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Self-interruptions in discretionary multitasking

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ABSTRACT

Human multitasking is often the result of self-initiated interruptions in the performance of an ongoing task. These self-interruptions occur in the absence of external triggers such as electronic alerts or email notifications. Compared to externally induced interruptions, self-interruptions have not received enough research attention. To address this gap, this paper develops a typology of self-interruptions based on the integration of Flow Theory and Self-regulation Theory. In this new typology, the two major categories stem from positive and negative feelings of task progress and prospects of goal attainment. The proposed classification is validated in an experimental multitasking environment with pre-defined tasks. Empirical findings indicate that negative feelings trigger more self-interruptions than positive feelings. In general, more self-interruptions result in lower accuracy in all tasks. The results suggest that negative internal triggers of self-interruptions unleash a downward spiral that may degrade performance.

1. Introduction

Multitasking, commonly defined as undertaking multiple tasks at the same time (Rubinstein, Meyer, & Evans, 2001), is characterized by interleaving independent tasks in the same time period and switching among them. While this interspersing contributes to the illusion of productivity as more tasks are performed in a period of time, many studies show that performance degrades when attention is divided (Bailey & Konstan, 2006), particularly during complex tasks (Speier, Vessey, & Valacich, 2003). Despite the potential negative consequences, multitasking is prevalent in everyday life (Benbunan-Fich & Truman, 2009). Since people frequently engage in multitasking with and without technological devices, researchers in various fields have begun exploring the triggers and consequences of multitasking in more depth.

Human–Computer Interaction (HCI) scholars are well positioned to undertake groundbreaking research in multitasking. Indeed, the combination of user behavior knowledge with a keen understanding of technology platforms enables HCI researchers to investigate this topic from a vantage point and make substantial contributions to improve user performance and the design of interfaces.

Prior research indicates that in multitasking situations, different tasks are combined in the same timeframe because of two different types of interruptions: external and internal (Gonzalez & Mark, 2004; Mark, Gonzalez, & Harris, 2005). The former refers to *external* alerts, notifications or environmental cues, while the latter points to *internal* decisions to stop an ongoing task to attend to another, due to personal thought processes or choices. The focus of this research is on internally-motivated interruptions, which have been called *self-interruptions* to emphasize that the decision to pause occurs in the absence of external or environmental triggers. In self-interruptions, the user may decide to interrupt their task briefly or for a longer period of time to attend to another task (Salvucci, Taatgen, & Borst, 2009). This behavior is pervasive. For example, Czerwinski, Horvitz, and Wilhite (2004) report that 40% of task switches are due to self-interruptions.

Despite the frequency of self-interruptions, with a few notable exceptions (Payne, Duggan, & Neth, 2007), the existing literature has not studied in depth the determinants of self-interruptions. In contrast, there is an abundance of studies investigating the nature, the reactions and the consequences of external interruptions (Bailey & Konstan, 2006; Gillie & Broadbent, 1989; McFarlane, 2002; Speier et al., 2003). There are also a few studies (Dix, Ramduny-Ellis, & Wilkinson, 2004; Jett & George, 2003; Jin & Dabbish, 2009) integrating both types of interruptions in a single classification scheme. For example, Jin and Dabbish (2009) provide a classification of self-interruptions that includes environmental causes. Our study seeks to contribute to the emerging body of research by developing a refined typology solely focused on internal self-interruptions and validating this typology in an experimental setting. A detailed categorization of internally motivated interruptions is poised to advance our understanding of the drivers and consequences of multitasking behavior.

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To investigate the determinants of self-interruptions, we delve into the literature of self-regulation (Carver, 2003) and flow (Csikszentmihalyi, 1990) and theorize that self-interruptions occur when the user fails to achieve a flow state with the ongoing task and engages in self-regulation behavior to improve performance. Our proposed typology of self-interruptions is examined with data collected from a sample of participants who used a custom-developed application that enabled multiple task performance. This application provides a closed multitasking environment with six pre-defined problem-solving tasks presented in different tabs that participants had to complete in a fixed amount of time. Users were allowed to move between the tasks (i.e., tabs) at their discretion and solve the problems in any order. With the behavioral data collected by the application and the participants' quantitative and qualitative answers to specific post-test questions, we test the proposed typology of self-interruption triggers and examine the relation between self-interruption triggers, multitasking activity and performance outcomes. A detailed understanding of the origins of self-interruptions, with respect to the positive or negative feelings that motivate them, will enable researchers to investigate their effects in more depth.

2. Theory background

Interruptions occur when users decide to stop their current activity and shift goals to perform different tasks (Mark et al., 2005). A goal is defined as "a mental representation of an intention to accomplish a task, achieve some specific state of the world, or take some mental or physical action" (Altmann & Trafton, 2002, p. 39). People start a new task when its associated goal is strengthened in memory to the point where its activation rises above other goals. In a multiple task situation, a newly activated goal becomes the focus of attention and directs behavior, while old goals are postponed until they are activated (Altmann & Trafton, 2002).

