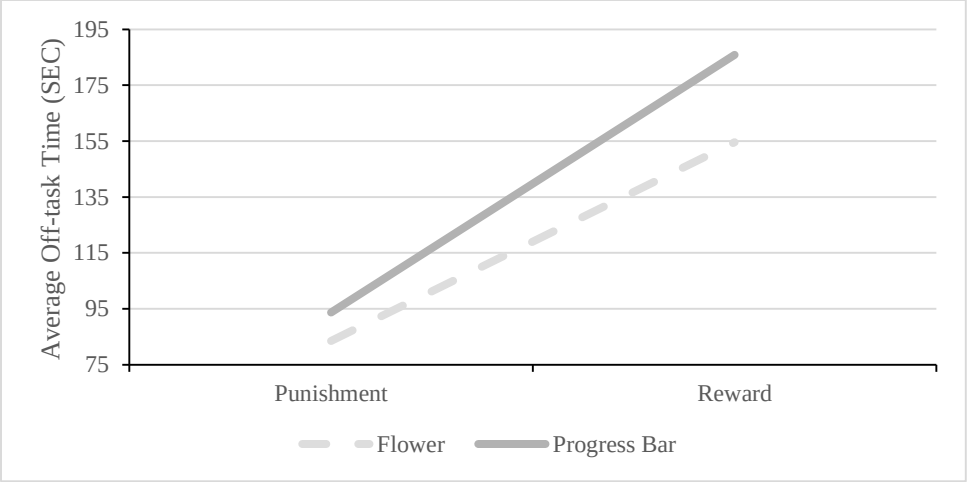


Figure 9. Interaction between Visualization and Persuasion Strategy on AOT

Factorial ANOVA on gender and visualization failed to find a significant main effect of gender or interaction effect of gender and visualizations in terms of average off-task time.

***Depletion Effect***

To investigate the depletion effect over time, analysis extracted all off-task time (OT) from log files. Time into the study is also calculated for each entry based on the timestamps. A multiple regression was run to predict OT from time and visualization type. Both variables significantly predicted OT, $F(2, 253) = 5.89$, $p < .01$, and both added significantly to the prediction, $p < .05$. Time's $\beta = 0.26$, meaning that regardless of the visualization type, OT increases over time. There was no significant interaction between visualization and time into the study.

***Secondary Switches***

The mean number of secondary switches was 34.7 ($SE = 4.06$) for the Flower group, 30.5 ($SE = 3.52$) for the Progress Bar group, and 42.0 ($SE = 4.60$) for the Empty Group. In terms of persuasion strategy, the mean VS was 31.3 ($SE = 3.61$) for the Punishment group and 33.9 ($SE = 4.05$) for the Reward group. The number of voluntary

switches was not significantly different across the five groups based on one-way ANOVA ($F(4, 20) = 1.86$, *ns*). Excluding the Empty group, a two-way factorial ANOVA of visualization and persuasion strategy also failed to find significant results ($F(3,16) = 0.516$, *ns*). This result rejects H3 and concludes that there is no significant difference in terms of secondary switching across visualization groups.

***Subjective Workload***

Subjective Stress

In answering the stress related question in the NASA TLX questionnaire ("How stressed do you feel throughout the task?"), the Flower group produced the lowest subjective stress level ($M = 2.40$, $SE = 0.50$), followed by the Empty group ($M = 2.70$, $SE = 0.63$), and the Progress Bar group with highest subjective stress level ($M = 9.20$, $SE = 1.78$). Non-normal distribution of subjective stress level required nonparametric analysis (Kruskal-Wallis), which indicated there was a significant subjective stress level difference across the three visualization groups ($H(2) = 11.23$, $p < 0.05$). Mann-Whitney tests were used to perform pair-wise comparisons using a Bonferroni corrected significance level of .0167 (3 comparisons). The Flower group's subjective stress level was significantly lower than the Progress Bar group ($U = 12.00$, $p < .0167$). The Empty group's subjective stress was also significantly lower than Progress Bar group ($U = 13.50$, $p < .0167$). The difference of subjective stress levels between the Flower group and Empty group was not significant. This rejected H5 but also shows that the Progress Bar elicited higher stress levels than other two visualizations. Figure 10 shows subjective stress across the three visualization groups.

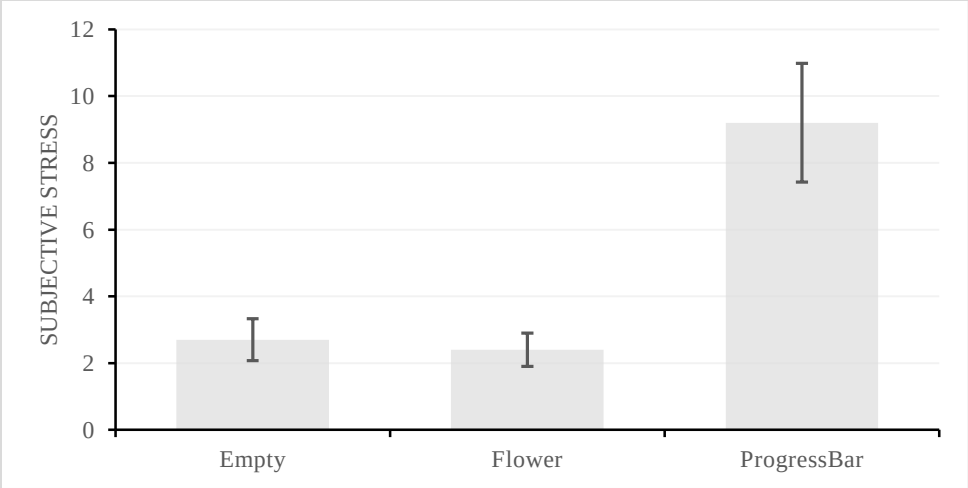


Figure 10. Subjective Stress across Visualization groups

A Mann-Whitney test also revealed that within the intervention groups, the Punishment strategy produced significant higher subjective stress levels ($M = 8.20$, $SE = 1.96$) than the Reward strategy ($M = 3.40$, $SE = 0.92$; Mann-Whitney's $U = 23.50$, $p < 0.05$). This result confirmed H6 that Punishment recipients have higher stress levels than Reward recipients. Figure 11 shows the subjective stress level between persuasion strategies. In the interview, P18 confirmed the result that Punishment produced higher stress level. He said: "I feel like the flower's speed of decaying is faster than recovering, and it made me more nervous."

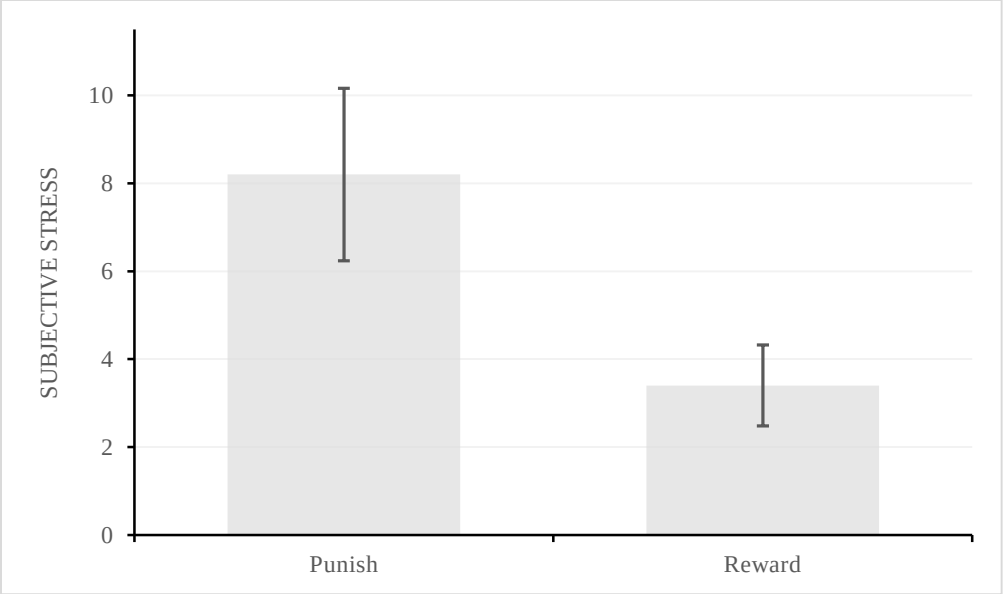


Figure 11. Subjective Stress between Persuasion Strategies

Subjective Time Pressure

For the survey question regarding time pressure ("How hurried were you while doing the task?"), visualization types did not have a significant effect on subjective time pressure. However, persuasion strategy did: Punishment produced a significantly higher self-reported time pressure ($M = 9.30$, $SE = 1.71$) than the Reward strategy ($M = 2.80$, $SE = 0.65$; Mann-Whitney's $U = 13.50$, $p < 0.05$).

***Subjective Likability and Gender***

Even though gender and visualization did not have a significant interaction effect on AOT performance, they did have significant interaction effect on self-reported liking of the visualization in the post-test survey. Factorial ANOVA revealed a significant interaction effect between visualization and gender ($F(3,16) = 17.74$, $p < 0.05$). Specifically, male participants rated both the Progress Bar ($M = 3.14$, $SE = 0.55$) and Flower ($M = 3.00$, $SE = 0.649$) similarly, while female participants liked the Flower visualization significantly higher ($M = 5.80$, $SE = 0.65$) than the Progress Bar ($M = 2.00$,

*SE* = 0.84). Participant 19 (Male) confirmed his preference for the progress bar by saying that "it gives direct feedback, and I can see where I am clearly."

## Discussion

### On Visualization

The significant difference of AOT across visualization groups indicates that providing visual feedback helps participants return to tasks faster. Even though the Flower group produced a somewhat lower mean AOT than the Progress Bar group, the effect of adding an emotionally attachable element like the flower does not significantly help. On the other hand, the Progress Bar elicited a significantly higher level of subjective stress than the Flower intervention, indicating that in the long run, immediate and direct feedback such as a progress bar could wear people out. It is thus recommended that amiable and emotionally attachable visualizations could achieve a similar level of effectiveness in boosting task resumption while creating less stress on users. However, due to the limitations of a lab-based study, how well these visualizations could support long-term use needs to be further studied in a real personal working environments, such as home or office.

### On Persuasion Strategy

The punishment strategy produced significantly faster resumption while also inducing significantly higher subjective stress levels and subjective time pressure. This result shows the double-edged effect of using the punishment method: it has higher effectiveness but also creates higher pressure on users. The Reward group's lower stress level and time pressure, as well as longer off-task time, may be explained by some information gathered in the post-test interview. Many Reward recipients mentioned the

opportunities of "taking a breath" granted by the Reward intervention. Once they attained a high level of the visualization (almost fully blossomed flower or almost full progress bar), they gave themselves a license to take a break by visiting non-work related websites. Since the reduction of the progress bar or flower is much faster in the Punishment condition, those participants did not perceive themselves as having this license. This "self-licensing" behavior is often seen as a motivation deficit or justification for immediate gratification and over-indulgence (De Witt Huberts, Evers, & De Ridder, 2012). Designing for a relaxing condition like Reward requires vigilance for excessive self-licensing behaviors and must balance the manipulation between encouraging high concentration and allowing mental and physical relaxation. The result from this study also gives evidence as to why the reward strategy could help persuasive technology's continuous use, as predicted by Consolvo et al. (Consolvo et al., 2009).

**On Depletion Effect**

As predicted by Ego Depletion theory (Baumeister et al., 1998b), a depletion effect on AOT was observed over time for all groups. Thus, H4 is confirmed. However, no significant interaction was found between the time of the study and the visualization type. Further study is still needed to investigate how visual feedback could influence the depletion effect.

**On Voluntary Switching**

The analysis of voluntary switching did not yield significant results. This is probably due to the relatively small sample size and limited study time (40 minutes on average). It might also have to do with the fact that some websites are better at grasping

user attention and making users stay (e.g. YouTube) than others and that is why the significant results in AOT are not reflected in the number of web pages visited.

**On Taking Breaks**

It is worth noting that tools such as these that continuously encourage people to get back to work should not prohibit taking breaks during working hours. Numerous studies indicate the benefits of taking breaks at workplaces (Henning, Jacques, Kissel, Sullivan, & Alteras-Webb, 1997; Jett & George, 2003). Research in attention restoration advocates taking breaks as a way of replenishing attentional resources (Berman et al., 2008). However, for more and more information workers, taking breaks often means visiting non-work-related websites, which tend not to replenish cognitive resources, compared to restorative activities such as taking a stroll in the park (Bock & Ho, 2009).

As predicted by previous research, visiting these websites as a way of taking breaks is counterproductive in replenishing cognitive resource. Firstly, these websites are what Kaplan and colleagues refer to as *hard fascinations* that fixate one's attention and disallow any reflection about anything else. Thus, they are less effective in attention restoration (Kaplan, 1995). On the contrary, *soft fascinations* are natural objects such as flowers and plants that promote reflection on other things and are validated ways of attention restoration. Secondly, Zeigarnik shows that unfinished issues could persist in memory (Zeigarnik, 1927). These *attention residues* (Leroy, 2009) create interferences with normal task execution by disrupting cognitive functioning (Berman, Jonides, & Lewis, 2009; Jonides et al., 2008). It is recommended that visual feedback be integrated with scheduled breaks to produce a sustainable working flow.

### On Multitasking Tendencies

Ophir et al. (Ophir, Nass, & Wagner, 2009) aim to debunk the myth of multitasking efficiency in the digital age. Their work recognizes that people are not as good at multitasking as they think they are, especially given the saturation of information in today's world. Their results indicate that heavy media multitaskers are habituated to "explorative" rather than "exploitative" ways of information processing, and they are more attracted to off-task stimuli. This means they are more likely to be disrupted by the external environment and more likely to interrupt themselves to explore novel stimuli.

Therefore, based on Ophir et al's results and those learned from this study, an intervention for heavy media multitaskers could aim to limit the extent of this "explorative" way of information processing by providing visual feedback reminding them about the scope and duration of off-task behaviors. This will narrow their attention allocation to more important tasks. In other words, for multitaskers, tools like those in this study serve as a container that prevents irrational time and attention allocation to secondary or irrelevant tasks.

## Design Implication

The effectiveness of providing visual feedback is confirmed in this study. The insignificant AOT differences between the Flower and Progress Bar shows that either dynamic cue can effectively remind and motivate task resumption. In addition, rewarding strategies are potentially more suitable for long time use since they produced lower stress level, as recommended by (Consolvo et al., 2009).

The interview data confirms the visualization likability results. The interview data identified a theme of male participants reacting rather lukewarm toward the Flower

visualizations. This indicates potential individual differences in terms of acceptance of different visualizations. Previous studies confirmed that in persuasive computing, designers should consider gender as a factor in persuasive design (Zanbaka, Goolkasian, & Hodges, 2006). For long-term use in real-life work environments, different people will respond differently to visualizations as motivators (Consolvo et al., 2009). It is important to match individual differences to maximize the motivation effect, or offer customizations that improve effectiveness.

A higher-level design suggestion is to recognize the differences between two modes of operating a computer: recreational and serious working. System designers should take into account the human cognition characteristics under the two modes and provide support accordingly.

**Limitation and Next Steps**

**Task Urgency**

One of the side-effects of this framing was misrepresenting real-life behaviors. 13 out of the 30 participants mentioned in their interview that if they knew the task was urgent, they would have spent much less time on irrelevant tasks and focus more on the editing task. Indeed, task urgency can increase the rate of task completion (Claessens, Van Eerde, Rutte, & Roe, 2010). Thus, the results of this study do not directly apply to contexts with high task urgency, whose effects on motivation for task completion could be large enough such that visual feedback is unnecessary. Because of the large effect of task urgency on task resumption and in order to prevent task urgency from masking the effect caused by visual feedback, the study had to bring every participant down to a similar low-level task urgency in order to observe how visual feedback alone could

influence the resumption efficiency. Further studies are needed to explore how external factors such as task urgency would enhance or diminish the effect of visual feedback on the rate of task resumption.

However, the results of this study still have validity in certain circumstances. First, workers whose tasks are not deadline-driven depend more on self-regulation capacity than task characteristics to manage interruptions and resumptions (Eerde, 2003). Second, claiming that situational differences would alter their behaviors does not stand as an excuse for self-control failure in non-urgent scenarios, which characterizes much of routine office work. Lastly, delaying a task to the last minute to increase its urgency is a common type of procrastination behavior identified by researchers as *arousal procrastination* (Ferrari, 1992), which is an extreme example of over-dependence on deadlines.

**Complex Real-life Interruptions**

We recognize the complexity of real-life interruptions and their formation (Mark et al., 2005). In particular, interruptions are often interleaved. Also, the setting of primary tasks often changes over time. This study demonstrated the efficacy of visual feedback in a simplified context and may not be fully replicable when faced with the complexity in real scenarios.

However, it is still easy to see the potential even with this complexity: as long as there is some relative difference of importance among tasks, more sophisticated tools can be built which intelligently learn about the environment and adjust the settings to accommodate this complexity. Examples include dynamically detecting the primary tasks or pausing the feedback upon important immediate interruptions. Other projects

demonstrate the potential of systems that are able to learn about working environments such as (Horvitz, Jacobs, & Hovel, 1999) and (Iqbal & Bailey, 2010).

### Sources of Interruptions

Real-life interruptions are not always coming from chat-based communication like this study. As described earlier, some interruptions have explicit cues for resumption while others do not. Thus, some interruptions are inherently easier to conclude, e.g. phone call vs. visiting Facebook. The effect of visual feedback should be more pronounced for wrapping up interruptions that are more open-ended.

### Limited Sample Size

The small number of participants prevented the analysis from arriving at other interesting conclusions such as gender differences, voluntary switching behaviors, and the effect on mental workload. These factors remain to be investigated in future studies with larger sample sizes.

## Next steps

The follow-up study applied field research methods to investigate the usage of such tools in real-life settings. A diary-based study recording daily use of the tool will enable a deeper understanding of the problems of interruptions in collaborative work settings and produce robust designs for addressing them. Natural settings give us opportunities to investigate contextual influences on task resumptions. Such context variables could be task urgency, task completion level, time of day, the nature of the task, and others.

In regard to supporting group motivation, this tool also could be extended to involve multiple group members competing with each other by sharing each other's

visualizations. Such effort in gamifying working spaces has seen positive results (Neil et al., 2013).

**Conclusion of Study I**

Disruptive environments and cognitive limitations delay timely task resumption after interruptions. The results of this study suggest that the use of visual feedback on task suspension can function as an effective intervention to help people resume tasks more gracefully and efficiently. Results also show the efficacy of using emotionally attachable objects of both reducing the off-task time and controlling the stress level. However, further studies are needed to address individual differences in responsiveness to visual persuasion to maximize its effectiveness. Lastly, future work must investigate the effectiveness of this intervention on long-term use and whether it is best used on an ongoing basis, or if it may function most effectively as a tool to train more productive behaviors, and then be discontinued.

# Chapter 7. Study II

## Purpose

The purpose of study II was to study empirically the effect of introducing visual feedback in a real computer-related working environment and investigate environmental, design-related, and individual factors that could influence the task-management behaviors.

Participants were recruited to install an updated version of WiredIn on their personal computers and use WiredIn while they work on real projects in their typical work environments. Both quantitative and qualitative data were collected. Combining results from both statistical regression models and organization of qualitative data, discussion about design interventions while working was conducted.

## WiredIn Modification

To accommodate real-life applications, WiredIn went through a couple of key modifications. Firstly, a wizard form is shown each time a user starts the WiredIn application. The wizard guides the users to enter key information about their work environment and tasks as well as defining the primary tasks. It serves several purposes:

1) It collects environmental and task-related information for each run. Each day at different times, the participant might be in a different working environment, having different energy and stress levels and doing various tasks. All these factors could influence the self-regulation behavior. The first two pages on this form collect this information in a quick and user-friendly way.

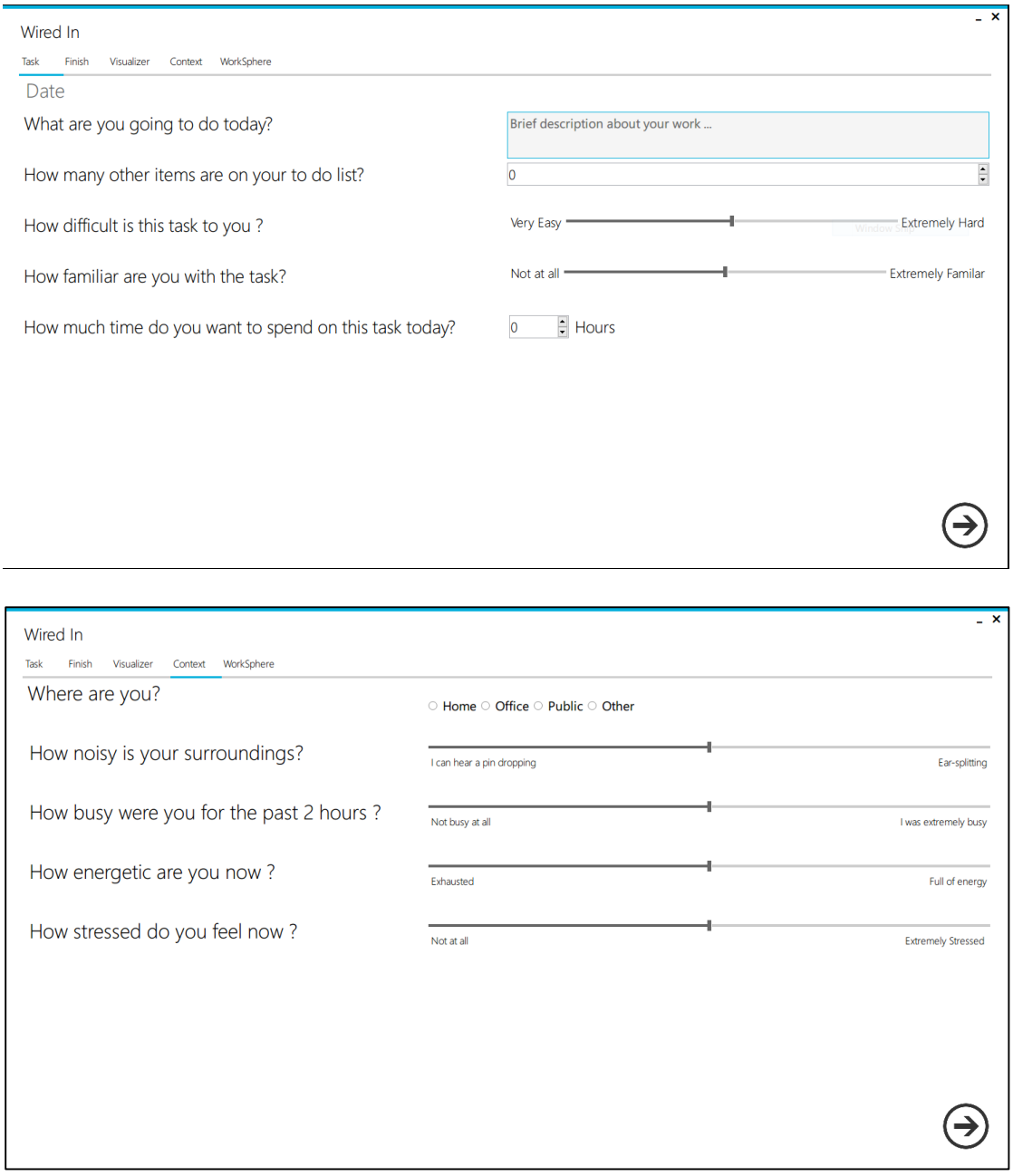


Figure 12. WiredIn Data Collection Forms

2) It configures WiredIn to identify primary task related applications: e.g. Word, Adobe Photoshop, etc. Since every time the task is different thus various applications might be needed to perform those tasks, WiredIn needs to know which applications are related to the declared task goal in order to determine if the participant is on or off task.

So the wizard form lets users configure which applications/windows belong to the "worksphere" (Mark et al., 2008). A worksphere is defined as a collection of entities (computer opened files, applications, or other references) that are needed in completing one particular task. As soon as a user lands on a top-most window that belongs to a non-worksphere application, WiredIn will deem it as being off-task.

However, there is a special case of Internet browsers. Browsers are important tools for information workers to search and filter information, however, they are also the usual suspect for the internet indulging, time-wasting, or "cyber-slacking" (Vitak et al., 2011). To solve this dilemma, WiredIn allows users to specify up to 20 keywords that describe his/her "safe" browser using. A web page with a title that contains any of the keywords will be deemed as "safe." If it does not contain any of the keywords, this web page will be deemed as "off-task."

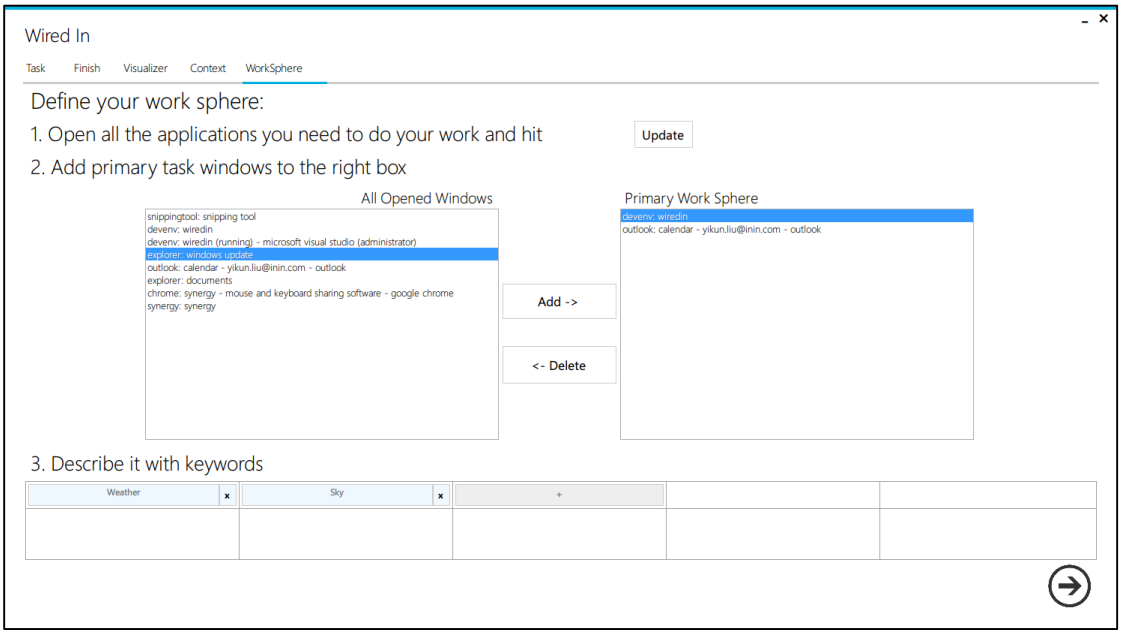


Figure 13. WiredIn Defining Work Sphere

3). It sets up images for custom interventions. Based on the summary of self-regulation theories, WiredIn uses images of the participants themselves to raise self-awareness or images of someone from the participant's social circle to generate a sense of social support. To do that, WiredIn allows users to import image files and use them as a means for visual intervention. Users are instructed to import up to three pictures. These three slots of images correspond to three states of "Stay on Primary Task" performances: Good, Normal, and Bad. It is the users' responsibility to assign each of the pictures to each of three states. When WiredIn determines if a user is on one of the states, the corresponding image will be shown.

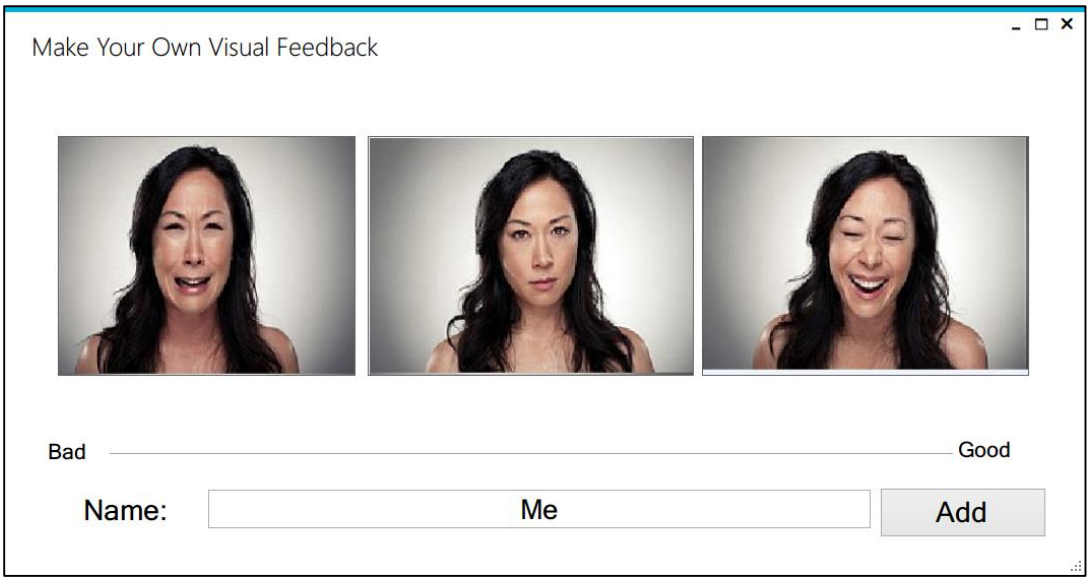


Figure 14: WiredIn Interface for Importing Images

It is worth noting that the speed at which the images transition from one state to another depends on how well a subject is able to maintain his current state. For example, a person who has just returned to his primary tasks would see the bad state image transitions into the medium state if he is able to maintain those primary tasks for 30 seconds. Sustaining the tasks for another 30 seconds will cause the image to continue

transitioning to the good state. It is the same rule for the other direction: if a person who has just left primary tasks will see his good state image transition toward the medium state if he keeps doing irrelevant tasks. Then his image will continue into the bad state if another 30 seconds pass by and he is still not back to primary tasks. During the progression toward the good state, if a person reverts to irrelevant tasks then the unfulfilled 30 seconds will be forfeited and a new 30-second clock will start counting toward the bad state.

4). WiredIn supports experience sampling. In addition to logging window switches, WiredIn also provides prompt windows asking participants to provide details on interruption tasks that last longer than five minutes. This method is similar to flow theories' Experience Sampling Method (ESM) (Larson & Csikszentmihalyi, 1983). The purpose is to capture real-time incidences of failed resumption and the participant's rationale for it. Each time the participant returns to primary tasks after an interruption that is longer than five minutes, the following popup will be shown (Figure 15). In this popup, the participant is asked to enter the reason as to why she is away from tasks for this long. In addition, she is invited to choose a simple rationale between "I was reluctant" and "I forgot". Finally, they are requested to rate how much the visual feedback motivated them to get back.

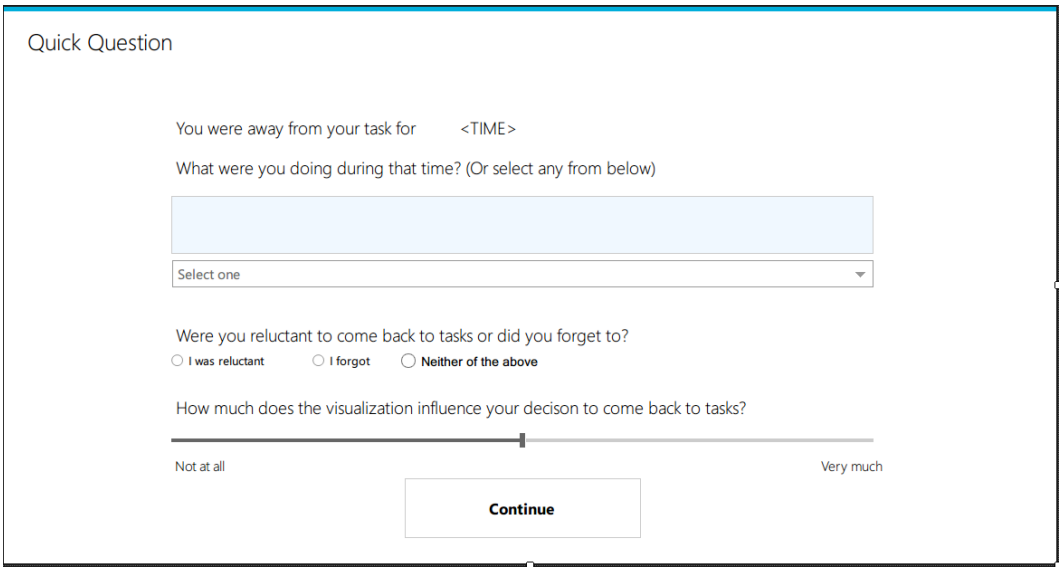


Figure 15. WiredIn Interface for Self-reported reason for lapse

In addition to recording extended interruption rationale, another popup will show up asking people to rate their satisfaction with their SPT performance.

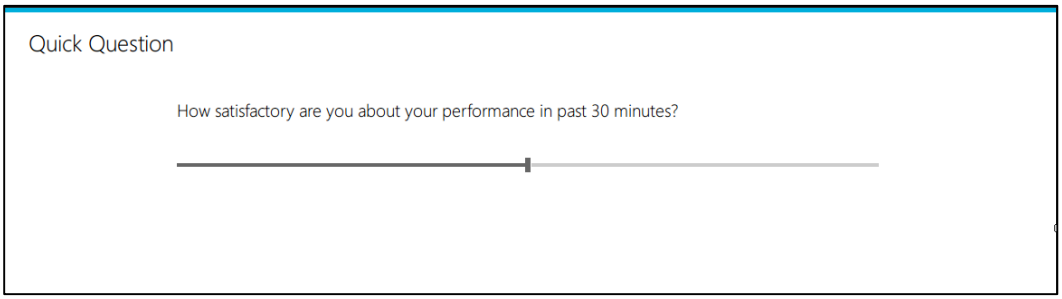


Figure 16. WiredIn interface for self-reported rating on performance satisfaction

**Experiment Process**

**Recruitment**

Recruitment advertisement was distributed on the IUPUI campus via the department mailing system and online bulletin services. Among many responders, only 10 participants were selected. The selection was based on several criteria:

1) The participant is required to be willing to commit at least 10 days for participation.

2) The participant is required to use a Windows PC as his/her primary workstation. This is because WiredIn is only compatible with Windows operating systems.
3) The participant was expected to spend the majority of his/her daily working hours using a computer. In other words, the work should be computer-dependent.
4) Participants should work on projects that rely on as few applications as possible. This condition is optional. It makes it easier to determine if a participant is on or off the task at any moment.
5) Participants with more diverse types of projects are preferred. This will allow data collection to be more inclusive. Following the same logic, participants who have more options of locations, who work both at night and at daytime, and who have more diverse lists of frequently visited websites are preferred.

**Orientation**

On the first day, the participant was invited to sit down with a facilitator to talk about the project and was asked to sign the consent form to begin participation.

The facilitator then installed WiredIn onto the participant's personal laptop with written permission from the participant. The facilitator then performs test runs to make sure it works on participant's computer. In case a participant worked on a desktop PC that is not brought to the meeting, the participant was given a copy of the installer for WiredIn and was asked to perform the installation.

Then the participant was briefed on what to expect for each day during the participation. Then the orientation was completed, and the participant was supposed to start the first participation the next day.

**Participation Details**

There were in total 10 participants, each of whom contributed 10 days of working hours to this study. In total, there were seven male and three female participants with ages ranging from 18 – 25. All of the participants are college students who rely heavily on computers to work on their schoolwork as well as personal projects. All of the students claim to be computer savvy and have more than eight years of experience using Windows PCs.

Each day the participants were asked to use WiredIn for at least five hours while they were working on their personal or professional projects. Participation did not have to be 10 consecutive days, as individual schedules might not permit. When the participant agreed to participate on a certain day, that day was counted as a "participation day".

On the morning of each participation day, the facilitator discussed via email with the participant about the plan for the day's involvement. The plan included:

1) Schedule: when does the participant plan to schedule the work?
2) Location: where does the participant plan to work on the project?
3) Description about the project: the participant describes the task today in a few sentences without giving away too much information

Between 9pm and 10pm in the evening of a participant day, participants were asked via email to send a short summary about their experience of using WiredIn on that day and complete an online diary form. The diary was semi-structured: each day

participants were asked to comment on some specific aspects of their experience using WiredIn: usefulness, acceptance, enjoyment, stress/distraction and self-reflection. In the diary, participants were also asked to raise one or two incidents they thought worth talking about in regard of any of the five aspects.

Then participants were asked if they were confident about working for five hours on the next day. If not, the facilitator rescheduled for another day. There were circumstances where a participant failed to meet the 5-hour requirement even though he/she had agreed on the night before. In that case, if the final count of hours was at least 4.5 hours, the result was accepted. Otherwise, that day's data was rejected.

Participants are of course allowed to take breaks while using WiredIn. They are encouraged to take regular breaks, as they would normally do. WiredIn is able to pause and resume at any time. However, they are told not to do pausing/resuming too many times because that would defeat the purpose of using WiredIn at all.