Two different conditions cause active goals to be suspended or set aside temporarily in favor of new goals. The first possibility is an *external interruption* that requires immediate attention and produces a displacement of the active goal. This displacement results in a reorganization of goals currently held in memory as people shift active goals and formulate the intention to resume the interrupted task later. The second goal-displacement situation occurs when there is a *discretionary decision to stop the current task (or self-interruption)* without any external prompt. In this case, the active goal is suspended and another goal becomes the focus of attention entirely at the volition of the individual. Payne et al.'s (2007) study of self-initiated task switching proposes that self-interruptions are motivated either by the propensity to temporarily abandon a task that is no longer rewarding, or by the tendency to switch to an unrelated task when a sub-task is completed.

In a conceptual study, Jett and George (2003) identify a fourfold typology of interruptions that includes intrusions, breaks, distractions and discrepancies, each with different causes and consequences. Intrusions result from external interruptions, while breaks are self-initiated. In contrast, distractions can be instigated by the environment or by competing activities, and discrepancies are perceived inconsistencies between the task at hand and external events or internal expectations. In this classification, only breaks would qualify under the label of self-interruptions.

In another study, Jin and Dabbish (2009) used a grounded theory approach to identify seven types of self-interruptions organized into two broad dimensions: internal and situational. Internal self-interruptions are initiated by the user's cognitive processes and can be traced to either the need to take a (mental) *break*, or to act on a *recollection* that reminds the user of something else to do, or to the tendency to follow habitual steps or *routine*s. In contrast, situational self-interruptions result from conditions in the environment conducive to stopping the current task. Such conditions include an *adjustment* of the workload, a *trigger* idea that leads to a different task, an *inquiry* to retrieve information needed to proceed with the present task, or a *wait* that induces the person to fill up downtime until a task underway can be continued.

From the perspective of time, an earlier study by Dix et al. (2004) outlines three types of temporally related triggers, namely: immediate, temporal and sporadic.[2] *Immediate* triggers occur when an activity starts immediately after the completion of a previous one. They are, however, inconsistent with the typical definition of an interruption because they occur at the conclusion of a task, when the person transitions to the next task. In a discretionary multitasking environment, individuals can exercise discretion on whether to switch tasks at all. Some may choose to perform tasks sequentially, instead of interleaving ongoing tasks. In this case, there is no interruption per se. *Temporal* are periodic triggers that happen at regular intervals, or actions that occur after a particular delay. A typical example is the intermittent checking of email when notifications are turned off. For instance, Renaud, Ramsay, and Hair (2006) found that most people tend to keep email running in the background at home and at work and that they switch to check their email about every 5 min. *Sporadic* triggers take place when a person suddenly remembers something that must be done. Unlike Jin and Dabbish's (2009) trigger idea, which points to a new task or novel pursuit, the sporadic triggers mentioned here occur when there is a cognitive reminder that something must be done.

A closed or restricted working environment, with pre-defined tasks, allows for a more in-depth examination of the reasons why people decide to switch between pre-planned tasks. In this kind of environment, triggers that occur periodically (such as regular checking of email) or sporadically (retrospective recollection of a pending task or prospective pursuit of a new idea) are not applicable. By isolating internal causes of self-interruptions, a more refined typology can be developed. We propose that these triggers can be identified from the theories of flow and self-regulation.

2.1. Flow Theory and Self-regulation of behavior

Conceptually, self-interruptions can be conceived as self-imposed disruptions in the flow of work. Flow Theory (Csikszentmihalyi, 1990) and Self-regulation Theory (Carver, 2003) provide two complementary explanations for the absence or presence of self-interruptions. The combination of these two theoretical explanations suggests that self-interruptions occur when the individual fails to achieve a flow state with the ongoing task and engages in self-regulation behavior to improve performance. Self-regulation thus indicates that there is a lack of flow with the current task and the person is seeking other tasks to improve his working experience.

Csikszentmihalyi (1990) defines flow as the mental state that takes place when a person is completely immersed in a particular task with total focus and involvement. In order to achieve this flow state, there must be a balance between the person's skills and the level of challenge provided by a task. This balance results in the feeling of "optimal experience" in the performance of a task. Flow Theory has been applied to study user behavior in computer-mediated communication (Trevino & Webster, 1992), in online consumer environments (Jiang & Benbasat, 2005; Koufaris, 2002), and more recently in virtual worlds (Nah, Eschenbrenner, & DeWester, 2011). While this theory has been used in HCI (Webster, Trevino, & Ryan, 1993), to the best of our knowledge, it has not been applied to study multitasking, or its opposite mono-tasking.

[2] Dix et al. also include in their typology two types of external triggers. One is due to external events, such as alarms and other signals, and the other is due to environmental cues, such as looking at an item in a to-do list.

Flow is an affective state of total immersion when individuals are involved in certain activities (Csikszentmihalyi, 1990; Jiang & Benbasat, 2005). In technology or systems use, flow is a self-reinforcing state consisting of a seamless sequence of responses, where a user is immersed in task performance mediated by the computer, and loses awareness of his/her surroundings and pending activities. The defining characteristics of flow are sense of control, focus of attention and cognitive enjoyment (Trevino & Webster, 1992; Webster et al., 1993).