## Data Collection

### Data Sources

#### *Window-Switching Logs*

The main source of data comes from windows-switching logs provided by WiredIn. Each window-switching log entry contains the timestamp as well as the title of the window that is switched to. During the five-hour working time, WiredIn randomly changed the intervention every 30 minutes. It chose one of the persuasion designs based on a random number from a uniform distribution. Thus each day the 5-hour long window-switching data was also divided into 30-minute segments. Incomplete segments were kept if they were at least longer than 20 minutes; otherwise, they were discarded. In

some cases, participants worked more than 5 hours and on some other days they failed to reach the 5 hours quota. From all the available dataset, all working hours were divided into 30-minute segments. Each 30-minute segment should be standalone and non-interrupted. Here "non-interrupted" means there is no turning WiredIn off and on happened during the 30 minutes. Participants should perform normal interruption on their work during the 30 minute. In the end, each person will have sufficient data to have at least 100 30-minute segments, which in total will give the regression analysis 1000 segments.

Similar to Study I, numerous measures were derived from these logs. These measures are used as SPT performance measures of how well a person is able to regulate his or her behaviors and stay on primary tasks.

***Startup Wizard***

The startup wizard records environmental and self-reported data. The wizard ran each time WiredIn was started and created data files in the installation folder. Typically this wizard should just run once a day if the participant is able to work continuously for 5 hours. However, this is not always true since circumstances might not allow. In that case participants needed to re-enter various values. Although repetitive, participants were told to keep the entered value faithful to the circumstance and not just blindly repeat previous inputs.

***Interview and Diary Data***

At the end of the 10-day participation, each participant was invited to return to the research lab and have an interview with the facilitator. The audio-recorded interview had participants talk at length about their experience of using WiredIn. They were also

encouraged to provide feedback on overall persuasion design. These recordings were later transcribed.

**Dependent Variables**

For objective dependent variables, this study extracted four quantities from windows-switching logs plus the self-reported SPT performance satisfaction rating.

***Average Off-task Time (AOT)***

AOT is the average time a person spends on task-irrelevant windows in a 30-minute segment. It is calculated by dividing the total amount of time spent on interruptions by the number of interruptions. It measures how well a person minimizes interruptions during the 30-minute segment. It does not precisely measure time wasted on task-irrelevant windows since some legitimate interruptions are also included. However, by averaging them, it gives a proper measurement on the targeted construct as most of the proper switches between work sphere windows are already excluded.

***Frequency of Switching-Off (FSO)***

During the 30-minute segments, the frequency of switching-off (FSO) is calculated by dividing the total count of switching to task-irrelevant windows by the number of minutes (because some segments are incomplete and less than 30 minutes). This quantity measures the frequency of interruptions the participants experienced. Note that only the switch from task-relevant windows to irrelevant windows is counted as one incident of being off-task.

***Frequency of Secondary Switches (FSS)***

Another significant quantity extracted from logs is the counts of secondary switches. A Secondary Visit is counted when a person switched to a second task-

irrelevant window after the first switch away from primary tasks. This is the measurement of how likely a participant will extend an interruption and fail to return to the primary task. Note, however, that search results are ignored during the counting. For example, if participant switches from a Word document to Google and then to a YouTube video, it only counts as one Secondary Visit.

Compared to Frequency of Switching-Off (FSO), this measurement also includes the visits to any of the non-work-related windows after the initial switch off. FSO only counts the initial switching away from primary task windows to non-work-related windows.

***Length of Lapse (LL)***

A lapse is defined as a long deviation from primary tasks (> 5 minutes). Length of lapses (LL) in Study II refers to the accumulated minutes of lingering on task-irrelevant windows. This is a measurement of task-disengagement or even giving up. The 5-minute threshold is derived from experiment data from Study I where only 2% of the interruption took more than 5 minutes to resume.

To calculate this quantity, for each 30-minute segment, all the interruptions that are longer than five minutes are selected, then for each of such interruption, five minutes is subtracted from the length to keep only the number of minutes that exceed the five-minute mark. In this study, five-minute is considered as the threshold of being "necessary" to handle interruption; the sum of all the remaining minutes thus denotes the total number of minutes that the person spends on "unnecessary" activities.

It is possible, however, that when the timer exceeds the five minute mark, the participants are still occupied with external interruptions that they cannot terminate

immediately of their own volition, e.g. going to the bathroom. To account for this, each time the participant lingers on task-irrelevant windows for more than 5 minutes, the returning to primary tasks will be intercepted and prompted with an inquiry for rational of task resumption delay. With articulated reasons for the lapses, the post-test data process is able to filter out these involuntary lapses in the study. Those moments are thus removed from the data analysis.

#### *Perceived Task Performance Satisfaction (PPS)*

In Study II, at the end of every four 30-minute segments there was a quick popup asking participants to rate their performance satisfaction on overall task performance on a seven-point scale. To minimize the disruption to people's workflow, this popup only shows up every two hours. This generated around 240 segments with feedback on perceived task performance.

Performance satisfaction measurement is a complicated issue, and there is no prevailing dedicated questionnaire for that purpose. However, it is often used as part of job satisfaction questionnaires by simply asking participants to rate their perceived satisfaction over their performance on tasks (Spector, 1985).

### Predictor variables

#### *Categorical: Persuasion design*

The first independent variable is the intervention used in WiredIn. This study employs four types of persuasion designs: Empty, Moon, Self-Portrait, and Social-Support.

The empty design is simply a transparent window; this is to simulate the scenario of having no intervention. The Moon is a series of time-lapse images of moon phases. It

is chosen based on feedback from Study I. Images of the moon represent a common, recognizable, and amiable object, and at the same time they are also distinguishable from nuanced changes. It combines the properties of both the flower and progress bar from Study I.

The self-portrait is one or several images of the user him/herself. Participants are asked to choose and import images on their own. Presenting a self-image has been widely used in self-awareness related research as a manipulator to raise self-directed attention (Fenigstein, Scheier, & Buss, 1975). Here it's used to elicit awareness of self and bring attention to the comparison of state and self-regulation goals (Igbaria & Tan, 1997; Sundstrom, Town, Rice, Osborn, & Brill, 1994). Social-Support is similar to Self-Portrait; the only difference is that it uses images from a significant member of the user's social circle.

Planned contrast is used to code persuasion designs into three contrasts: the three constructs are coded as I1, I2 and I3.

Table 8. Study II Regression Model Persuasion Design Contrasts

| Intervention | I1: Empty vs. Others | I2: Moon vs. Self-Portrait | I3: Moon vs. Social-Support |
|---|---|---|---|
| Empty | -3 | 0 | 0 |
| Moon | 1 | -1 | -1 |
| Self-Portrait | 1 | 1 | 0 |
| Social-Support | 1 | 0 | 1 |

***Categorical: Types of Interruption Tasks***

Each windows-switching entry has the title of the target window (the new topmost window). Thus, it is possible to deduce and label what type of interruption task the person is on by looking at the title of the target window.

By going through all the log files and systematically categorizing each entry using a bottom-up approach, four types of interruption tasks emerged: Social Network, Videos, Articles, and Other. To determine the type of interruption tasks for each segment, a computer program was developed to automatically split log files into 30-minute segments and extract the titles of windows that a person first lands when switch away from primary tasks.

Then by going through these titles the data processing then manually determined what types of the tasks in this segment the person went to when first deviating away from primary tasks. The process of categorizing off-task types was based on following rules:

1) It's the first window (except search engine pages) that the person landed after leaving primary task that determined the off-task type. Within the 30 minutes,
2) The set of "Video", "Social Network" and "Articles" is predefined. These three categories dominated the off-task types from Study I.
3) There could exist some accuracy issues with this measure as both articles and videos can be embedded in social media sites while videos sites can also allow visitors do social media-like activities like commenting or chatting. But if the main site is a social network site, it's counted as "Social Network", or "Video" if the primary purpose of the website is to streaming videos.
4) The rest of the off-task types including more diverse types of non-work-related activities such as changing music, managing files or there is no significant off-task activities.

Table 9. Study II Regression Model Interruption type contrasts

| Interruption task types | O1: Others vs. Social-Network | O2: Others vs. Video | O3: Others vs. Article |
|---|---|---|---|
| Social Network | 1 | 0 | 0 |
| Video | 0 | 1 | 0 |
| Article | 0 | 0 | 1 |
| Other | 0 | 0 | 0 |

***Categorical: Time of Day***

Each day participants start working at different hours. It is also not uncommon that they distribute the five-hour working hours across the day. To simplify the analysis, one day was divided into four periods: Early Morning (2am – 8am); Morning (8am-2pm); Afternoon (2pm – 8pm); and Night (8pm – 2am). Each 30-minute segment is labeled as one of the four periods depending on which period majority of the segment falls. For example, if one segment starts from 1:50 pm and ends at 2:20 pm, it's labeled as "Afternoon."

Participants contributed most of their participant time in afternoons and evenings. Given the participants were college students and the majority of the participation was done during and around the midterm part of the school semester, it was not surprising that the highest percentage of participation time of day was in afternoon or evening. Planned contrasts for coding time of day focus on comparing morning vs. other time of the day.

Table 10. Study II Regression Model Time of Day Contrasts

| Time of Day | P1: Night Vs. Day | P2: Morning vs. Afternoon | P3: Morning vs. Evening |
|---|---|---|---|
| Early Morning | -1 | 0 | 0 |
| Morning | 1 | -1 | -1 |
| Afternoon | 1 | 1 | 0 |
| Evening | -1 | 0 | 1 |

***Categorical: Location***

Each time WiredIn is run, it asks the users to select a type of location they are in. Given the scope of this study, the types of the environment were narrowed down to only four: Home, Open Office, Private Office, and Public. By interviewing and verifying with the participants, these four types cover all the possible locations they would choose to work in a short period of time during their participation. Note the difference between Open Office and Private Office is whether the office room is shared with other people or it belongs to the participant exclusively. Public refers to open public spaces such as libraries, coffee shops, and so forth. The difference between Public and Open Office is the person's familiarity with the environment and social connection with the people within close proximity.

Among four types of environment that participants worked at, only six segments' location was labeled as "Private Office". After consulting this statistic with the corresponding participant, it was an error when he intended to select "Open Office" when running WiredIn startup form. With no entries for "Private Office", this predictor only contains three levels. Contrasts and dummy variables are coded as following:

Table 11. Study II Regression Model Location Dummy Coding

| Location | L1: Home vs. Office | L2: Home Vs. Public |
|---|---|---|
| Home | 0 | 0 |
| Office | 1 | 0 |
| Public | 0 | 1 |

***Categorical: Task Types***

After categorizing task descriptions provided by the participants, there are three types of tasks participants were undertaking during the time of participation: Writing; Designing and Programming. Writing tasks include tasks such as project reports, essays,

or any forms of academic writing. Designing tasks include any computer-supported creative artwork such as website design, Photoshop, and video editing. Programming tasks include any coding-related activities. Contrasts are planned as following:

Table 12. Study II Regression Model Task Type Dummy Coding

| Task Type | T1: Writing vs. Design | T2: Writing vs. Coding |
|---|---|---|
| Writing | 0 | 0 |
| Design | 1 | 0 |
| Coding | 0 | 1 |

***Continuous: Days of Using***

For each segment, an integer value is given to indicate the number of days the participant has been using WiredIn. The regressed prediction, if significant, could indicate that how the duration of using WiredIn influenced SPT performance measures.

***Continuous: Perceived Task Urgency***

The startup wizard also asks the participant to rate the urgency on the task's time line on delivery. Task urgency is rated as between a 100-scale between "Not urgent" to "Extremely urgent."

***Continuous: Self-estimated Task Familiarity and Difficulty***

Different levels of perceived task familiarity and perceived task difficulty entail task engagement as well as persistence in performing tasks. Each time WiredIn is run, it asks the participants to rate their familiarity with the task and the how difficult the task is to the participant.

***Continuous: Perceived Energetic and Stress Level***

The WiredIn startup wizard also asks four other questions that relate to people's energetic and stress level before embarking on the tasks. The questions are:

1. How energetic do you feel coming into this task?

2. How stressful do you feel coming into this task?

## Data Analysis

### Basic Statistics

#### *Predictor Variables*

Among the collected 1000 segments, the distribution of persuasion types is roughly equal across the four types (each with around 250 segments under its name) due to the programmed randomness control.

In terms of Time of Day, most of the logging happens during the afternoon and evening period (combined 86%).

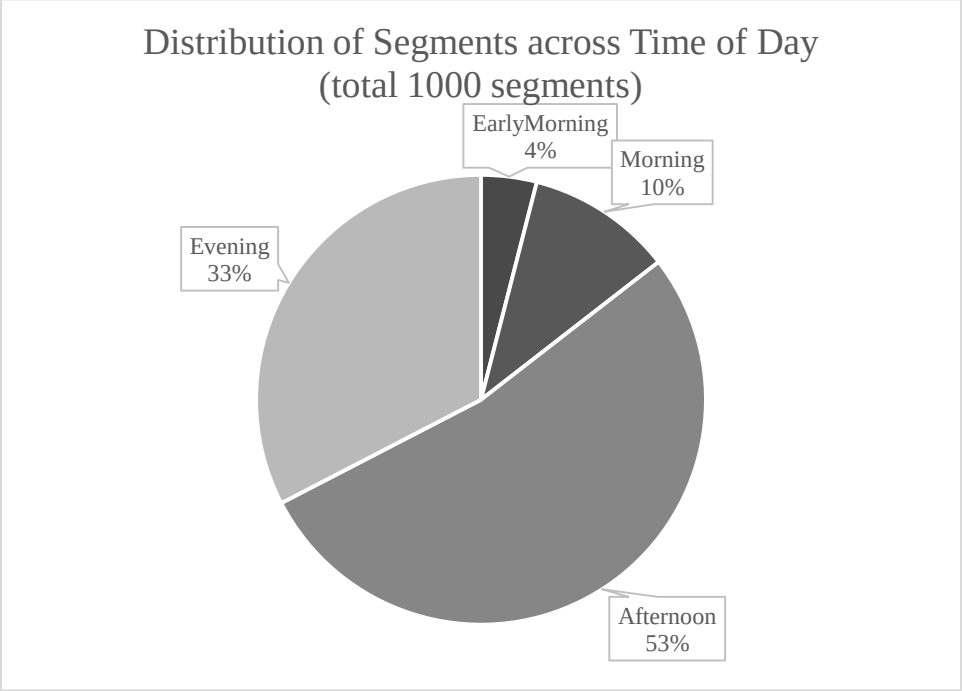


Figure 17. Distribution of Segments across Time of Day

Location-wise most of the segments are recorded while the participants were working in home environments:

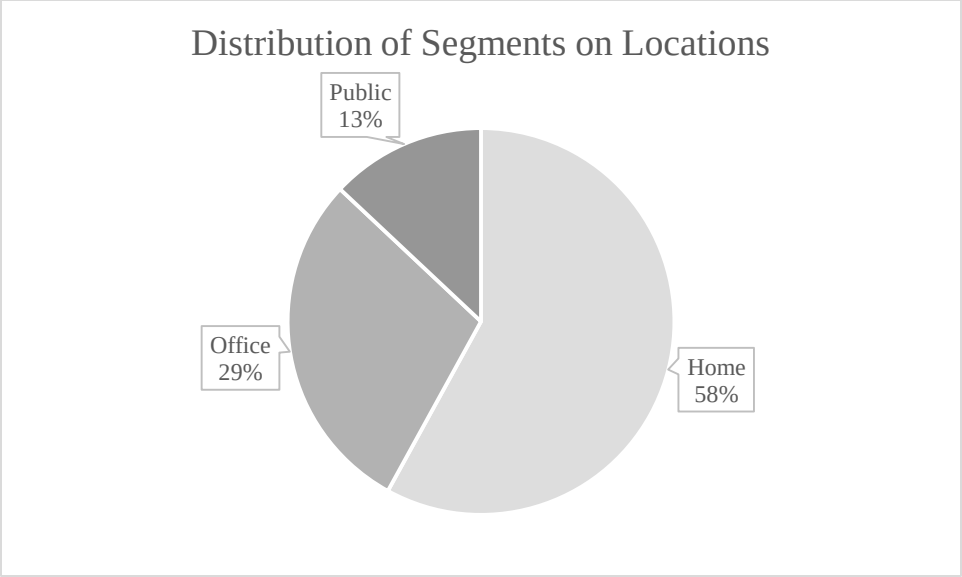


Figure 18. Distribution of Segments on Locations

On Task Type, most of the segments are devoted to doing tasks that are related to Writing.

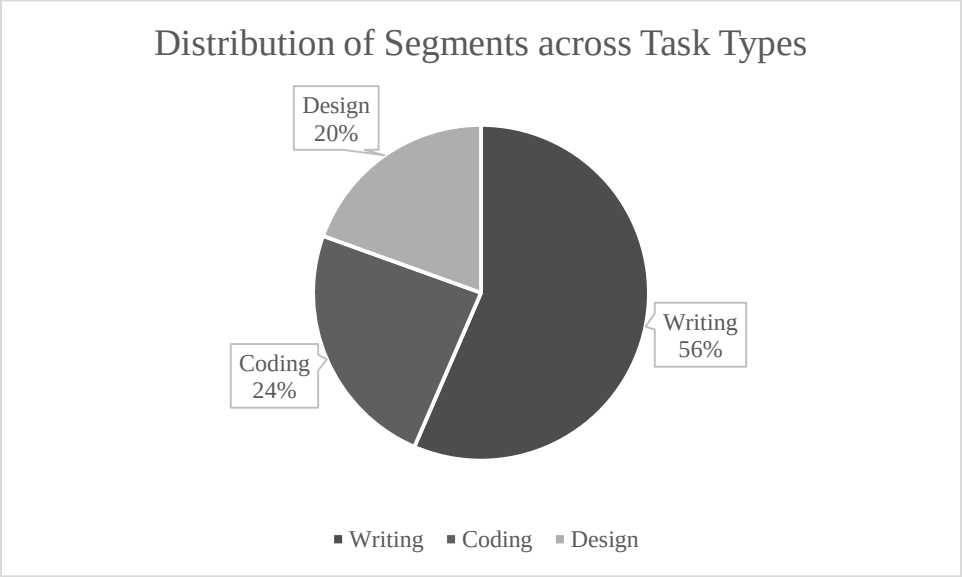


Figure 19. Distribution of Segments across Task Types

Lastly, in terms of interruption task types, Social network visits occupies the majority of off-task windows (42%). Reading articles and watching videos account for about 18% and 19% respectively. Recall that it's based on the majority rule: if the

majority of segment off-task windows are social network types of windows, for example, then the segment is labeled as “Social Network.”

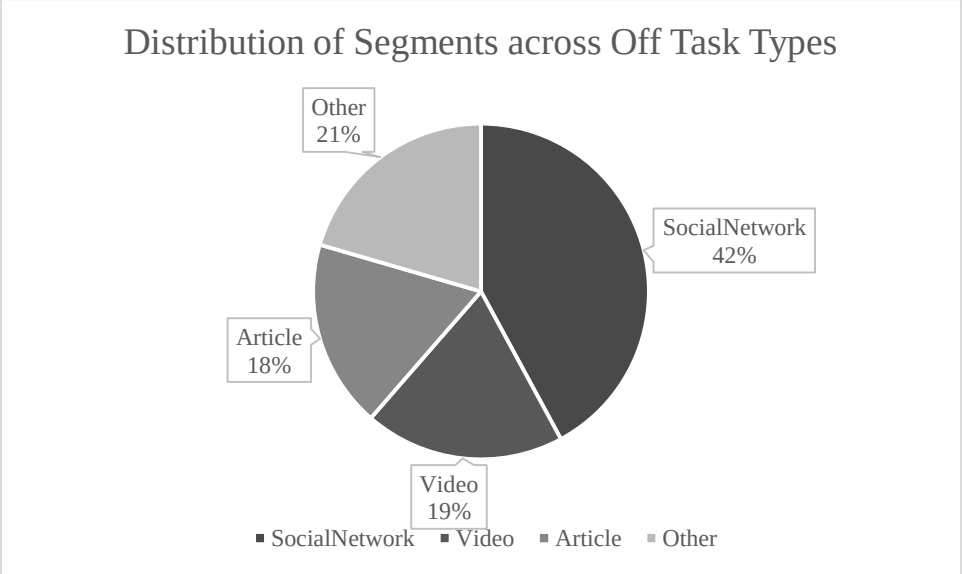


Figure 20. Distribution of Segments across Off-task types

***Performance Metrics***

On average people spent 11.89 seconds (*SD* = 5.00) on interruptions. The highest AOT on any segment was 27.70 seconds while the lowest AOT was 0.72 seconds. On average people switched to task-irrelevant windows 0.16 (*SD* = 0.05) times per minute, which translates to around 4.65 times in 30 minutes. The highest frequency observed switching to task-irrelevant windows is 27 times in 30 minutes while the lowest was 0 times. On average people paid 1.33 (*SD* = 0.15) secondary switches per minute and had 8.77 (*SD* = 3.33) minutes of lapse with the longest lapse being 23.00 minutes, which is 28 (23 + 5) minutes of total time not working on primary tasks.

Analyzing the SPT performance metrics by groups, the empty group had the highest AOT (*M*= 19.26, *SD* = 2.79) while the self-portrait group had the lowest mean

AOT (*M* = 8.54, *SD* = 2.38). Overall, any form of intervention had a lower AOT than the Empty group (moon: *M* = 10.29, *SD* = 2.38; social-support: *M* = 9.31, *SD* = 2.36).

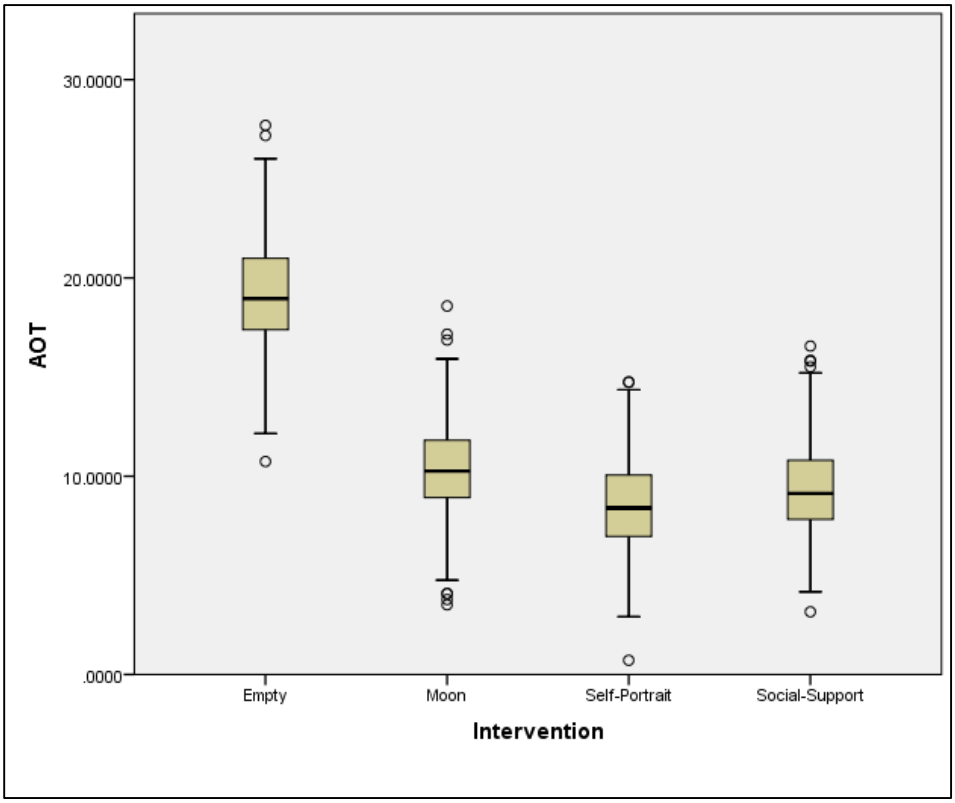


Figure 21. Boxplot of AOT across persuasion types

It was a similar situation with Frequency of Switching-off. The Empty group had the highest FSO (*M* = .21, *SD* = .039) and all other three types of persuasion type had similar levels of FSO.

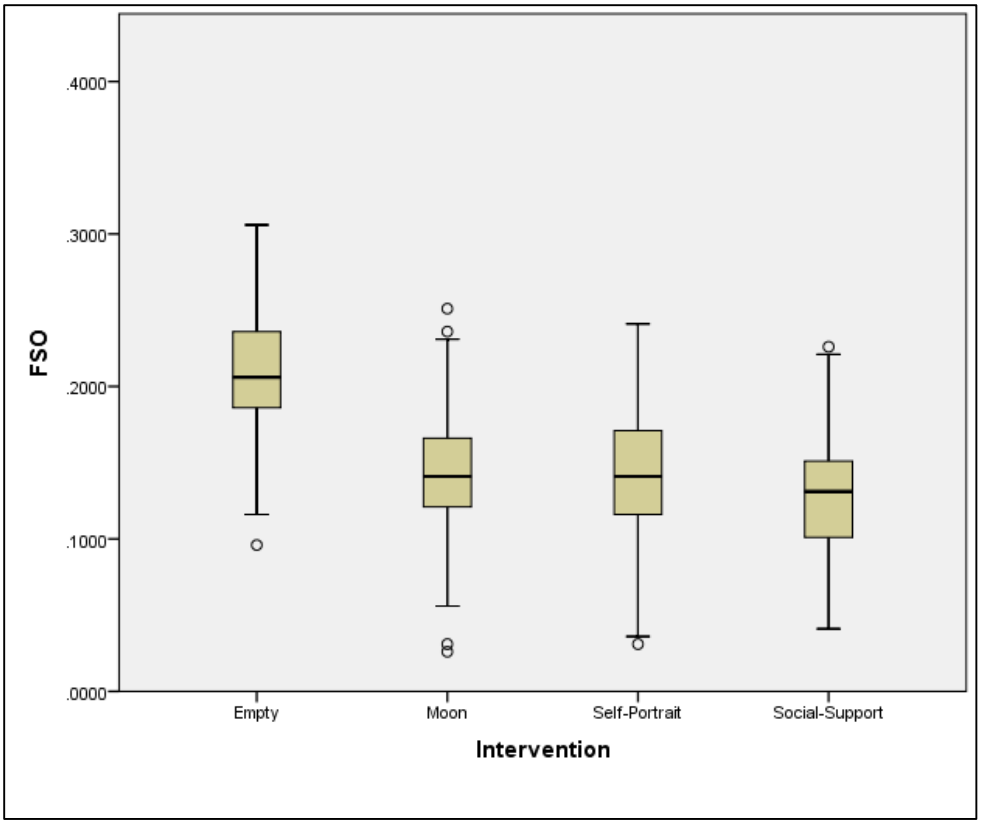


Figure 22. Frequency of Switching-off across persuasion types.

Frequency of Secondary Switches (FSS) and Length of Lapse (LL) all had the same pattern when viewed across persuasion types. The Empty group had the highest mean FSS and LL while the other persuasion types all had similar levels of low FSS and LL.

Table 13. Performance metrics by persuasion type

| Metrics | Empty | | Moon | | Self-Portrait | | Social Support | |
|---|---|---|---|---|---|---|---|---|
| | M | SD | M | SD | M | SD | M | SD |
| AOT | 19.26 | 2.79 | 10.29 | 2.38 | 8.54 | 2.38 | 9.31 | 2.36 |
| FSO | 0.21 | 0.039 | 0.014 | 0.039 | 0.014 | 0.042 | 0.129 | 0.037 |
| FSS | 1.47 | 0.086 | 1.26 | 0.128 | 1.29 | 0.129 | 1.29 | 0.115 |
| LL | 12.65 | 2.62 | 7.64 | 2.42 | 7.35 | 2.23 | 7.38 | 2.49 |

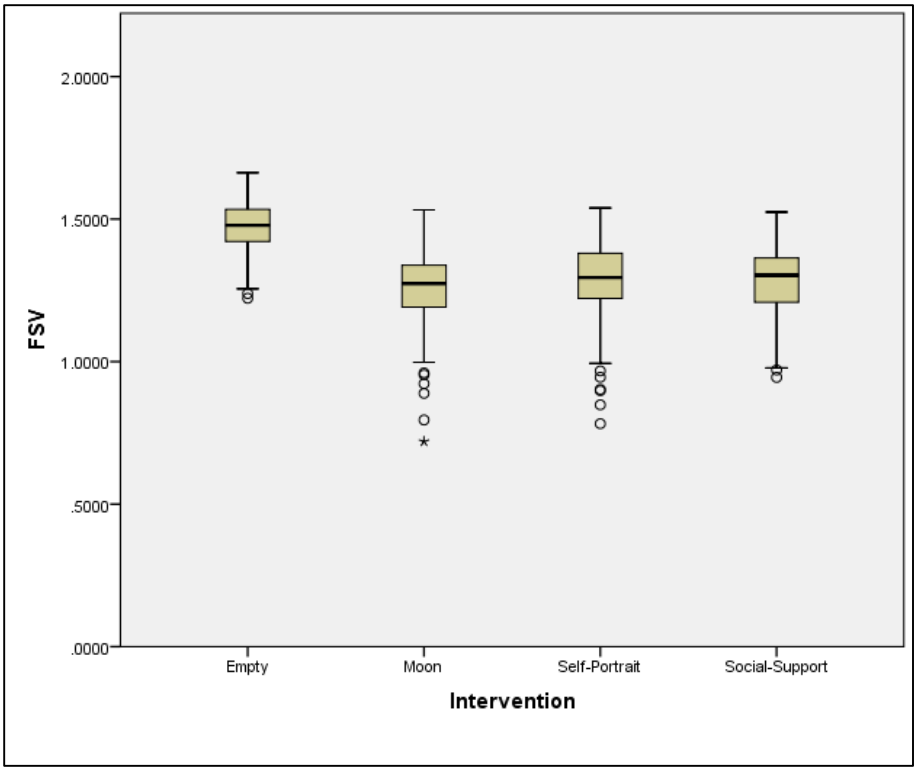


Figure 23. Frequency of Secondary Switches across persuasion types.

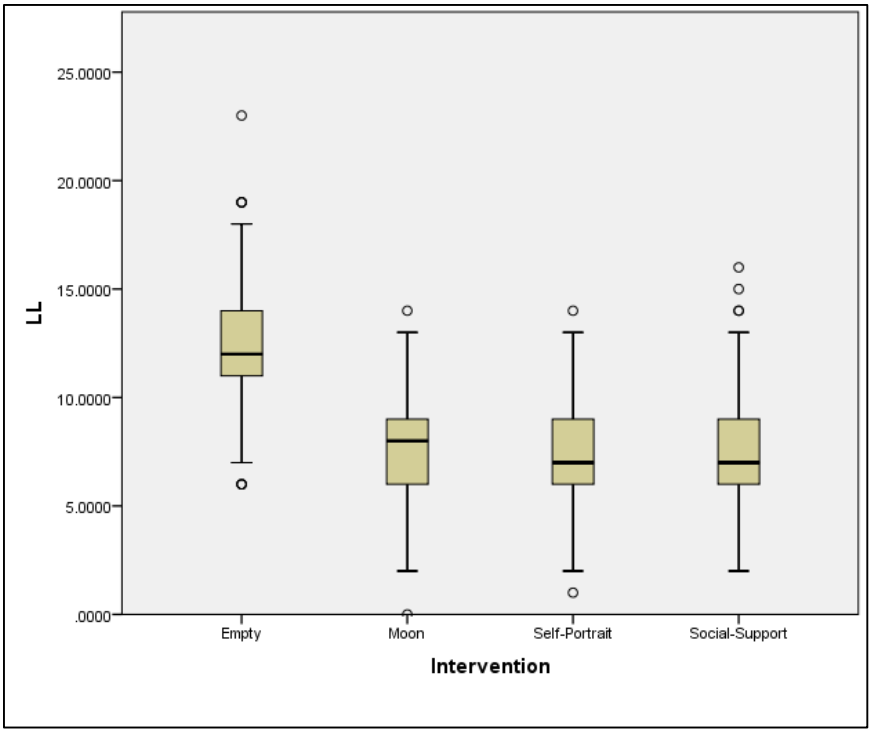

Figure 24. Length of Lapse across persuasion types

**Quantitative Analysis and Regression Models**

With both subjective and objective data, the analysis consisted of two steps: first, this analysis used stepwise multiple linear regressions to model the predictive relationship between independent variables and dependent variables. Then by systematically combining regression models with observations in qualitative interview data, meaningful themes can be discovered. This approach of combining statistical models and qualitative observations can also be seen in communication-related research (Brendgen, Bowen, Rondeau, & Vitaro, 1999; Heath & Luff, 1991).

***Average Off-task Time (AOT)***

Stepwise forward regression analysis was used to develop a model for predicting AOT from predictor variables listed in the previous section. Seven predictors (including dummy variables and interaction terms) were found to be significant predictors for AOT in the final step model and these predictors are able to account for 81.0% (Adjusted $R^2$ = .81) of the variance in AOT, $F\ (7,992) = 610.82$, $p < .001$.

Table 14. Regression results for AOT

| Model | B | Std. Error | Beta | t | Sig |
|---|---|---|---|---|---|
| (Constant) | 6.892 | .415 | | 16.621 | <0.01 |
| I1: Empty vs. Others | -1.479 | .125 | -.515 | -11.797 | <0.01 |
| Task Urgency | .847 | .068 | .172 | 12.478 | <0.01 |
| I2: Moon vs. Self-Portrait | -.913 | .097 | -.130 | -9.405 | <0.01 |
| I1xStress | -.168 | .021 | -.354 | -8.164 | <0.01 |
| P1: Night Vs. Day | -.459 | .071 | -.088 | -6.417 | <0.01 |
| I1xO2 | -.516 | .106 | -.074 | -4.874 | <0.01 |
| I1xP1 | .196 | .041 | .068 | 4.781 | <0.01 |

The final model can be expressed as:

$$\mathrm{AOT} = 6.892 - 1.479 * \mathrm{I1} + 0.847 * \mathrm{TaskUrgency} - 0.913 * \mathrm{I2} - 0.459 * \mathrm{P1} - 0.168 * \mathrm{I1xStress} - 0.516 * \mathrm{I1xO2} + 0.196 * \mathrm{I1xP1}.$$

Type of persuasion design stands out to be a strong predictor for AOT (I1 and I2). Adding intervention reduces AOT significantly (I1: $t(992) = -11.80$, $p < 0.01$, $\beta = -.52$). This result corroborates the basic conclusion from Study I. An image of self does appear to be linked with lower AOT than moon image (I2: $t(992) = -9.405$, $p < 0.01$, $\beta = -.130$), confirming the potential benefit of adopting techniques of raising self-awareness in self-regulation interventions. I1 (Empty vs. Others) actually out-performs other predictors with largest standardized coefficient beta ( $\beta = -.515$). Notice, however, that of three contrasts on persuasion design, I3 (Moon vs. Social-Support) does not yield strong predicting power. Location, perceived task difficulty and task familiarity, perceived stress and energetic level and self-control questionnaire factors all fail to emerge as strong predictors for AOT.

The interaction between I1 (Empty vs. Others) and perceived stress level emerges to be a significant predictor ($t(992) = -8.164$, $p < 0.01$, $\beta = -.354$). Without any forms of intervention feedback, an increasing trend of perceived stress is associated with an increased amount of AOT. However, this trend is reversed when a form of intervention is presented. With an intervention, the increasing perceived stress is associated with a drop of AOT.

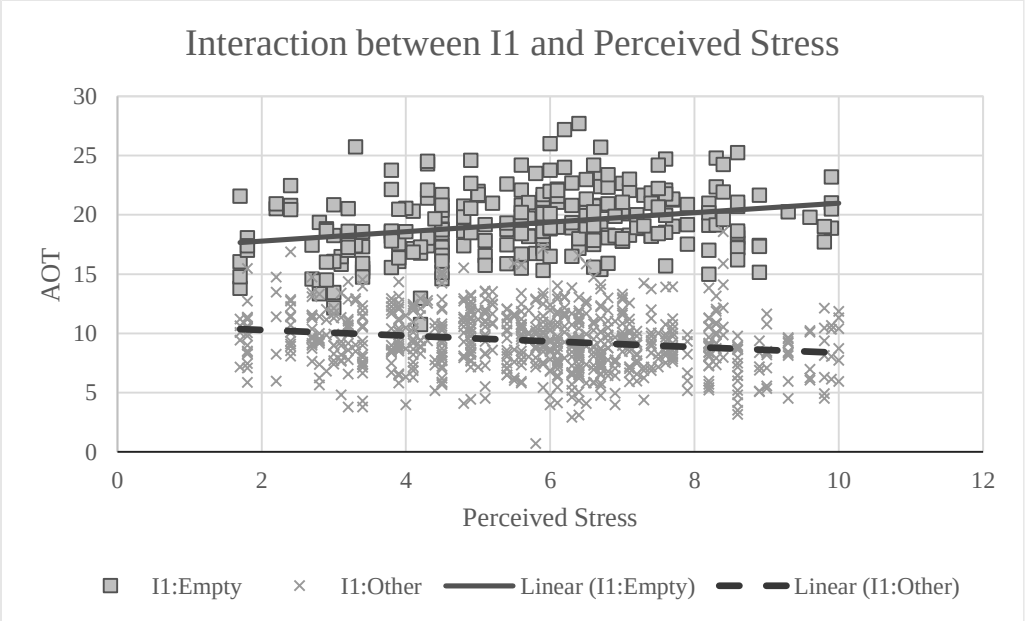


Figure 25. Interaction between I1(Empty vs. Others) and Perceived Stress on AOT

Choosing to work in the daytime vs. at night is a good predictor for AOT ($t(992) = -6.417$, $p < 0.01$, $\beta = -.088$). Working at daytime is linked with a lowered AOT.