On the basis of Flow Theory, a person who experiences a "state of flow" is totally focused in a single task (Csikszentmihalyi, 1990) and not likely to multitask. Thus, the triggers of multitasking can be conceptualized as conditions that prevent an individual from achieving a state of total task immersion. These conditions stem from an imbalance between the level of challenge provided by the task and the level of skills of the person performing the task. This imbalance occurs when the person is under-qualified for the task, or over-qualified for it. In this context, we propose that negative feelings of being stuck in a difficult task (non-rewarding task progress), as well as positive feelings of easy achievement emerging from non-challenging tasks, explain the tendency to look for alternative tasks, and therefore the likelihood of engaging in multitasking. Fig. 1 (adapted from Csikszentmihalyi (1990)) illustrates these two alternative scenarios.

When flow is not achieved, an individual self-regulates his behavior to restore the balance between task demands and skills by changing tasks (Carver & Scheier, 2009). For instance, when a task is too difficult for a person's level of skill, s/he may experience *frustration* or other *negative* emotions. Under sub-optimal task conditions, these negative feelings are likely to trigger self-interruptions of ongoing action. Inadequate progress induces people to either exert more effort in order to overcome obstacles, or to look for alternative solutions, in order to improve the rate of progress. Occasionally, people are unable to exert additional effort due to fatigue (*exhaustion)*, or are unable to continue working towards the attainment of the current goal due to specific obstacles that impede progress (*obstruction)*. In these cases, people also tend to find something else to do, at least temporarily. As a result, experiences of *exhaustion* or *obstruction* in the process of goal attainment are likely to trigger self-interruptions.

A natural strategy to overcome tiredness, or *exhaustion*, is to take a break from the current task. Stopping the current task promotes the replenishment of cognitive resources that were drained in the pursuit of the goal and the task can be resumed later with renewed energy (Madjar & Shalley, 2008). Although the break might be physical, most breaks are mental because attending to a different task also has the positive benefits traditionally associated with physical recess (Lim & Chen, 2009). For example, Lim and Chen (2009) found that 75% of their subjects felt that cyberloafing (using their companies' Internet for non-work related tasks) made their work more interesting by providing the opportunity to engage in mental breaks.

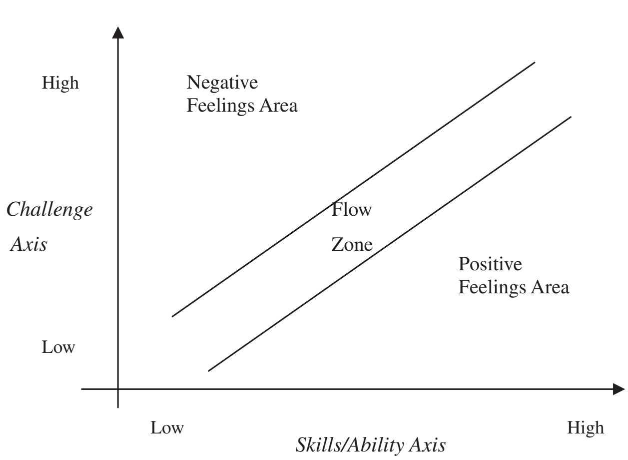

Fig. 1. Flow Theory.

In the case of a temporal setback in the performance of the ongoing task (*obstruction*), focusing on other tasks is also beneficial. A period away from the task allows time for the user to unconsciously continue processing the necessary information thereby improving performance when the original task is resumed (Goodwin, 1987). In fact, taking a break from the current situation when "one is stuck" might allow time for incubation (Jett & George, 2003) and to approach the task later with a different mindset (Speier et al., 2003).

Overall, negative feelings regarding the task or the progress toward the goal are likely to be resolved with self-interruptions in search of other tasks with more rewarding outcomes. The original task will be resumed when the problem preventing its completion disappears and/or when cognitive resources are replenished. Therefore, self-interruptions may help relieve individuals suffering from exhaustion with their current task or experiencing an obstruction in its performance. While it is clear that negative discrepancies would trigger self-interruptions, the mechanisms whereby positive feelings may be responsible for self-imposed breaks are less intuitive. Such positive feelings arise from the realization of being over-qualified for a task, or from faster than expected progress toward task completion.

When the task is too easy for one's level of skill, positive feelings associated with the current task lead individuals to self-imposed stoppages. This strategy helps to overcome the monotony of the ongoing endeavor. In the presence of non-challenging tasks, people may need the additional *stimulation* afforded by new tasks. Positive feelings may also arise when people exceed their expected rate of progress towards a goal. In this case, there is a tendency to reduce subsequent effort (or coast). Slowing down is a self-regulation mechanism to prevent needless energy expenditure as a goal is approached.

In particular, people who have multiple simultaneous concerns would turn to another goal and exert effort in that domain. Instead of optimizing the outcome in one area, they would try to deal with all of the areas satisfactorily. The decision to "satisfice" instead of optimize in a single area allows people to handle multiple goals adequately. In other words, if progress in one area exceeds current needs, the tendency to "coast" would produce a shift to another domain at little or no cost. This *reorganization* strategy helps ensure satisfactory goal attainment across multiple domains (Carver, 2003).

Positive feelings may also induce people to take advantage of emergent opportunities or to engage in exploration to discover enticing alternatives. When individuals experience a better than expected rate of progress in a particular goal, they can afford to engage in opportunistic behavior to discover more exciting possibilities. The positive feelings that lead to *exploration* reflect a broadened focus of attention (Carver, 2003).