Among all interaction terms, the interaction of I1 (Empty vs. Others) x P1 (Night vs. Day) ($t(992) = -6.417$, $p < 0.01$, $\beta = .068$) is also shown to be a good predictor in AOT, indicating a moderating effect on Intervention's predicting power: during day time, the increase of AOT predicted by I1 (Empty vs. Others) is smaller compared to night time. This shows that time of day has a strong influence in self-regulation and should put under consideration when designing interventions.

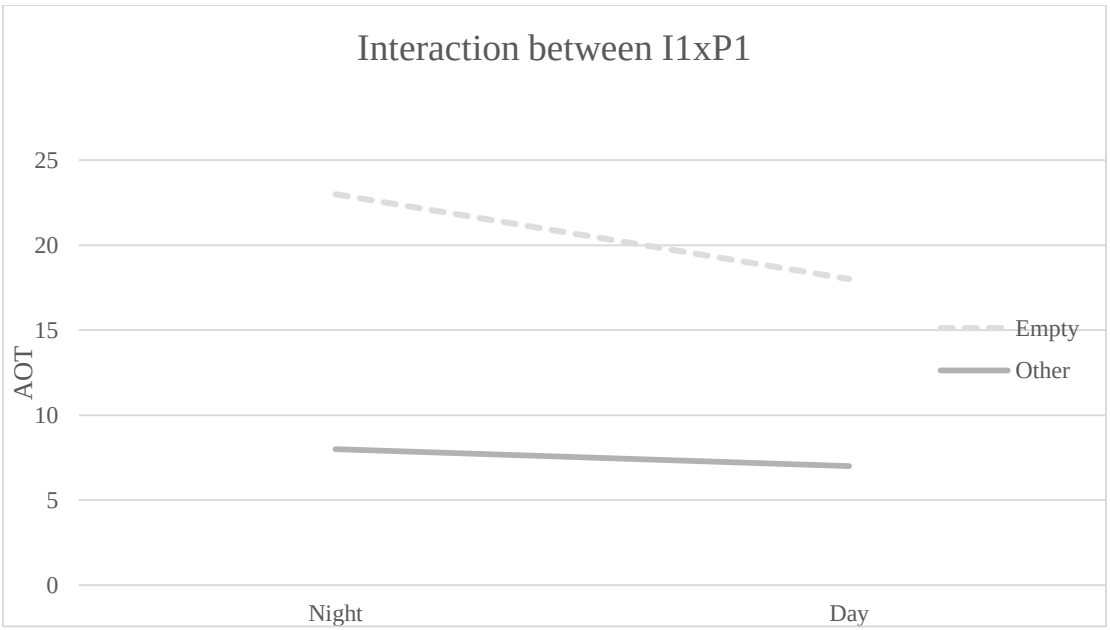


Figure 26. Interaction between I1(Empty vs. Others) and P1: (Day vs. Night)

Task urgency also emerges as one of the strong predictors for AOT ($t(991) = 12.478$, $p < 0.01$, $\beta = 0.172$). The positive valence of the task urgency coefficient indicates that pressure on finishing the task quicker might worsen people's ability to regulate behaviors and make interruptions longer.

Regarding interruption task types, both O1 (Others vs. Social-Network) and O2 (Others vs. Video) fail to enter the model with significant coefficients. However, the significant predictor of interaction between I1 and O2 shows that if interruption tasks were videos, the addition of feedback accounts for a larger reduction in AOT than with other types of interruption tasks ($t(991) = -4.874$, $p < 0.01$, $\beta = 0.074$).

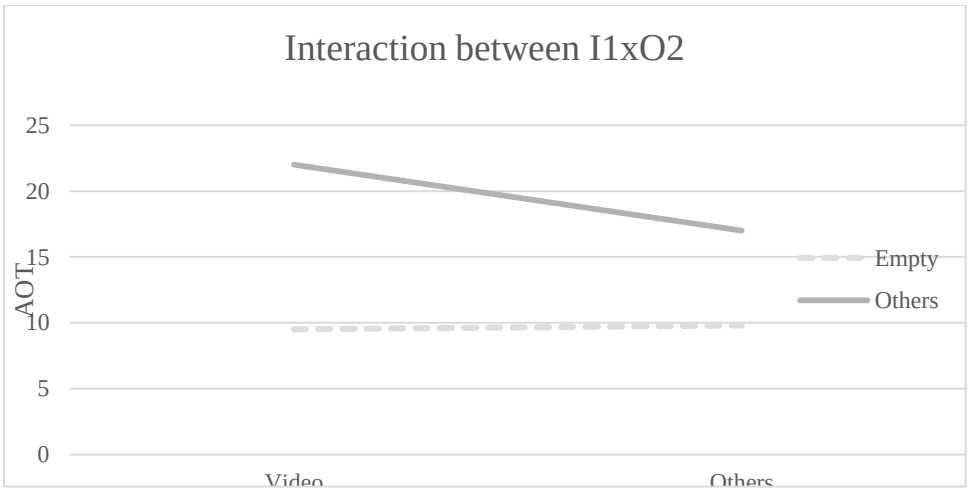

Figure 27. Interaction between I1xO2 on AOT

***Frequency of Switching-Off (FSO)***

The final model contains seven significant predictors that account for 43.1% of the variance observed on FSO ($F(7,992) = 109.194$, $p < 0.01$). FSO can be expressed as:

$$\text{FSO} = 0.174 - 0.016 * \text{I1} + 0.013 * \text{O1} - 0.002 * \text{PerceivedEnergetic} - 0.007 * \text{I3} - .005 * \text{I1xO1} + 0.006 * \text{T2} - 0.002 * \text{TaskUrgency}$$

Table 15. Regression Results on FSO

| Model | B | Std. Error | Beta | t | Sig |
|---|---|---|---|---|---|
| (Constant) | .174 | .008 | | 22.300 | <0.01 |
| I1: Empty vs. Others | -.016 | .001 | -.549 | -17.270 | <0.01 |
| O1: Other vs. Social Network | .013 | .002 | .128 | 5.333 | <0.01 |
| Energetic | -.002 | .001 | -.107 | -4.488 | <0.01 |
| I3: Moon vs. Social Support | -.007 | .002 | -.095 | -3.986 | <0.01 |
| I1xO1 | -.005 | .001 | -.113 | -3.558 | <0.01 |
| T2: Writing vs. Coding | .006 | .003 | .054 | 2.238 | .025 |
| Task Urgency | -.002 | .001 | -.048 | -1.991 | .047 |

Feeding different types of persuasion design continues to be significant predictors for FSO (I1: Empty vs. Others, $t(992) = -17.270$, $p < 0.01$, $\beta = -.549$; I3: Moon vs. Social Support, $t(992) = -3.986$, $p < 0.01$, $\beta = -.095$). In particular, I1 has the largest standardized coefficient among all the significant predictors. In addition, providing an image from participant's social circle, compared to providing the Moon, appears to have a strong association with a lowered frequency to leaving primary tasks.

Increased task urgency ($t(992) = -1.991$, $p < 0.05$, $\beta = -.048$) and perceived energetic levels ($t(992) = -4.488$, $p < 0.01$, $\beta = -.107$) are both significantly associated with lower FSO. Working on programming type task vs. writing tasks appears to increase the frequency of switching away from primary tasks ($t(992) = 2.238$, $p < 0.05$, $\beta = .054$).

Within a segment, if the main target of interruption is social media websites, the overall frequency of switching away in the segment is predicted to be higher than other types of interruption task (O1: Others vs. Social-Network, $t(992) = 5.333$, $p < 0.01$, $\beta = 0.128$).

An interaction term again enters the final model with the interaction between I1 (Empty vs. Others) and O1 (Others vs. Social-Network): $t(992) = -3.558$, $p < 0.01$, $\beta = -$

0.113. Visiting social network sites is associated with an increased frequency of switching off. However, this increment is moderated if a participant is exposed to visual feedback versus no feedback at all.

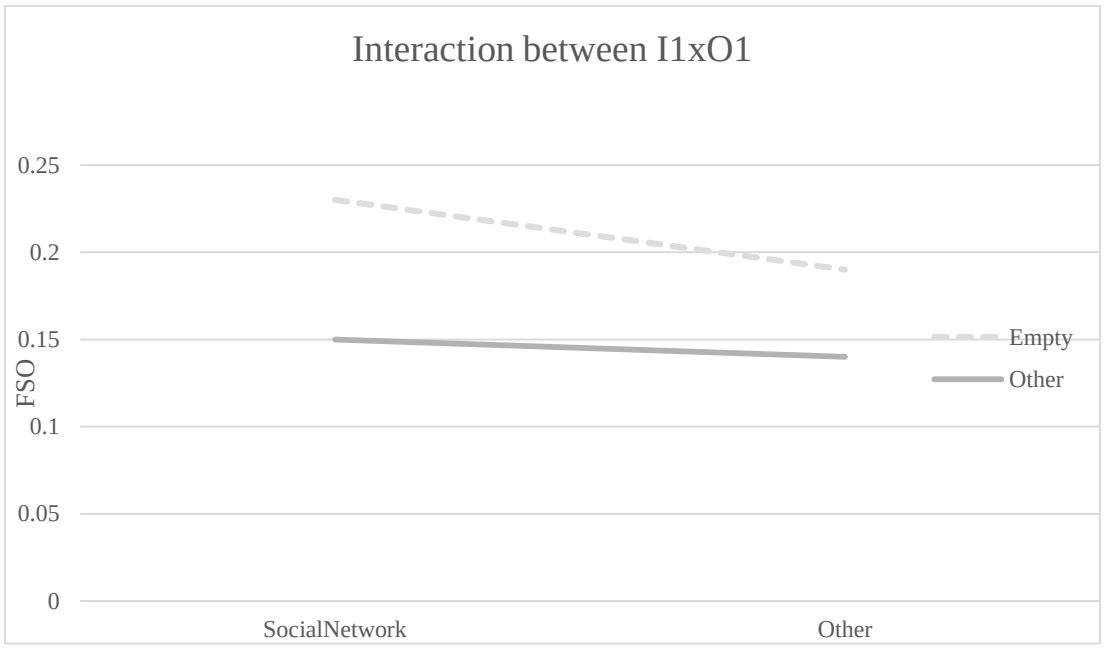


Figure 28. Interaction between I1 and O1 for FSO

***Frequency of Secondary Switches (FSS)***

In total seven variables including interaction terms enter the final model ($F(7,992) = 88.939$, $p < 0.01$). They have a combined predicting power of explaining 38.1% of the variance of FSS in the data. The linear expression is as follows:

$$\text{FSS} = 1.380 - 0.046 * \text{I1} - 0.009 * \text{TaskFamiliarity} + 0.034 * \text{O1} + 0.031 * \text{O2} - 0.021 * \text{T1} + 0.010 * \text{I2} - 0.008 * \text{I1xO1};$$

Table 16. Regression results for FSS

| Model | B | Std. Error | Beta | t | Sig |
|---|---|---|---|---|---|
| (Constant) | 1.380 | .017 | | 79.423 | <0.01 |
| I1: Empty vs. Others | -.046 | .003 | -.555 | -16.705 | <0.01 |
| Task Familiarity | -.009 | .002 | -.109 | -4.357 | <0.01 |
| O1: Other vs. Social Network | .034 | .008 | .116 | 4.230 | <0.01 |
| O2: Other vs. Video | .031 | .010 | .084 | 3.072 | <0.01 |
| T1: Writing vs. Design | -.021 | .009 | -.058 | -2.317 | .021 |
| I2: Moon vs. Self-Portrait | .010 | .005 | .050 | 2.015 | .044 |
| I1xO1 | -.008 | .004 | -.066 | -1.981 | .048 |

Again, having any of the three forms of feedback significantly predicts a drop in frequency of visiting a secondary target (I1: Empty vs. Others, $t(992) = -16.705$, $p < 0.01$, $\beta = -.555$). A self-image predicts a lower frequency of secondary switches as well (I2: Moon vs. Self-Portrait, $t(992) = 2.015$, $p < 0.05$, $\beta = 0.050$).

Familiarity on tasks is also linked with lowered level on secondary switches ($t(992) = -4.357$, $p < 0.01$, $\beta = 0.109$). Doing design related work versus writing is accompanied by increase of frequency of secondary switches (T1: Writing vs. Design, $t(992) = -2.317$, $p < 0.05$, $\beta = -.058$).

And finally, if the majority of the interruption targets are either Social-network or Video, it is more likely for the participants to go to irrelevant targets and stay away from primary tasks. (O1: Others vs. Social-Network, $t(992) = 4.230$, $p < 0.01$, $\beta = 0.116$; O2: Others vs. Video, $t(992) = 3.072$, $p < 0.05$, $\beta = 0.084$)

Similar to the frequency of switching-off (FSO), an interaction between I1 and O1 significantly predicts FSS. With an intervention, the rise in FSS introduced by social media sites is moderated (I1xO1, $t(992) = -1.981$, $p < 0.05$, $\beta = 0.066$).

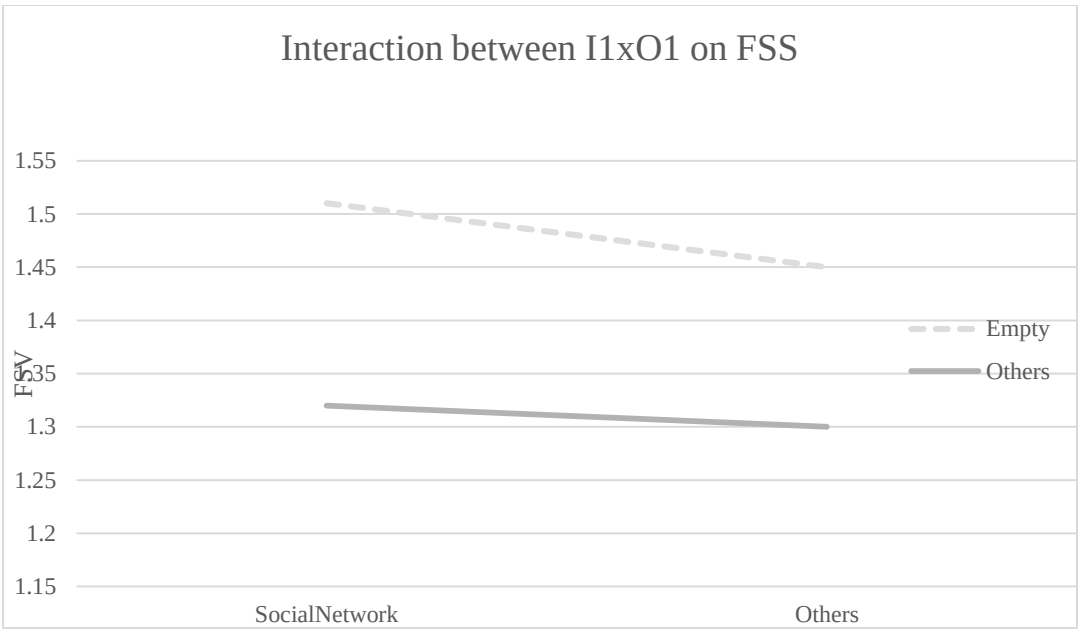

Figure 29. Interaction between Persuasion type and Off-task type.

***Length of Lapse (LL)***

A significant linear model is constructed with 7 variables entered ($F(7,992) = 217.927$, $p < 0.01$). The model is able to explain 60.3% of variance (adjusted $R^2 = 0.60$) observed in the data.

Table 17. Regression results on Length of Lapse

| Model | B | Std. Error | Beta | t | Sig |
|---|---|---|---|---|---|
| (Constant) | 7.315 | .468 | | 15.645 | <0.01 |
| I1: Empty vs. Others | -1.207 | .042 | -.631 | -28.697 | <0.01 |
| Task Difficulty | .333 | .030 | .220 | 10.919 | <0.01 |
| P1: Night Vs. Day | -.793 | .069 | -.230 | -11.474 | <0.01 |
| I1xO2 | -.682 | .102 | -.147 | -6.677 | <0.01 |
| O2: Other vs. Video | .888 | .170 | .105 | 5.226 | <0.01 |
| Task Urgency | -.179 | .065 | -.055 | -2.736 | <0.01 |
| L1: Home vs. Office | .329 | .147 | .045 | 2.243 | .025 |

Finally the Length of lapse can be expressed as:

$$\mathrm{LL} = 7.315 - 1.207 * \mathrm{I1} + 0.333 * \mathrm{TaskDifficulty} - 0.793 * \mathrm{P1} + 0.888 * \mathrm{O2} - 0.179 * \mathrm{TaskUrgency} + 0.147 * \mathrm{L1} - 0.682 * \mathrm{I1xO2}.$$

I1 (Empty vs. Others; $t(992) = -28.697$, $p < 0.01$, $\beta = -.631$) continues to be strongly linked with Length of Lapse. Any persuasion type other than empty will predict a shorter accumulated length of lapses.

In terms of choosing time to work, working at night time is associated with a worse performance of limiting lapses compared to day time (P1: Night vs. Day; $t(992) = -11.474$, $p < 0.001$, $\beta = -0.230$). Location also appears to be one of the strong predictors of length of the lapse. Working at the office has a significant link with an increased duration of lapse compared to working at home ($t(992) = 2.243$, $p < 0.05$, $\beta = 0.045$). Urgent tasks predict shorter lapse while difficult tasks predicts longer lapse ($t(992) = -2.736$, $p < 0.01$, $\beta = -0.055$).

The type of interruption task plays a role in predicting number of lapses. If the more of the landed pages are video related sites, a higher number of lapses is predicted (O2: Others vs. Video, $t(992) = 5.226$, $p < 0.01$, $\beta = .105$). However, the amount of predicted increase on lapses is reduced if a participant is presented with a visual intervention (I1xO2, $t(992) = -6.677$, $p < 0.01$, $\beta = 0.147$).

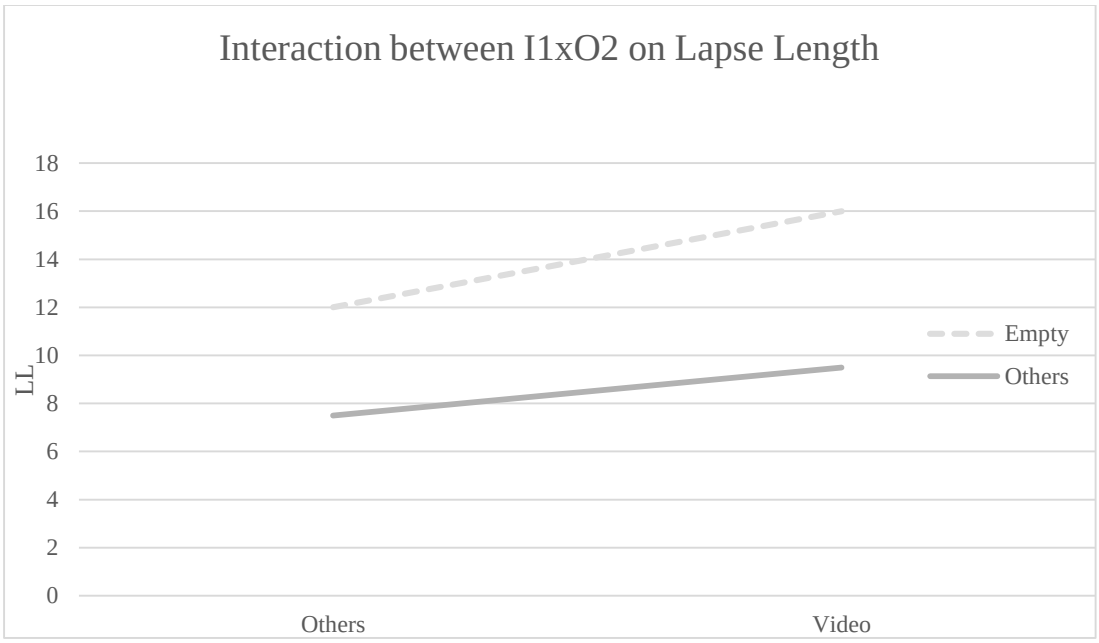

Figure 30. Interaction between I1(Empty vs. Others) with Off-task Type (Others. Vs Video) on Lapse Length

***Perceived Task Performance Satisfaction (PPS)***

In final model there are four variables including interaction terms entered as significant predictors ($F(4, 245) = 17.772$, $p < 0.01$). The model accounts for 21.2% of the variance observed in the data. The overall model can be described as:

PPS = 2.621 + 0.576 * I3 + 0.671*O3 + 0.209*Task Urgency + 0.427 * I1xO2

Table 18. Regression results for PPS

| Model | B | Std. Error | Beta | t | Sig |
|---|---|---|---|---|---|
| (Constant) | 2.621 | .440 | | 5.961 | <0.01 |
| I3: Moon vs. Social Support | .576 | .100 | .326 | 5.776 | <0.01 |
| I1xO2 | .427 | .091 | .264 | 4.673 | <0.01 |
| O3: Other vs. Article | .671 | .194 | .195 | 3.459 | <0.01 |
| Task Urgency | .209 | .072 | .165 | 2.920 | <0.01 |

Presenting a picture of a significant member of the participant's social circle is linked with an increment on perceived task performance satisfaction compared to just series of moon images (I3: Moon vs. Social Support; $t(992) = 5.776$, $p < 0.01$, $\beta =$

0.326). Also, reading articles, compared to other types of interruptions, also predicts higher ratings on task performance satisfaction ($t(992) = 3.459$, $p < 0.01$, $\beta = 0.195$). Urgent tasks predict higher satisfaction on task performance ($t(992) = 2.920$, $p < 0.01$, $\beta = 0.165$).

The interaction between persuasion type and interruption task type again enters the model. The predicted increment of task performance satisfaction by providing intervention type is larger if the landed page was a video related website (I1xO2, $t(992) = 3.459$, $p < 0.01$, $\beta = 0.264$).

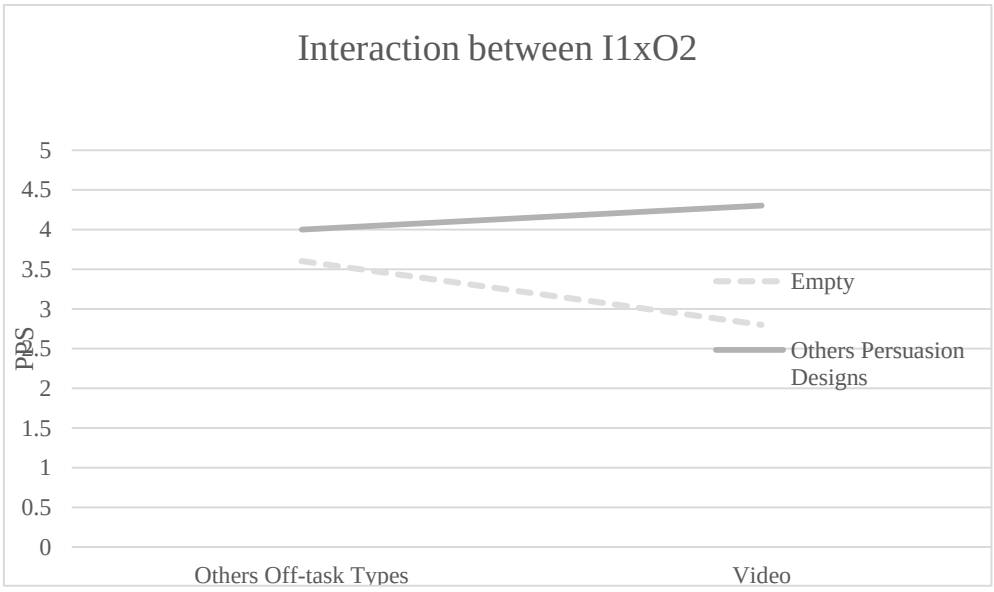


Figure 31. Interaction between Persuasion Type and Off-task Type

**Qualitative Analysis**

With all the diary entries and interview transcription, the qualitative analysis used an Affinity Diagram (Britz, 2000) as a method for organizing topics and themes.

With the affinity diagram, a total of 48 low-level topics were found in the interview and diary entry. These topics were grouped into six high-level categories:

Persuasion design; Experience; Causes for Lapse; Adherence; Adaptability and Self-Reflection.

***Persuasion design***

Comments in this category concern the acceptance of the three designs by the participants. It also includes the comments on the absence of them, i.e. empty. The following table summarizes some of the most mentioned points in this category:

Table 19. Persuasion design quotes

| Topics | Mentions | By # of Participants |
|---|---|---|
| 1. Likes the "Moon" best, because it's calming/soothing/nice/easy to the eye… | 15 | 5 |
| 2. Likes the "Self-Portrait" best, because it draws attention. | 2 | 2 |
| 3. Likes the "Social-Support" best, it makes me want to do better/don't want to disappoint [friends/family], "As if [friend/family] is counting on me." | 24 | 8 |
| 4. Dislikes the "Moon" because it gets boring quickly | 7 | 3 |
| 5. Dislikes the "Self-Portrait" because "I don't like looking at myself that much"/because "it's weird/uncomfortable." | 5 | 2 |
| 6. Dislikes the "Social-Support" because "I feel like I'm being judged". | 9 | 2 |
| 7. Without the feedback, "I feel lost", "unless I'm immersed in my work, I like the feedback". | 14 | 7 |
| 8. Without the feedback, I feel "I'm in control." | 10 | 5 |

The key question during the evaluation of the WiredIn is whether participants felt it was useful to have any forms of visual feedback. Did it help them to stay aware of the interruption time? The general response toward the question of "usefulness" is positive. Most of the responses are between medium and strong agreement. P7 feels it is useful but still claims he can manage his tasks even without the feedback. The other participants strongly agree that the WiredIn is useful. They comment that it helps them stay focused especially during the downtime of their motivation and keeps them going. This

corresponds to the significant interaction between predictors of I1xP1 and I1xStress on AOT.

P3, who is least enthusiastic about WiredIn, also suggested that this tool should have more direct representations of time on task-irrelevant tasks. He remarked he would do better with a direct representation such as progress bar. He said he did not understand the reason to use obscure images instead of just reminding him with simple messages.

P4 remarked on how easy it was for him just to glance to know the relative time he spent on less important tasks. He noted that it also created a "mental clock" that ticked in his head when he was away from his tasks. P4 further commented, "It's helpful, and it's not irritating. The Moon images are fresh and relaxing."

***Experience***

This category contains excerpts from interview and diary data that concern descriptions about experiences using WiredIn while working, compared to their normal days of working.

Table 20. Quotes on experiences

| Topics | Mentions | By # of Participants |
|---|---|---|
| 1. Using WiredIn, I feel more productive/accomplished/satisfying at the end of day | 23 | 9 |
| 2. With WiredIn, I am constantly checking on the feedback | 27 | 10 |
| 3. It's like someone is babysitting me. | 4 | 4 |
| 4. I feel extra pressure from WiredIn, but simultaneously it makes me switched on. | 5 | 5 |
| 5. I like it's "game-like", I feel more engaged. | 10 | 10 |
| 6. It makes the tasks less boring and less overwhelming. | 21 | 10 |
| 7. I feel quite bad if I score a small moon. | 5 | 4 |
| 8. I work extra hard to maintain the full moon. | 3 | 3 |
| 9. I sometimes don't know how the Moon behaves. | 5 | 5 |
| 10. The visual feedback works better at afternoon/evening | 6 | 6 |
| 11. If the task is challenging and difficult, I pay less attention to the images, and I'll be more focused | 3 | 3 |

When describing their experience, the general response is a cautious welcome, especially toward the use of Self-Portraits. P8 stated that using her own images is not fun. "If I wasted too much time, I feel awful. And I just want to shut it down to stop looking at myself." P6 remarked, "Without any images I sometimes feel relaxed and wanted to take a break, and then I realize that I should stay on tasks." P2 commented, "I like having an image of my dog, once I was gone away for too long and I just wanted to make my dog be happy, and then I got back."

P1 felt that the WiredIn is most useful for "the situations where she is immersed in another less important task." This view was echoed by P10, who said "if the task is really challenging and I'm really into it, I don't want the feedback to give any more hints on how to manage my tasks and hope it can leave me alone."

Some of the participants (P3, P5) recognized that because the images are changing slowly and not responding to their action in a timely fashion, they lost the trust in the software and thus lost interest in checking out the tool anymore. This raises a real question about how such persuasion tools should behave in order gain confidence from users that the tool is actually monitoring and changing the state based on a fair and open set of rules. P3 said: "After some days of using it I sometimes don't know why the Moon behaves. I don't know if there is a bug because when I was actually working on the project the Moon didn't pick it up."

***Causes for Lapse***

This category contains feedback from popup form when interruption time exceeds five minutes. It contains responses from participants when they are asked why they were away from tasks for that long.

Table 21. Quotes on causes of lapse

| Topics | Mentions | By # of Participants |
|---|---|---|
| 1. I was watching a video | 23 | 9 |
| 2. I was distracted by something I saw from [social media]. | | |
| 3. I was caught up by some people talking/messaging me. | 27 | 10 |
| 4. I was out, not on my computer. [e.g. lunch/bathroom/helping my mom with something] | 4 | 4 |
| 5. I was working on [something else, not on this computer] | 9 | 4 |
| 6. I was playing with my [smart phone] | 11 | 7 |

In addition to the various messages for lapse captured by WiredIn, the question of whether it was due to **reluctance** or **forgetfulness** also reveals the cognitive cause for the lapse. Among 153 recorded lapses, 37 are registered as being "reluctant" while 50 were recorded as being "forgetful" and 66 are recorded as "others." It's interesting to see that 24% of the times people admitted that they were reluctant even though they knew they should come back.

Some participants (P1, P3, P7, P8 and P9) do complain about the insensitivity of WiredIn when they are entangled by some interruptions that they cannot get out of. WiredIn is not able to tell if the lapse is voluntary or involuntary, thus resulting in a lot of times participant responding by choosing "Neither of the above [reluctance or forgetfulness]".

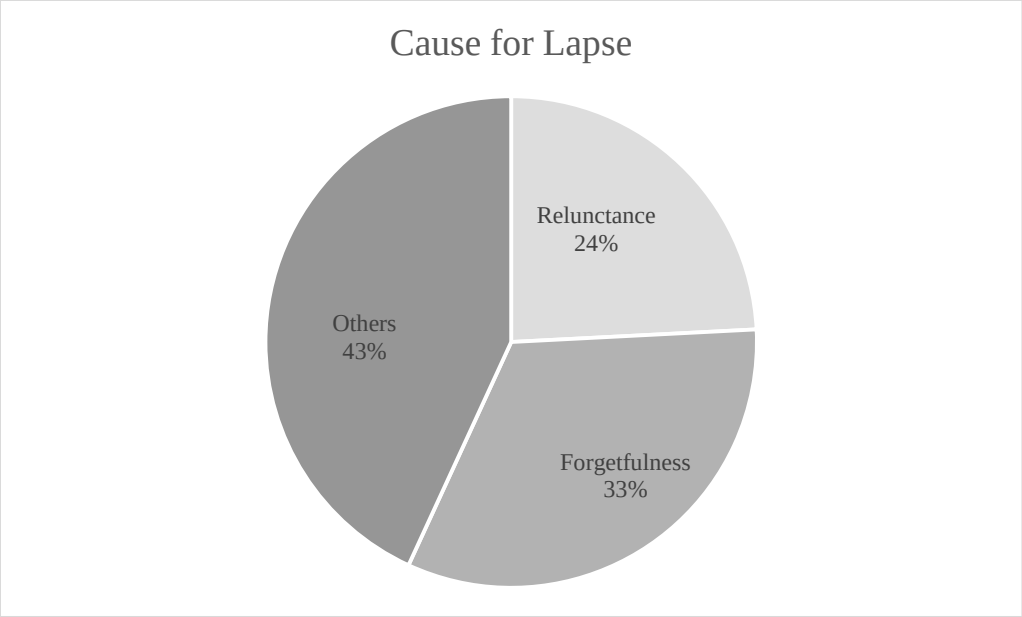


Figure 32. Causes of lapse

***Adherence***

Adherence refers to the extent to which WiredIn continues to have an effect in bringing down unnecessary task switches. It also reveals users' adherence to keep using it.

Table 22. Adherence Quotes

| Topics | Mentions | By # of Participants |
|---|---|---|
| 1. I feel a bit bored with it after a couple of days. | 6 | 6 |
| 2. I like to try new images after [5/6/7] days. | 4 | 4 |
| 3. The Moon just stopped working for me after couple days | 1 | 1 |
| 4. I think I'll keep using "Moon" after the study. | 6 | 4 |
| 5. I don't like Self-Portrait anymore, as I get tired looking at myself. | 6 | 6 |
| 6. After couple days, I don't feel like being "supervised"/"monitored"/"controlled" anymore. | 8 | 7 |
| 7. I'll keep using Social-Support I like images of my [Friends/Family/Pet] | 5 | 5 |

The general consensus is that the abstract images still works in the later stages of study with only P4 claims that "after a couple of days, the novelty was gone, and it didn't

work for me". Most of the people say they will keep using the Moon. P8 says she still finds it "satisfying to see a full moon".

Other participants mentioned the sense of being "supervised" or "disciplined" (P2, P8 and P9). "After a couple of errors, I feel like I'm small kid being disciplined, especially I was not doing any of the bad stuff, I just wasn't able to go back …" P2 says.

***Adaptability***

This category contains comments about how WiredIn could improve in terms of being more intelligent about the task attributes and environments.

Table 23. Adaptability Quotes

| Topics | Mentions | By # of Participants |
|---|---|---|
| 1. It's not smart enough, I was just switching to [do something related to tasks], and it thinks I'm going away. | 11 | 7 |
| 2. I wish I could tell it I was doing all right when WiredIn was wrong about my status. | 3 | 3 |
| 3. A couple of times I was [talking to someone/going somewhere else] for too long and forget to pause it. | 2 | 2 |
| 4. It'll be good if I could change the rate of image changing | 4 | 4 |
| 5. It'll be good if it could tell I'm interrupted by my phone/checking my phone too often, and remind me of spending too much time on my phone. | 6 | 5 |
| 6. It should block [frequently visited sites] for me. | 6 | 6 |
| 7. It should visualize my [performance] data for me to review. So that I could know how I allocate my time on different things. | 4 | 4 |
| 8. I like to customize the images and make it more game-like | 2 | 2 |

P1 says she felt "frustrated and wronged" if WiredIn goes into a bad state while she is clearly still on tasks. Her view is shared by P9 as his tasks involve searching various materials for his design tasks, and it becomes difficult for WiredIn to tell true off-task behavior from actual working. "At sometimes I just feel like it might not be doing the detection at all," he says.

Other participants agree that more adjustment can be made to make WiredIn smarter. In particular, they would welcome a report summarizes how well they are for a period of a day or a week. "[Visualizing performance data] It will help me to know my progress and give me more satisfaction," P4 remarked.

***Self-Reflection***

This category summarizes the quotes that concern the reflection from participants regarding their behavior management in terms of staying on primary tasks and reducing interruption time.

Table 24. Self-Reflection quotes

| Topics | Mentions | By # of Participants |
|---|---|---|
| 1. I'm now aware how often I switch-off during working. | 23 | 9 |
| 2. I begin to think twice before switching off. | 14 | 10 |
| 3. I feel frustrated if I keep switching off, and I don't even want to | 5 | 5 |
| 4. I like competing with myself and beating myself | 6 | 5 |
| 5. I now am more conscious when I working on my computer tasks | 10 | 10 |
| 6. If someone interrupts me, I'm anxious to get back. | 5 | 3 |
| 7. I spent too much time on [social media/YouTube/email] | 6 | 6 |
| 8. Existing tools/technologies/habit makes it too easy for me to switch off. | 4 | 4 |

P9 describes the how using WiredIn has changed his perspective on using social media: "I didn't know how much time I've been spending on scrolling pages of pages on Facebook. I used to think this is harmless, but after couple times when I see how it always leads me to something else then something else. Then my brain just switched off."

P5 states that he has known this problem for long that "it does not surprise me that how many times I'll try to check out the other pages… I'm just glad that there are tools to let people be more aware of the problem."

# Chapter 8. Discussion

## Main Results

Both studies validated or predicted the effect of having a persuasive agent in working environment on SPT performances.

Study I accomplished its goal of validating the effect of the persuasive agent in a lab setting environment. The results also revealed the negative impact of over-stress the participants using rushed and punishing strategies in regulating behaviors.

Study I also provided a toolkit and template for conducting experiments in similar contexts. The experiment tool WiredIn can be extended and reused in future research, as well as the format of simulating interruptions and observing voluntary resumption actions.

Study II enriched the previous results by allowing data collection in real-life environments. The following four themes are summarized combining results from both studies.

### Theme 1: Visual feedback and its interaction with other variables

The potential benefit of bringing intervention feedback into the workplace has been demonstrated both in regression models and qualitative analysis of interview and diary data. Other than perceived task performance satisfaction, the addition of any form of visual feedback (I1: Empty vs. Others) was associated with an improvement of quantifiable SPT performance measures: it predicted shorter interruption time and fewer times of switching to interruption tasks. This result was in line with ANOVA results from Study I.

Besides the predicting power of I1 (Empty vs. Others), I2 (Moon vs. Self-Portrait) and I3 (Moon vs. Social Support) also had predicting power in some of the dependent measures tested above. Moreover, comparing to emotionally-attachable objects such as the moon, presenting an image of self or significant member of participant's social circle was associated with an improved interruption time, frequency of lapse and also improved task performance satisfaction rating.

More importantly, the various interactions between I1 and other variables showed that the introduction of visual feedback altered the mechanism by which environmental, task-related, and other factors influence interruption management behaviors. In particular, one can see the interaction between I1 and interruption task types was prominent compared to other types of interactions. For example, with the help of intervention feedback the detrimental effect of visiting social network or video-related sites was moderated, and in some cases even reversed.