To summarize, multitasking occurs when the "state of flow" (Csikszentmihalyi, 1990) in an ongoing task cannot be achieved. Positive or negative feelings regarding the nature of the task and/or the progress towards the achievement of its goal lead to self-regulation of behavior (Carver & Scheier, 2009). In this context, self-interruptions of the ongoing task to attend to other tasks are adjustment mechanisms to seek a more optimal experience. Frustration, exhaustion and obstruction are triggered by negative discrepancies, while stimulation, reorganization, exploration are produced by positive discrepancies. Table 1 summarizes each one.

Table 1
Proposed Typology of Self-Interruptions.

Self-interruption	Description
Negative triggers	
Frustration	Ongoing task is too difficult given the level of skills
Exhaustion	Person experiences cognitive fatigue
Obstruction	Temporary roadblock in the performance of a task
Positive triggers	
Stimulation	Ongoing task is too easy given the level of skills
Reorganization	Restructuring of the workload to improve performance
Exploration	Opportunistic behavior to discover enticing alternative tasks

2.2. Hypotheses

According to our theoretical development, triggers of self-interruptions are intrinsically related to the type of discrepancy in the process of goal attainment. In a multitasking situation, a better than expected progress in one task (positive deviations) redirects attention in search of another area where performance gains can be realized as well (Carver, 2003). In contrast, negative deviations might require many self-interruptions until the underlying causes of the undesirable progress toward the goal can be corrected. Positive divergences can be more easily addressed by diverting attention with a limited number of self-interruptions. However, when a task underway is no longer rewarding (Payne et al., 2007) due to negative discrepancies, more frequent self-interruptions may ensue as people attempt repeatedly to address the problems preventing successful task completion. Therefore,

H1. In the presence of negative triggers, individuals will experience more self-interruptions than in the presence of positive triggers.

In a multitasking situation, negative feelings about the progress or possibility of attaining the goal in the main task have carry over effects that negatively influence performance in the other tasks (Jett & George, 2003). Thus negative discrepancies in one task are likely to have a detrimental effect on overall performance (Gillie & Broadbent, 1989). When self-interruptions are motivated by negative feelings of progress or accomplishment, tasks under way are more likely to interfere with each other and impair effectiveness (Pashler, Johnston, & Ruthruff, 2001). Accordingly, we propose the following hypothesis:

H2. In the presence of negative triggers, individuals will experience lower performance than in the presence of positive triggers.

Individuals can resolve their negative or positive discrepancies by broadening their focus of attention and undertaking other activities (Jett & George, 2003). When people work on several tasks at the same time, their working memory helps them switch tasks by storing information related to the abandoned task and redirecting attention to the new task (König & Oberacher, 2010). Sometimes the newly loaded task representation might be incomplete or suffer from interference from the previous task leading to performance mistakes (Pashler et al., 2001). With repeated self-interruptions, failures to recall the details of previously abandoned tasks are likely to cause errors when tasks are resumed. Thus, we hypothesize

H3. The number of self-interruptions will be negatively related to performance.

Taken together, these hypotheses indicate that negative triggers of self-interruptions may have a multiplicative and detrimental effect on performance. Self-interruptions triggered by negative feelings may occur in larger numbers since people may not be able to solve the original problem that motivated them to self-interrupt. In addition, self-interruptions, due to their disruptive nature can have detrimental effects on performance.

3. Research methods

To test the typology and the hypotheses, an experimental multitasking environment was implemented through a custom-developed application using Microsoft Visual C++. Participants had to work in this restricted multitasking environment and solve a set of pre-defined tasks in a specific period of time. The system featured a main task and five mini-tasks; all presented in different tabs (see Fig. 2). Each task had a correct solution and a time limit for its completion. The aim was to provide a closed multitasking environment with multiple pre-defined tasks of different duration and cognitive requirements where tasks interleaving is more likely to occur (Payne et al., 2007). The main task was a Sudoku problem of medium difficulty. The goal of Sudoku is to fill in all the boxes in a 9×9 grid, so that each column, row and 3×3 box have the numbers 1 through 9 without repetitions. In addition, there were five mini-tasks of shorter duration, one textual, two visual and two numeric series challenges. The textual task required participants to unscramble the letters provided and create up to 20 different words of three or more letters. The visual tasks consisted of identifying the figure or shape that did not fit the pattern in a series of questions. There were two visual task sets with ten problems each. The numeric tasks consisted of identifying the missing number in the series. As in the case of the visual task sets, there were two numeric series sets with 10 problems each.

The maximum allotted time for each task was determined from pilot studies and was set intentionally shorter than the average amount of time a typical user would need to complete these tasks (18 min for Sudoku, 1 and a half minutes for the word task and about 1 min for the remaining four secondary tasks). Time restrictions were in place to avoid participant idleness due to early termination of tasks. The application managed total time on each task to control for the potential effects of time on performance. Moreover, to avoid the effects of task sequence, the tabs were randomized. The main task, however, was always displayed in the first tab. The application kept track of the participant's activity (keystrokes and mouse clicks) and recorded the results for each user. Participants using this application were able to multitask at their *discretion* by clicking on the corresponding tab at any moment.