The predicted ability of WiredIn to offset the unfavorable effect of other factors shows the true promise of using persuasion design in real working environments. A person's native tendency toward self-regulation temptation is a relatively constant factor. It is difficult to influence this tendency in a short period of time (Green & Myerson, 2004). Tools like WiredIn is able to add another layer of defense against the temptation that could compromise SPT performances.

From qualitative data, this effect of persuasion design was corroborated with exchanges between participants and interviewer in the post-study interviews.

P2: "I didn't know how much time I spent on watching YouTube until now. Now I'm more aware of the length of the video and won't play it if it's too long."

P6: “When I’m caught up with messaging with somebody, I sometimes switch back and forth quickly, the Moon does not change much, but I will still try to finish the conversion quickly and go back to work.”

Given the limitation of this study, it’s hard to demonstrate the effect of persuasive design on actual long-term behavior change. However, the results from these exchanges show the short-term improvement of raising self-awareness. Indeed, as many personal informatics studies have shown, the first step toward behavior change is cognitive awareness of the problem (Klasnja, Consolvo, & Pratt, 2011). How long this change will persist is still unknown. Longitudinal studies might be needed to answer that.

It is also worth noting that among all the factors that fed into the regression model, some of the factors seldom or never emerges as strong predictors for SPT measures. For example, the self-reported energetic level, self-reported stress level as well as self-reported familiarity with tasks and difficulty of the tasks. The reason might be a lack of variance from the data collected for these quantities as most participants performed similar or same tasks throughout the 10-day period.

**Theme 2: Social-support vs. Self-portrait**

It was demonstrated that Social-support predicted better task performance satisfaction than the moon ($t(992) = 5.776$, $p < 0.01$, $\beta = .326$) while Self-portrait vs. Moon did not enter the model. Interview data did reveal the appealing effect of Social-Support:

Participant 3 said: “I like my girlfriend picture looking at me, it gives me more motivation.” Participant 4 said: “I put my Mom’s picture, I don’t like her yelling at me, but her picture looking at me silently somehow makes me calm and more focused.”

On the other hand, most of the comments on self-portrait were about the aversive affect people had by failing to meet the self-prescribed standard. Only 2 participants thought the images of self gave them a boost in regulating their behaviors.

Statistical models, however, drew a different picture. The introduction of Self-Portrait was a good predictor for both average off-task time and frequency of secondary switches. Both models indicated that it was linked with better AOT and FSS compared to the Moon. Raising self-awareness thus provided the incentives to regulate behaviors but produces some levels of aversive affect.

The contradiction between the statistical results and verbal feedback from participants was similar to the result from Study I about using Punishment mode. A designer of similar persuasive tasks should be aware of the aversive affect created by stressful design elements and the potential of such design to discourage users in a long run.

The resistance to both self-portrait and social-support persuasion might also be the result of the blatant display of people's images. Compared to direct representations of social presence, a more delicate approach is to introduce proxy representations that highlight the certain features of the represented individual (Fox et al., 2014). Using avatars will be one of the examples.

For social-support persuasion, it also depends on the social relationship between the subject and represented individual. Most participants chose family members as persuader in the study. Research in persuasion suggested that family members are among most effective sources for behavior persuasion (Hsiung & Bagozzi, 2003).

**Theme 3: Adherence and Gamification**

Although none of the regression models had interaction between "Days Of Using" and persuasion type, comments from participants demonstrated a low level of adherence to the persuasion.

Participants seemed to get easily weary of the Self-Portrait. As shown in excerpts from qualitative analysis, participants gradually grew bored, though only to a low degree, at the sight of themselves. The lesson here is that behavioral change interventions via the heightened self-awareness need to take into account the potential aversive affect that arises from the very use of self-awareness. Theories in self-awareness go so far as to claim that aversion goes hand in hand with self-awareness, just a matter of to what degree (Csikszentmihalyi & Figurski, 1982). Another source of weariness on visual feedback might relate to the simplicity of feedback. Participants simply grew bored with it. The dogmatism that users sense from using WiredIn can largely be explained by its rigidness in design. The only feedback people get from WiredIn is an either improved or deteriorated image.

However, this is not to say that interventions could not be designed to meet both effectiveness and sustainability. As predicted by Flow theory (Csikszentmihalyi, 1991) and related theories, positive affect and behavior change can be achieved by maximizing the flow experience. One possible solution, as demonstrated by its encouraging development in both academia and industry, is gamification.

This leads to the customization and to what degree do designers strive for gamification. The conundrum, however, is that personal or professional workplaces are not necessarily suitable locations to introduce gamification. As stress, attention

allocation, as well as other cognitive responses are inherent components of games (Ikehara, Crosby, & Silva, 2013), adding game-like elements will introduce new level of complexity to the system. The designers need to be delicate so that gamification in places where people work will not backfire.

**Theme 4: Personalization under different circumstances**

Task urgency, stress level, time of day as well as types of work all had various degrees of predicting powers in those performance metrics from Study II. Task urgency had conflicts predicting the direction of dependent value change in first 4 metrics: In AOT, the higher urgency of the task, the worse a person did on minimizing interruption time. While in predicting Length of Lapse, higher task urgency predicted lowered amount of length of the lapse. Previous studies indicated that urgency could ease the problem of task-disengagement (Eerde, 2003), however, studies also have shown the negative effect of task urgency on producing task avoidance and disengagement (van Randenborgh, Hüffmeier, LeMoult, & Joormann, 2010). It is thus recommended that personalization should gear toward accommodating task attributes such as task urgency. When task urgency is sufficient in motivating people on staying on tasks, intervention should tune down the feedback to allow more autonomy. When task urgency is overwhelming, the designer should provide sufficient and non-threatening feedback to motivate a comeback.

It is thus proposed a better persuasion design would be catering to different circumstance with different parameters factored into the design such that the system will carry out personalized intervention scheme. This level of computer intelligence in detecting and responding to various personalized demands is, of course, a great

challenge. Efforts have been made to tackle the learning of complex working environment though still primitive (Horvitz, Kadie, Paek, & Hovel, 2003).

However, one can also argue that there is only so much that tools like WiredIn can do. This is still largely a human's self-regulation failure. As Fogg's Behavior Model has suggested, persuasive technologies are able to provide impetus on some of the three components (Fogg, 2009a): Trigger, Motivation, and Ability, but at times it might not provide all the conditions and ingredients to allow significant and continuous behavioral change.

**Limitations**

It is important to raise the limitations on this study II. Firstly, the duration is only 10 days, and it is not sufficient to record tangible long-term behavior improvement. Although participants revealed their heightened awareness of their previous behaviors, statistical results failed to reveal significant improvement in SPT performance metrics.

Secondly, the duration of 10 days with only 10 student participants can only provide so much variance to the environment and task-related attributes that Study II was not inclusive of other types of workers, environments, and tasks. Job requirements are vastly diverse even for information workers. Thus, it remains to be seen how well designs like this can be integrated into different working environments and helping different kinds of workers. However, the strong link between providing the feedback and improved SPT performance metrics showed the potential of further generalization.

Thirdly, the vision was currently the only channel adopted in feedback from both studies. It will be interesting to see how other channels can be employed to enhance the intervention (Fogg, 1998a). Although multi-channel interaction may make the visual

feedback less rigid and more appealing, the challenge is not to disrupt or block the cognitive channels for working, as multiple channeling is demonstrated to add complexity and mental load on users (Hede, 2002).

**Sustaining Behavior**

Another important issue worth discussion is the possibility for participants to sustain learned behavior and continue to regulate behavior properly without the intervention of tools like WiredIn. The classic view on how people turn their attitudes into sustained behavior is the psychological framework of conditioning. Operant conditioning (Skinner, 1976) is the theory of imposing behaviors through the use of punishment and reward. To enable the voluntary behaviors so that behavior change can be sustained, there are methods that can be utilized:

1. Positive reinforcers: A behavior is followed by a positive stimulus (reward).
2. Negative reinforcers: A behavior is followed by the removal of a negative stimulus (punishment).
3. Positive punishment: A behavior is followed by a negative stimulus.
4. Negative punishment: A behavior is followed by the removal of a positive stimulus.

This theory posits that after a period of exposing a subject to the numerous combinations of the these four manipulations, a subject might exhibit the behavior of extinction: that the behavior becomes conditioned so that the subject does not need more conditioning schemes to either reinforce the acceptable behavior or remove the unacceptable behaviors. Though theoretical, operant conditioning points out the value of the continuous use of a combination of schemes.

Another possible way of stabilize changed behavior is to enable autonomy. By shifting the tone of interaction with the subject from being persuasive toward suggesting, a great sense of self-enabled control can be produced. A great amount of literature has demonstrated the appropriate use of autonomy in improving self-regulation tasks (Black & Deci, 2000; Pelletier, Fortier, Vallerand, & Briere, 2001; Ryan & Deci, 2006). In discussion about persuasion theory's application in environmental sustainability, Brynjarsdottir et al. (2012) suggests changing the rhetorical tone of the persuasion from "prescription" to "reflection", that is: enabling an open-system where reflections on the behaviors can be facilitated so that the inner drive for improving qualities of task performances could be enhanced. A few studies have already shown the effect of this approach in both environmental protection and health-related scenarios (Gaver, Beaver, & Benford, 2003; Sengers, Boehner, David, & Kaye, 2005; Strengers, 2011). In these examples, the purpose is not so much about regulating or telling people what to do, but more about pointing out the consequence of behaviors and relating the problem in a personal and intimate level.

**Holistic Design**

Another important takeaway from results in Study II is the acknowledgment of the entirety of the working lifecycle and working environment. Many participants raised the issue that it was not enough to just focus on interruptions alone. The dynamics in working environments, as well as personal approaches to working, is so diverse and unpredictable that it is difficult just to regulate one issue on the table. A more holistic view of the problem should be adopted. For example, many of the participants mentioned the situations where unpredictable events happened, and they were not able to get out of

those events to resume to the original tasks. They also raised the inability of WiredIn to recognize fatigue as a strong factor for deteriorated task management and hoped that WiredIn could be able to "pause" to allow relaxation.

Taking a holistic view in persuasion design is also recognized in Brynjarsdottir et al. (2012)'s critique about current designs in persuasion technologies for environmental-friendly behaviors. They argue that the design "rather than focusing on specific, isolated behaviors", should consider "broader socio-cultural practices" (Brynjarsdottir et al., 2012). In the context of task management, a holistic view will take into account various factors that are both in and beyond the scope of this study, focus on what current practices are and what can be changed without disrupting the overall workflow.

An example of extension to the current study could consider people's reliance on multiple utilities while working: e.g. some people like to listen to certain types of music, some might want to look at peripheral information in order to take break, as mentioned by P9: "I don't think checking social media is such a big deal, I usually get back pretty quickly, I want to have a brief breakout from the problem I have." While it is an interesting topic to investigate empirically whether or not distractions such as social media should be good or bad while working, a shared recognition is that its influence has already arrived and it will not go away for the time being. Designers may as well deal with the consequences and try to maximize the possibilities of mitigating its adverse effects.

# Chapter 9. Future Work

## Proposition on Fast Persuasion

Based on the results from both studies, especially from insights from Study II, a set of design principles are proposed for contexts that are similar to SPT tasks. This type of context is called "fast persuasion" tasks. "Fast" refers to the fact that the feedback loop is shorter and more frequent than common persuasion tasks such as promoting fitness or exercise. These contexts also entails a person paying attention to primary tasks. In these scenarios, the subject is required to allocate the main focus of attention on their tasks at hand. Fast persuasion tasks have some unique properties that demand new design thinking for persuasion.

### Properties of Fast Persuasion Tasks

#### *Small-scale*

The target goal of WiredIn is to encourage healthy interruption management behaviors that preserve productivity. However, to achieve this objective requires the person to regulate behaviors consistently at a micro-level, i.e. to always return to primary tasks in a timely fashion and shorten long interruptions. In practice, this translates to always ending lengthy conversations with colleagues, finishing breaks earlier, closing social network tabs on browsers, stopping distractions with smartphones, etc. All of these behaviors look trivial and require little effort to perform. However, neglecting to carry out these behaviors **consistently** leads to more severe consequences such as poor job performances in the long run.

Although the ideal behaviors in Fast Persuasion tasks are relatively small in scale, the accumulated effect can make a big difference. One of the designer's jobs is to

magnify the small details of trivial behaviors and raise awareness about its accumulated bad consequences.

***Continuity***

Another feature of Fast Persuasion tasks is that the process is continuous, and it requires constant monitoring. By stating that it is continuous, it is in comparison with domains such as health intervention, in which the persuasion message is intermittently delivered at specified decision-making times: e.g. time to take medicine. In the temporal scale, the frequency of persuasion delivery in Fast Persuasion tasks is much higher than those in health-related persuasion.

Continuous monitoring faces the challenge of "over management" (Sarpong & Rees, 2014). Constant monitoring could lead to frustration and resistance from users. One suggested design solution is to highlight the concept of "voluntary" and foster the sense of ownership of tasks at hand (Marcel, 2003).

***Attention-intensive***

The primary tasks in Fast Persuasion contexts usually depend on a person to allocate sufficient attention. As a persuasive act, the intrusion should be minimal so that the persuasion does not negatively influence primary tasking. Because of the high-tempo of constantly monitoring and quick feedback, the relationship between the subject and persuasion is an intimate but conflicting one: the subject "lives with" the existence of persuasion as it is constantly needed in maintaining the intended state. However, the subject's main target of attention allocation is still on the tasks at hand, rather than paying attention to the persuasion. Therefore, in the race for attention, persuasion is competing

with primary tasks, but by combating the declining awareness on task management, the persuasion is assisting the subject to complete the primary tasks.

**Use Cases**

The context of interruption management is not the only scenario that has these properties for persuasion design tasks. Similar scenarios will also benefit from a well-designed persuasive intervention.

The first example of such persuasion targets is modern classrooms. There is known epidemic of students' attention decline in classrooms (Bunce et al., 2010; Wilson & Korn, 2007). Bunce et al. (2010) reports that students tend to take on and off cycles during lectures. Inventive and effective designs can be used to alleviate this problem and engage students. Similar to the use of WiredIn, the challenge is how to create a universal persuasion intervention that interacts with a group of subjects without comprising the students' focus on the lecture. The difference between classroom and personal working environments is that the action the person needs to take is even more trivial: diverting attention. However, it also makes the monitoring and detection extremely difficult (Corrigan, Peters, & Castellano, 2013).

Another scenario in which a persuasion tool like WiredIn could be beneficial is promoting safe driving behaviors. Attitudes toward reckless driving are still problematic despite generations of education (Shinar et al., 2001). Although driving is very attention-intensive, careful designs could still be employed in the vehicles to regulate driving behaviors. For example, persuasive presence could inform the exceeding of the current speed limit, punish abrupt turns, or reward courtesy behaviors such as yielding (O'Neill et al., 2014).

**Proposed Design Principles:**

The following principles are proposed for Fast Persuasion tasks, and future works can expand on these points.

***Timing of Feedback***

Because of the continuity property, the feedback needs to be timely and appropriate. The on-going task, in this case managing tasks, could be deviating from the acceptable path at any time. Although it is not necessary to punish such deviation at the first time possible, it is critical that the persuasion entity would have the knowledge of each of the deviations and provide intelligent feedback at a suitable moment.

The timing of feedback is not about abruptly reminding the participant about their good or bad behaviors. Because of the "attention-intensive" property, in these contexts it is not a good idea to recklessly capture a subject's attention. Thus, the trick is in manipulating the secondary communication channels and making subjects aware of the state by gradually changing an environmental cue. A rather faster graduated change will be more likely to capture the attention of subject while a slower change will be less likely to do so (Bacon & Egeth, 1994).

In Study I, two modes of feedback timing schemes were under the test as independent variables: punishment or reward. The difference, in a sense of timing, is how soon the persuasion entity fed the information about the deviation back to the subject. In the reward mode, the deviation was not immediately signaled back to the subject as the state of flower or the progress bar ran toward the bad state at a relatively slow pace. In the punishment mode, on the other hand, the visual images signaled the deviation back to

the subject more instantly, as the flower or the progress bar ran toward bad state faster. The result, as shown in the discussion part of Study I, showed that subjects performed better with the punishment strategy in place but liked the reward mode more than punishment mode.

In study II, the speed of changing state is not manipulated as it would cloud other types of predictor variables. However, from the qualitative discussion about types of Persuasion types, participants acknowledged the frustration with the images not turning into the good state immediately when they are resuming to primary tasks (the clock is set to 30 seconds to see if the subject will be able to hold on to current state).

It thus depends on the design goal and context. For example, in the case of regulating driving behaviors, the punishment for unacceptable actions should be made clear to users immediately because in this context the consequence of not performing properly is much more important than rewarding good behaviors. On more benign and less intensive situations such as classroom behavior regulation, it is more profitable to give out rewards to keep encouraging motivation.

***Auxiliary Model***

The second principle is for designers to recognize that the persuasion entity should be auxiliary and secondary. There are two ways to explain why being auxiliary is key principle.

Firstly, it should take secondary and peripheral channels for interaction. As stated in the previous point, the persuasion entity should not interfere with the primary tasks.

The second perspective on the point that the persuasion entity should be auxiliary is about the motivation source. Both studies have shown the effect of persuasion designs

on reducing frequency and length of interruptions. However, the motivation it generates that leads to the better behaviors is not on par with the innate motivations from subjects themselves. Persuasion entities can only spur so much motivation from subjects that it still depends on existing external and internal incentives for performing the tasks well. In study II, the results show that task urgency is a strong predictor in predicting most of task management metrics (except for the frequency of secondary switches). Often it has one of the largest standard beta coefficients. This shows the predominance of realistic sources of motivation in behavior regulation.

For persuasion entities in situations where other motivation stimuli are sufficient in regulating behaviors, it is thus more suitable for persuasion designs to yield or even halt persuasion. This point was shared by some of the participants. Interview discussion showed that if they were already immersed in the tasks they preferred not to be disturbed. P10 mentioned that "if the task is really challenging and I'm really into it, I don't want the feedback to give any more hints on how to management my tasks and hope it can leave me alone." P6 raised a case where the existence of WiredIn interfered with his normal tasks: "My task involves switching back and forth between two windows frequently, the Moon images stand in the way when I look from one application to another."

In the end persuasion tools are assistants. The responsibility is on the users to take care of the quality and deliver the results of their work in time. Tools like WiredIn cannot replace established productivity drivers such as personality, work ethic, and self-control ability.

### *Ambient/Subtle*

Because of the attentional demand for primary tasks, the persuasion entity can only sit in peripheral positions. In addition, the way persuasion entities signal changes should also be subtle and under-the-radar. The mechanism by which ambient persuasive technologies can capture attention is well documented in both cognitive and HCI literature (Ham & Midden, 2010; Ham, Midden, & Beute, 2009). The challenge, however, is to design and develop the appropriate metaphor for the target behavior that persuasion is going after (Hallnäs & Redström, 2001; Holmquist & Skog, 2003).

In Moere's work, the persuasion rhetoric can be categorized into types of conveying information: visualization as a transformation, visualization as augmentation, or visualization as an embodiment (Vande Moere & Offenhuber, 2009). In the situation of regulating interruption behaviors, the idea is to use visualization as both a way of embodying the state of the managing tasks. As an embodiment, the information should be transparent but implicit, easy to understand but not overt.

### *Engagement*

Another important issue is to demonstrate the possibility of engagement with the subjects by the persuasion entity.

Engagement has always been an attribute of persuasion technologies (Nakajima & Lehdonvirta, 2013). In the context of this study, the requirement for enhanced user engagement goes beyond the point of being decoration but as a necessity. Because of the continuity property of these contexts, the user could be easily get bored with the persuasive idea.

There are generally two approaches to raise the level of user engagement in persuasive design, and they are not mutually exclusive. The first approach is to utilize emotion. Displaying a non-intrusive object does not utilize enough motivation to drive actual behavior change. As stated in the previous discussion, raising self-awareness is linked to higher motivation but it also depends on how much a person is attached to the task and persuasion goal. It is important to make the user care about the consequences of a computer system by linking metaphors in the persuasion entity to the personal values in reality. Examples of emotional engagement design have seen positive results (Dillahunt, Becker, Mankoff, & Kraut, 2008; Lin et al., 2006). These designs typically use people's affection for animated animals to persuade behavior change. In Study I, the use of the flower image has some level of emotional engagement, and the results show the improved interruption management with a relatively lower burden on participants.

The second approach is to use virtual games as a way of engagement. In the fields of digital rhetoric, the view is that the rhetorical exchanges between entities in media production has the power and means to provide persuasion on how people should live their lives (Buchanan, 1985). Serious games are a typical use of such rhetoric in persuading healthy behaviors (Guillén-Nieto & Aleson-Carbonell, 2012; Matei, Rughiniş, & Rughiniş, 2014; Wang & Singhal, 2009).

Although it will be overkill to design a full-fledged game in the context of management personal interruptions during work time, it is still very useful to employ certain game techniques to enhance user engagement. In his book, Bogost (2007) discusses the possibility of using games as a way of persuasion and how properties of video games have the most potential to change the world for the good. The overall

position that Bogost holds is that the way to influence people through video games is by bringing the perspectives closer to people's awareness in order to change their attitudes and behaviors. With game-like techniques, the dynamic between the persuasive entity and subject becomes more rhetorical, rather than coercive. One example of such design the use of participatory game mechanics in Hirsch (2010)'s serious game design for water-shortage.

***Progress Reports***

The final point in designing for contexts such as time management is to use progress reports to consolidate changed behaviors. As suggested by many of our participants in Study II, it is a good encouragement if they can view how much they have progressed since the beginning in terms of regulating their task management behaviors.

Reporting progress is a good strategy in overall persuasive design. However, what makes the reporting particularly important in this context is because of the small-scale of the behaviors such as switching windows. The triviality of these behaviors makes them easier for people to neglect them. Apart from reporting how well people are progressing in terms of defined SPT performance metrics such as average off-task time, the reporting also serves the purpose of enabling the visualization of "what-if" scenarios. For example, WiredIn will be exerting more persuasive power for participants to regulate irresponsible task switching by reporting statistics about task management behavior without the intervention, such as accumulated time on irrelevant tasks, number of unnecessary switches, and number of interruptions.

**Machine Intelligence**

The gamifying process should be taking a more personalized and environment-sensitive approach. An interesting approach is machine learning factors in working environments. Namely, an intelligent computer system will be able to detect task attributes, environment factors, and individual abilities.

Task attributes refer to how the primary tasks should be carried out. Is this is solo work or is it group coordinated? What tools does it need and how the workflow look like? All these questions determine how the design structure of intervention should be presented. Environment factors take into account the context at which the tasks are carried out. An intelligent persuasion system will know how interruptive the environment is and will produce configurations to make it better for working. Individual abilities refer to the general tendency of self-regulation abilities while working as well as fluctuating factors such as mood, physical fatigue, or knowledge base.

**Game Mechanics**

Numerous ways to increase motivation could be achieved by borrowing game mechanics from game research. For instance, it will be interesting to see how manipulating the level of social factors can play a role in a better self-regulation. For example, bringing close members of the social circle's SPT performance statistics for comparison, ranking the best SPT performances, etc.

Another way of using game mechanics is to enhance reward. The current level of reward is not sustainable for long time adherence to the persuasion. The reward can be given through reporting as the discussion in previous chapters. Giving affirmation that

the person is performing at a consistent, but progressing level gives hope and a sense of achievement from the user, which enables self-belief and autonomy for future motivation.

# Chapter 10. Conclusion

This dissertation takes on the challenge of intervening with personal interruption management behaviors during work time. The focus is to create persuasive systems that monitor and motivate a more healthy way of dealing with interruptions.

Using knowledge on both self-regulation and persuasive technology domain, WiredIn was designed as a primary tool for studying the effect and design implication in this domain. Study I validated the effects of bringing visual interventions into a simulated working environment. The results showed the significant impact of peripheral visual designs on shortening interruptions lags. In addition, adding pressure (by manipulating the pace of image progressing) showed an even bigger effect in reducing time spent on irrelevant tasks. However, the cost of it turned out to be a higher stress level from participants who went through high pressure. The takeaway, therefore, was that a persuasive design at intense contexts such as workplaces should be less intimidating and more amiable. Positive encouragement and less punishment will be more welcome to the persuaded subjects.

From Study I, it was also learned that individual differences might play a role in people's perception of the persuasion metaphor. For example, male participants responded better to the progress bar images than the flower images. Although it did not impact the performance in the short term, individual differences can have an effect on adherence to the persuasion in a long run.

The limitation of Study I being a lab-based environment gave rise to the second study in which participants were allowed to use WiredIn in their real working environments to work on real projects. The purpose of the study II is not to manipulate

environmental factors but to record real-life variables and use regression models to explore the correlation between these factors to SPT performance metrics. The results showed that the use of visual intervention had a reasonable link with improved SPT performance. In addition, various factors had different levels of predicting power to the metrics. One of the factors standing out was task urgency, as higher urgency is strongly linked with better SPT performances. Also, factors such as perceived stress level, working hours, and location all had different levels of predicting connection to the metrics. Using social elements for motivating was also linked to metrics such as frequency of switching-off. Another interesting finding was that the type of irrelevant tasks also predicted SPT performance metrics to a large extent. This showed that some types of interruptions were harder to abandon than others.

The interactions between factors listed above and the addition of visual intervention also showed up as strong predictors. Designers need to consider intelligent management of the strategy, the volume, and the target of the persuasion under different circumstances.

Finally, a new set of design principles were proposed that are tailored for fast and attention intensive contexts. The emphasis put on the principles will enable the persuasion design for these contexts to be more likely to succeed.

# Appendices

## Appendix A. Pre-study Questions in Study I

Please fill in the forms as it applies to you:

Sex: Male Female

Age: 18-20; 20-25; 26-30; 30-40

How many hours a day do you spend on using computers for work (mobile devices excluded)? Less than 1 hour, 1-3 hours, 3-5 hours, 5-6 hours, more than 6 hours

How do you rank yourself in terms of computer using skills? Rookie; Amateur; Regular; Professional.

Which are your most visited social media sites? (Multiple choices)

- Facebook.com
- Twitter.com
- Youtube.com
- Pininterest.com
- Instgram.com
- Reddit.com

Other: _____

For the top three sites you visit, how many connections (i.e. friends, followers) do you have on that social media service?

## Appendix B. Post-study Questions in Study I (Modified NASA TLX)

[Mental Demand]

How mentally demanding was the task?

Lowest |__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__| Highest

[Physical Demand]

How physically demanding was the task?

Lowest |__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__| Highest

[Stress]

How stressed do you feel throughout the task?

Lowest |__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__| Highest

[Temporal Demand]

How hurried or rushed was the pace of the task?

Lowest |__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__| Highest

[Performance]

How successful were you in accomplishing what you were asked to do?

Lowest |__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__| Highest

[Effort]

How hard did you have to work to accomplish your level of performance?

Lowest |__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__| Highest

[Frustration]

How insecure, discouraged, irritated, and annoyed were you?

Lowest |__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__| Highest

**Appendix C. Self-control Scale (Tangney, Baumeister, & Boone, 2008)**

Using the scale provided, please indicate how much each of the following statements reflects how you typically are.

1. I am good at resisting temptation. 1———2———3———4———5

(R) 2. I have a hard time breaking bad habits. 1———2———3———4———5

(R) 3. I am lazy. 1———2———3———4———5

(R) 4. I say inappropriate things 1———2———3———4———5

5. I never allow myself to lose control. 1———2———3———4———5

(R) 6. I do certain things that are bad for me, if they are fun. 1———2———3———4———5

7. People can count on me to keep on schedule. 1———2———3———4———5

(R) 8. Getting up in the morning is hard for me. 1———2———3———4———5

(R) 9. I have trouble saying no. 1———2———3———4———5

(R) 10. I change my mind fairly often. 1———2———3———4———5

(R) 11. I blurt out whatever is on my mind. 1———2———3———4———5

(R) 12. People would describe me as impulsive. 1———2———3———4———5

13. I refuse things that are bad for me. 1———2———3———4———5

(R) 14. I spend too much money. 1———2———3———4———5

15. I keep everything neat. 1———2———3———4———5

(R) 16. I am self-indulgent at times. 1———2———3———4———5

(R) 17. I wish I had more self-discipline. 1———2———3———4———5

18 I am reliable. 1———2———3———4———5

(R) 19. I get carried away by my feelings. 1———2———3———4———5

(R) 20. I do many things on the spur of the moment. 1———2———3———4———5

21. I don't keep secrets very well. 1———2———3———4———5

22. People would say that I have iron self- discipline. 1———2———3———4———5

(R) 23. I have worked or studied all night at the last minute. 1———2———3———4———

–5

24. I'm not easily discouraged. 1———2———3———4———5

(R) 25. I'd be better off if I stopped to think before acting. 1———2———3———4———

5

26. I engage in healthy practices. 1———2———3———4———5

27. I eat healthy foods. 1———2———3———4———5

(R) 28. Pleasure and fun sometimes keep me from getting work done.

1———2———3———4———5

(R) 29. I have trouble concentrating. 1———2———3———4———5

30. I am able to work effectively toward long-term goals. 1———2———3———4———5

(R) 31. Sometimes I can't stop myself from doing something, even if I know it is wrong.

1———2———3———4———5

(R) 32. I often act without thinking through all the alternatives.

1———2———3———4———5

(R) 33. I lose my temper too easily. 1———2———3———4———5

(R) 34 I often interrupt people. 1———2———3———4———5

(R) 35. I sometimes drink or use drugs to excess. 1———2———3———4———5

36. I am always on time. 1———2———3———4———5

(R) – Reversed Items

**Appendix D. Study II Pre-trial questions**

These questions are asked when participants start to work for the day and about to launch WiredIn:

- Task
    - Describe your primary task in simple text.
    - How many other task you on your to do list today?
    - For today, how much time do you expect to spend on this task?
    - How difficult do you think about this task?
    - How familiar are you with doing this task?
- How are you feeling now?
    - How busy are you for the past 2 hours?
    - How energetic do you feel now?
    - How stressed do you feel now?
- Environment:
    - Where are you now?
    - How noisy is your surrounding?

## Appendix E. Experience Sampling Method Questions

These questions are asked while using WiredIn.

1. It took you ___Minutes and ___Seconds to come back to your primary task. What were you doing during that time?

2. Use the slider to indicate the reason for your delay is because of: 1) Total neglect or lost of awareness.

3. Use the slider to indicate how much influence does the visualization has on your decision to come back?

**Appendix F. Study II Diary Lead Questions**

- How long have you worked today with WiredIn turned on?
- What's is your overall experience of using WiredIn? Give us some simple description about your experience.
- Which visualization did you use? Do you like it?
- Why do you like/dislike it?
- Did WiredIn motivated you stay longer on your tasks?
- Why do you think WiredIn succeed in / failed to motivate you?
- Is there anything you feel uncomfortable using WiredIn? Please explain
- Did you feel you are productive today? Explain why yes or no. Did you feel you've accomplished your goals today?
- How frustrated were you today (about your performance on work, not necessarily about WiredIn)? Explain how frustrated you were at your work today, e.g. your performance, you satisfaction with work results...
- How stressed were you today? Explain your stress level, not about using WiredIn, but your overall perceived stress from tasks and work and etc.
- What interrupted you most day? If you could name couple things that interrupted you from your work today, what would those things be?
- What's the biggest difference from your experience using WiredIn today compared to yesterday or previous days?

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Zimmerman, B. J. (2000). Self-efficacy: An essential motive to learn. *Contemporary educational psychology, 25*(1), 82-91.

# Curriculum Vitae

## Yikun Liu

**Education:**
**Ph.D., Informatics**, Human-Computer Interaction Track (September 2015)
Indiana University, Indianapolis, IN, USA. Advisor: Dr. Mark Pfaff.
Dissertation: Supporting working time interruption management through persuasive design
Minor: Computer Science (Purdue School of Science and Engineering)

**M.A., Systems Engineering** (July 2009)
Xi'an Jiaotong University, Shaanxi, PRC. Advisor: Dr. Jianhua Zou.

**B.A., Automation, Electronic Engineering** (July 2006)
Xi'an Jiaotong University, Shaanxi, PRC

**Honors and Awards:**
**Graduate Research Assistantship** (2009 – 2014)
Indiana University Purdue University Indianapolis.

**Outstanding Graduate with Excellent GPA** (December 2006)
Xi'an Jiaotong University.

**Research Experiences:**
**Pre-doc research assistant**, Decision Space Visualization with Optional Awareness
PI: Dr. Mark Pfaff (August 2010 – August 2013)

**Pre-doc research assistant**, Navigating the Aural Web, three-year NSF-funded project
PI: Dr. Davide Bolchini (August 2011 – August 2013)
- Sub-Project#1, Aural Fast Browsing (November 2011 – July 2013)
- Sub-Project#2, Topic- and List-Based Back Navigation (August 2011 – August 2012)

**Research assistant**, Multimedia Learning Support System, PI: Dr. Jianhua Zou (September 2007 – June 2009)

**Teaching:**
**Teaching Assistant** (TA) for NEWM101 Introduction to Web Development (No. of students: 60). (Fall 2014)

**Lecturer** for NEWM315 Online Document Development II. (Spring 2014)

**Volunteer**, UPA World Usability Day, IUPUI, Indianapolis (November 2009)

**Publications:**

Yikun Liu, Mark S. Pfaff. (2014). Wiredin: using visual feedback to support task resumption. CHI Extended Abstracts 2014: 2539-254

Yikun Liu., Jia, Y., Pan, W., & Pfaff, M. S. (2014, February). Supporting task resumption using visual feedback. In Proceedings of the 17th ACM conference on Computer supported cooperative work & social computing (pp. 767-777). ACM.

Yikun Liu, Haidan Huang (2011). TimeCapsule: Connecting Past. CHI Extended Abstracts 2011: 995-1000

Yikun Liu, Pfaff, M. S., Drury, J. L, Klein, G. L., Moon, S. P., (2010). Collaborative Option Awareness for Emergency Response Decision Making. Proceedings of the 8th Annual International Conference on Information Systems for Crisis Response and Management (ISCRAM), Lisbon, Portugal.

Pfaff, M. S., Klein, G. L., Drury, J. L., Moon, S. P., Liu, Y., & Entezari, S. O. (2013). Supporting complex decision making through option awareness. Journal of Cognitive Engineering and Decision Making, 7(2), 155-178.

Pfaff, M., Drury, J. L., Klein, G. L., More, L., Moon, S. P., and Liu, Y. (2010). Weighing decisions: Aiding emergency response decision making via option awareness. In Proceedings of the 2010 IEEE international conference on technologies for homeland security, Waltham, MA, November 2010.

Yang, T., Ferati, M., Liu, Y., Rohani, R., & Bolchini, D. (2012). Aural Browsing On-The-Go: Listening-based Back Navigation in Large Web Architectures. In proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI), 277-286. [23% acceptance rate].

Bolchini, D., Ferati, M., Liu, Y., Luebke, J., Rohani Ghahari, R., Yang, T. (2011). Navigating the Aural Web. Poster Presented at the UPA World Usability Day, IUPUI Campus Center, Indianapolis, November 10, 2011.

Bolchini, D., Ferati, M., Liu, Y., Luebke, J., Rohani Ghahari, R., Yang, T. (2011). Navigating the Aural Web. Invited Poster Presented at the IUPUI TRIP (Translating Research Into Practice) Showcase, IUPUI Campus Center, Indianapolis, September 12, 2011.

Bolchini, D., Ferati, M., Liu, Y., Luebke, J., Rohani Ghahari, R., Yang, T. (2011). How We May Navigate (the Aural Web). Invited Poster Presented at the IUPUI Research Day, Community Research Showcase, IUPUI Campus Center, Indianapolis, April 8, 2011.

Bolchini, D., Ferati, M., Rohani Ghahari, R., Liu, Y., Luebke, J., Yang, T. (2010). Navigating the Aural Web. Poster Presented at the UPA World Usability Day, IUPUI Campus Center, Indianapolis, November 11, 2010.

Bolchini, D., Ferati, M., Rohani Ghahari, R., Liu, Y., Luebke, J., Yang, T. (2010). Navigating the Aural Web. Poster Presented at the Indiana TechPoint Innovation Summit, Indiana Convention Center, Indianapolis, October 27, 2010.

Jia, L., & Liu, Y. (2008, January). A novel thresholding approach to background subtraction. In Applications of Computer Vision, 2008. WACV 2008. IEEE Workshop on (pp. 1-6). IEEE.

**HCI & Technical Skills:**

HCI Methods

- Online user evaluation/experimentation through crowdsourcing
- Usability testing with sighted, blind, or visually impaired users
- Contextual inquiry, focus group, requirement analysis, conceptual and architectural modeling, low/high-fidelity prototyping

Experiment Design

- Taken up to four experiment/research design classes in Informatics, Psychology, and Marketing
- Designed and conducted around five major experiments during PhD study, and the results were published in peer-reviewed international conferences and journals

Analytical & Statistical Skills

- Proficient in analyzing multi-group and factorial research experiments through either parametric or non-parametric statistical methods
- Good at developing and validating psychometric research instruments (i.e., scales, questionnaires) through exploratory and confirmatory factor analyses
- A good understanding of meta-analysis, multivariate regression, and the structural equation modeling technique
- A good mastery of the SPSS, JMP, and AMOS software

Web Design & Programming

- Objective Oriented C++, C#, Java
- Web Development: HTML, Javascript, Nodejs, AngularJs