3.1. Procedures

Before working on the tasks, the application presented each participant with a pre-test questionnaire to collect demographic information including their age, gender, academic level (ranging from 1 = freshman to 4 = senior and 5 = graduate), and level of computer and Sudoku skills, each measured with a 5-point scale (1 = poor and 5 = excellent). Subjects who indicated that they had never played Sudoku before were assigned a zero to the Sudoku skills scale. These demographics were used as controls due to their potential explanatory effects on participants' performance. In this type of environment it can be perceived that participants' age, gender, academic level, computer skills, and particularly their prior Sudoku skills may impact performance. After completing the pre-test questionnaire subjects were taken to a practice round of Sudoku where they had up to 10 min to familiarize themselves with the task. During the actual exercise, the tasks were displayed all at once in different tabs. Upon completion, the application provided a post-test questionnaire to capture whether the participant knew that s/he could switch tasks. The final screen of the interface

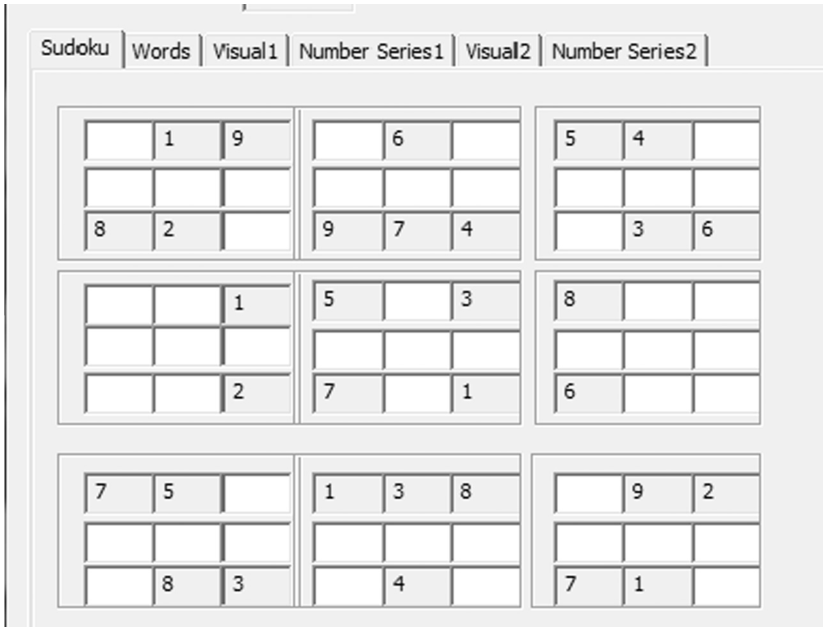

Fig. 2. Tab-based multitasking environment.

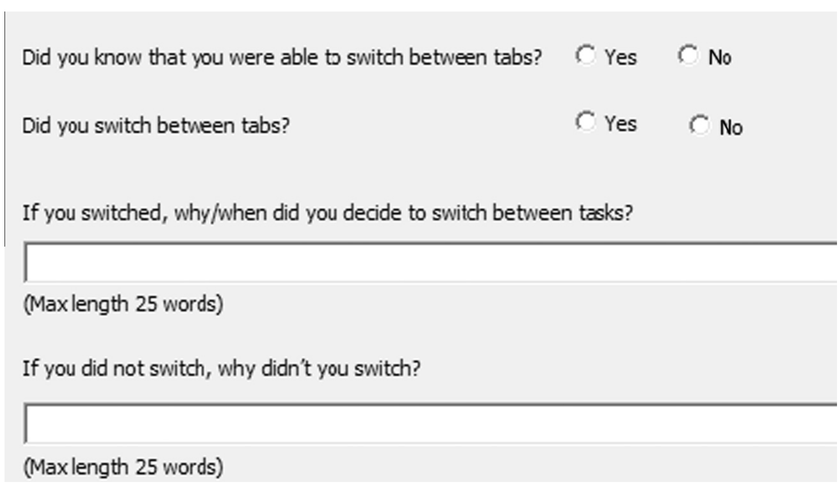

Fig. 3. Open-ended post-test questions.

provided space to answer an open-ended question asking why subjects decided to switch tasks (see Fig. 3).

3.2. Measures

Performance scores for each task were calculated as the number of correct responses a subject entered divided by the total number of required responses. For example there were 49 empty squares in the Sudoku puzzle. The Sudoku score was the percent of correct numbers entered out of 49. Secondary tasks' scores were calculated in a similar fashion (i.e., the number of correct responses entered divided by the number of problem sets). Overall performance was therefore computed as the average of the scores obtained in each task.

The number of *self-interruptions* was calculated as the number of voluntary switches during the completion of the tasks. For example, a subject performing all six tasks sequentially (without multitasking) would have five switches. Therefore, the number of self-interruptions was calculated as the total number of switches (tab clicks) minus five.

3.3. Sample

We recruited a total of 212 participants from the undergraduate student population[3] of a large urban college in the Northeast of the US in two consecutive semesters. In the first semester of data collection, subjects received monetary compensation ($10) for their participation. In the second semester, participants received course credit. While participants were free to undertake the assigned tasks in any order and switch among them at their discretion, an analysis of the post-test questionnaire responses indicated that 26 subjects were not aware that they were free to switch tasks at will. Data from these subjects was removed from the sample. The qualitative answers to the open-ended questions were analyzed for the remaining participants.

[3] Although recruiting was mostly done in the undergraduate population, there were some graduate students who participated in the experiment through word of mouth and flyers.

4. Results

4.1. Validation of the typology

Two independent coders classified the responses to the open-ended question about reasons for switching tasks. Based on Flow Theory, their responses were categorized into three groups: negative, positive, and no-switching. The inter-coder reliability calculated with the percentage of agreement was 91%. The discrepancies between the coders were solved by discussing the differences and reaching agreement in each classification. The agreed upon coding was used in the analysis.

Over 90% of the reasons given by participants were placed in the typology. Only 9% of the reasons (20 answers) could not be classified into any of the self-interruption categories. A closer analysis of these statements indicated that either the participant did not provide meaningful information (8 cases) or participants were trying to make time adjustments given the task time limits (12 cases). Subjects with these types of responses were removed from further analysis.

From the remaining 166 participants, about one third (54) switched tasks for negative reasons. By contrast, 45 participants, about 28%, did so for positive reasons and the rest (67, about 40%) reported no self-interruptions, due to their deliberate strategy to focus on one task at a time. Due to the absence of reasons for switching, the responses of the latter group (no self-interruptions) could not be classified into positive or negative. Their answers explained instead why they did not multitask (i.e., their comments were entered in the second open-ended question of Fig. 3). Most of those explanations were equivalent to the statement "I wanted to finish one task at a time."

Table 2 shows the number and percentage of subjects in each coded category: positive, negative and reported no self-interruptions.

In order to verify whether the reported non-multitaskers did in fact have less self-interruptions than the other participants, we divided the sample into two groups, those who indicated that they focused on one task at a time (i.e., reported no self-interruptions) vis-à-vis those who reported having self-interruptions (positive or negative). According to the results of a *t*-test, the average number of self-interruptions between these two groups is significantly different (Reported No Self-Interruptions Mean = 1.46 vs. Self-Interruption Mean = 4.58; $t = 5.81$; $p < .0001$). From the 67 subjects who reported no self-interruptions, only about half (33) actually had zero self-interruptions (i.e., no switches). The other half had a minimal amount of self-interruptions. This comparison provides an initial validation of the qualitative self-interruption data with respect to actual patterns of behavior. The mean for the reported no self-interruptions group is greater than zero, because although the subjects answered that they did not multitask, some of them did switch tasks to a small extent.

4.2. Test of hypotheses

To test H1 and check whether the participants' amount of self-interruptions varied depending on the nature of the trigger, we conducted an ANOVA, using prior Sudoku and computer skills, age, gender, and academic level as controls. Results shown in Table 3 indicate that those who experienced negative feelings interrupted their work more often than those in the positive category. A Duncan analysis produces three distinct groups ordered by the average number of self-interruptions ($F = 5.01$, $p < .001$, R-squared = 18%). As shown in Table 3, those who interrupted their work due to negative reasons had significantly more switches than subjects who interrupted their work due to positive triggers. Therefore, H1 is supported.

In order to study the consequences of different self-interruption triggers, the 67 subjects who reported no self-interruptions were removed from the sample and the data for the 99 subjects who reportedly engaged in multitasking was analyzed.

Therefore, H2 was tested by analyzing the performance results of the 99 subjects whose answers were classified into positive and negative reasons. The number of self-interruptions collected by the application ranges from 1 to 23 (mean of 4.58 and a standard deviation of 4.61). A zero in the number of switches would indicate that the user chose to perform all six tasks in succession. However, here the minimum value is 1 because those who reported having no multitasking were removed from this group. Overall performance

Table 2
Reasons for self-interruptions.

Triggers	Freq (%)	Examples of illustrative quotes from participants
Negative reasons		
Obstruction	30 (18%)	• *When I couldn't figure out what I was doing wrong* • *In the beginning when I started with the Sudoku and I got a little stuck* • *When I'm stuck on one specific task*
Exhaustion	14 (8%)	• *When I needed to clear my head, I would switch to another task* • *I wanted my mind to be refreshed when I went back to Sudoku* • *After I came a little tired of the Sudoku*
Frustration	10 (6%)	• *I switched because the Sudoku was hard* • *I switched when I got frustrated with the task I was working on at the time* • *Because the Sudoku was making me feel nauious [sic]*
Positive reasons		
Reorganization	31 (19%)	• *To finsih [sic] the easiest one first* • *To knock out all questions I knew before I dealt with difficult ones* • *I wanted to complete the task with less amount of time first*
Exploration	8 (5%)	• *Just to see the actual content of each task* • *To see the other questions* • *Curiosity*
Stimulation	6 (4%)	• *When I get bored from the task and wasn't giving proper attention* • *I switched to avoid getting bored*
Reported no self-interruptions		
Focus-task-strategy	67 (40%)	• *I was focused on completeing [sic] one task at a time* • *I like getting one thing done before moving onto the next*
Total	166 (100%)	

Table 3
Analysis of number and type of self-interruptions.

Type of self-interruption	Number of self-interruptions
Negative	5.26 (A)
Positive	3.76 (B)
Reported no self-int.	1.46 (C)
Model *F*	5.01***
R^2	18%
Type of self-interruptions	14.99***
Sudoku skills	0.00 (ns)
Gender	0.31 (ns)
Age	1.03 (ns)
Computer skills	1.32 (ns)
Academic level	0.97 (ns)

Duncan group (A, B or C) in parentheses.
Significance level:
*** $p < .001$.

was calculated as the average score of the corresponding tasks. The average performance for this group is 39.80 (standard deviation 12.38), and a range of 12.94 to 67.5 out of a possible maximum of 100 points.

For the overall performance analysis, we computed an ANOVA model based on the participants' reasons, once again using prior Sudoku and computer skills, age, gender, and academic level as controls. As shown in Table 4, the model is significant. A Duncan analysis produces two distinct groups. The lowest overall score was obtained by those in the negative trigger group, while the positive trigger group had a higher overall performance. Therefore, H2 is supported. Overall, those who experienced negative feelings performed worse than those who experienced positive feelings, and also performed worse than those who reported no multitasking (Reported No Self-Interruptions Mean = 41.94 vs. Negative Self-Interruption Mean = 37.16; $t = -1.99$; $p < .05$).

It is noteworthy that, according to the results reported in Table 4, two of the control variables (gender and Sudoku skills) are significant. While these two controls are significant explanatory variables for performance, they did not affect the nature of the multitasking triggers. A chi-square analysis of gender with the reasons for self-interruption is not significant (Chi-Square = 0.91). Likewise, a *t*-test showing the Sudoku skills between the two different trigger groups is not significant either (Positive Triggers Mean = 1.47 vs. Negative Triggers Mean = 1.41; $t = -0.22$ (ns)).

Given the importance of the previous level of Sudoku experience for performance, we performed an additional analysis to investigate whether prior skills influenced the positive or negative feelings of task progress or the strategy chosen by participants to solve the assigned tasks. For this analysis, we divided Sudoku skills into three categories: No prior experience (Sudoku Skills = 0), low experience (Sudoku skills <3) and high experience (Sudoku skills $\geqslant 3$). A chi-square analysis of Sudoku skills with self-interruption reasons is not significant (Chi-Square = 3.39). According to these results, participants experienced positive or negative triggers of self-interruptions regardless of their previous level of Sudoku experience.

Table 4
Performance Analysis.

Type of self-interruption	Overall performance
Positive	42.98 (A)
Negative	37.16 (B)
Model *F*	9.76***
R^2	39%
Type of self-interruptions	5.22*
Sudoku skills	38.19***
Gender	7.99**
Age	0.07 (ns)
Computer skills	0.86 (ns)
Academic level	0.13 (ns)

Duncan group (A or B) in parentheses.
Significance:
* $p < .05$.
** $p < .01$.
*** $p < .001$.

H3, which predicted a negative relation between the number of self-interruptions and overall performance, was tested via a correlation analysis for the 99 subjects who reported multitasking. The number of self-interruptions is significantly and negatively related to performance ($\rho = -0.24$; $p < 0.05$). Therefore, those with higher number of self-interruptions had significantly lower overall performance. Thus, H3 is supported.

5. Discussion

The typology developed in this paper proposes different triggers of self-interruptions derived from Flow and Self-regulation Theory, and the conceptualization of task progress and goal attainment in terms of positive and negative discrepancies. The validation of this typology was done in a restricted multitasking environment where participants had to complete six pre-assigned tasks in any order of their choosing. Subjects were asked to report in the post-test questionnaire why they did (or did not) multitask. The qualitative responses of those who reported multitasking were examined and the results indicate that the typology adequately explains most of the reasons for stopping ongoing tasks.

As expected, multitasking triggers included both positive and negative reasons. Negative reasons include frustration, obstruction, and exhaustion, and positive reasons for multitasking include exploration, stimulation, and reorganization. The nature of the triggers influences the pattern of subsequent behavior. For example, when a person experiences negative feelings due to difficulties in performance of an ongoing task, the most frequent reaction is to stop and take a break. Stopping the current task promotes the replenishment of cognitive resources that were exhausted in the pursuit of the goal and allows him/her to resume it later with renewed energy. By contrast, when individuals experience positive feelings because of a better than expected rate of progress in a particular goal, they may also choose to take a break. In this case, the break would allow them to engage in exploratory behavior.

When examining the number of self-interruptions for the different multitasking triggers, those who experience negative feelings choose to stop their work more often than others (as predicted in H1). A user may feel that self-interrupting his work will help in overcoming the negative feelings associated with the current task. Upon his return, task difficulties may still be present and more self-interruptions can ensue. By contrast, self-interruptions due to positive triggers are scarcer and may help to keep the user stimulated and satisfied with his/her performance. As expected, those who experience positive feelings have a better overall performance than those who experience negative triggers (H2). In addition, the number of self-interruptions is negatively correlated with performance (H3).

Our findings suggest that positive triggers are correlated with good performance and negative triggers with more self-interruptions and with bad performance. However, we cannot definitely establish causality. While our theoretical development suggests that negative triggers ultimately affect performance, it is possible that a lower than expected performance produces the self-interruptions. Further experimental investigations are needed in order to establish causality.

5.1. Limitations

While the typology of self-interruptions is the main contribution of this study, it has only been tested in one experimental environment with pre-defined tasks. The application prevented participants from initiating their own tasks such as checking their email or browsing the Web. The nature of the tasks and the knowledge that total time on each task was limited may have affected how participants chose to allocate their time. However, participants were free to organize the performance of their assigned tasks in any order, and switch tasks before their completion. In addition, given the limited space to report the reasons for switching tasks, participants probably reported the most salient cause for self-interruptions. In practice, every self-interruption could be produced by a different trigger. In spite of these limitations, the typology developed in this study and its validation advance our understanding of the drivers and consequences of self-interruptions in multitasking environments.

6. Implications for theory, research, and practice

Although the distinction between self-initiated and externally-initiated interruptions has been acknowledged (Miyata & Norman, 1986), in-depth research on self-interruptions is particularly scarce. In this context, our typology of self-interruptions fills a theoretical and empirical gap. Since the proposed typology is built upon the integration of Flow Theory with Self-regulation of behavior, its theoretical roots are firmly established. Flow Theory provides an insightful view of the balance between personal skills and task challenges, and Self-regulation Theory sheds light on alternative triggers of self-interruptions. Future work at the theoretical level should seek to enhance the proposed typology with other categories, such as time adjustments. Time-related reasons could be categorized as positive or negative; depending upon the nature of the adjustment, or they could be considered a separate category. Further theoretical development is needed to determine the placement of time adjustments in the proposed categorization.

In addition to its strong theoretical roots, the classification of self-interruptions developed in this study has many potential uses. In the literature, the current distinction between internal and external interruptions assumes that all self-initiated (internal) interruptions are alike and that all are beneficial because the person controls the timing and the content of the interruption (Rennecker & Godwin, 2005). Our proposed classification shows that there are different types of self-interruptions depending upon the conditions under which they are initiated. Awareness of the differences in self-interruptions has research and practical implications. Further research using the proposed classification will be better able to explain in more detail the nature and type of self-interruptions and can begin to elucidate the differential effects of self-interruptions on performance. At a more pragmatic level, an understanding of these differences can be used to prescribe specific courses of actions or regulate behavior for users who engage in self-interruptions.

From the research standpoint, the typology could be applied to other experimental environments in order to extend its validation. For example, future research can examine the applicability of the proposed triggers in actual organizations, when workers are performing real tasks in a less controlled environment. In more controlled environments, future studies can vary the number or nature of the tasks and compare the performance effects of multitasking due to self-initiated interruptions vs. multitasking due to external mandatory interruptions, such as electronic notifications. Cumulative validation efforts with different populations and settings would solidify the proposed classification.

At the practical level, the results of this study indicate that people multitask more when there are negative feelings associated with the primary task, for example, when a user becomes frustrated, stuck, or saturated. By contrast, positive feelings also lead users to switch tasks but not as often. Understanding the triggers of multitasking can help designers create interfaces that are conducive to optimal task performance. This objective can be achieved by counteracting the negative feelings around task performance or by facilitating multitasking breaks without losing the context of abandoned tasks. For example, as Jin and Dabbish (2009) suggest, one way for designers to improve users' performance when resuming their primary task is to add a replay of the users' last few actions.

In the workplace, an enhanced understanding of the triggers and consequences of task switching can raise user awareness about the importance of minimizing unnecessary self-interruptions when handling important tasks (Palladino, 2007). This knowledge is important for both managers and employees who engage in multitasking behavior. When the performance results of a person's primary task is critical, limiting multitasking activity with behavioral controls or software restrictions may be beneficial.

The contribution of this study is to provide a theoretically developed and empirically tested typology of self-interruptions. The integration of flow and self-regulation theories indicates that self-interruptions occur when the user fails to achieve a flow state with the ongoing task and engages in self-regulation behavior to improve performance. Consistent with out-of-flow conditions, people may experience positive feelings when over-qualified for the task at hand, or negative feelings when their skills are insufficient for the task. In both cases, self-interruptions will ensue as a result of self-regulation of behavior. However, the drivers of self-interruptions are significantly related to performance. Results of the empirical tests, with data collected from a sample of participants using a custom-developed multitasking environment, provide an initial validation for the typology and the proposed hypotheses.

In sum, the proposed typology has descriptive and prescriptive uses. As a descriptive tool, the ability to classify the nature of self-interruptions is poised to advance our understanding of the origin and effects of self-interruptions. Although they are all initiated voluntarily, they should not receive the same treatment. As a prescriptive tool, we can use this finer grained classification to help understand actual Information Technology use and thereby recommend solutions for more effective working conditions.

7. Conclusion

This study proposes a typology of triggers for discretionary self-interruptions in computer-mediated work based on the integration of Flow and Self-regulation Theories. The typology was validated with a sample of participants working in a custom-developed multitasking environment with pre-defined tasks. The results of the validation indicate that the typology incorporates the spectrum of reasons for self-imposed interruptions stemming from positive and negative discrepancies in the process of goal attainment. Results also suggest that those who experience negative feelings stop their work more often than others. A high number of self-interruptions in the flow of work coupled with performance difficulties may produce sub-optimal results across all tasks. Thus, negative triggers of self-interruptions can unleash a downward spiral that ultimately affects performance.

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