

Effects of Interruptions on Creative Thinking

Research-in-Progress

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Abstract

Ubiquitous connectivity has brought about continuous interruptions to our thought processes and tasks. Many people have expressed the concern about potential deterioration of performance and productivity caused by the division of attention and fragmentation of thoughts associated with interruptions in the mass media and on the web. This research offers a novel insight into the effects of interruptions on creative thinking. Drawing on the recent observation that processing disfluency could elevate the construal level that people use to mentally represent objects and conceive ideas, which in turn facilitates creative cognition, we suggest that intermittent low-cognitively demanding interruptions can enhance creative thinking. However, if interruptions impose significant cognitive load on the individual, creative thinking will be impaired. Results from a preliminary experiment largely confirm our propositions.

Keywords: Interruptions, processing disfluency, creative thinking, creativity, construal level theory

Introduction

Sophisticated information and communication technologies (ICTs) grant us constant social connectivity. While bringing about numerous benefits, this ubiquitous connectivity also exposes us to continuous interruptions that disrupt our thinking processes and tasks (Carr 2010; Conley 2011). For example, office workers are interrupted every five minutes by e-mails alone (Jackson et al. 2001). Undergraduates are interrupted every two minutes by instant messages, e-mails, and other sources of disruptions when using computers (Benbunan-Fich and Truman 2009). As NBC columnist Bob Sullivan (2013) puts it, “Interruptions are the scourge of modern life. Our days and nights are full of gadgets that ping, buzz and beep their way into our attention, taking us away from whatever we are doing”.

Interruptions are often related to loss of concentration and focus, which are believed to be the key to superior performance and productivity. The potential deterioration of performance and productivity caused by the division of attention and fragmentation of thoughts associated with interruptions has been widely discussed in the mass media and on the web with comments such as “kids interrupted: the price of losing concentration”, “student can't resist distraction for two minutes ... and neither can you”, and “improving our ability to multitask hampers our ability to think deeply and creatively” (Carr 2010; Sullivan 2013).

This research addresses the above concerns by offering a novel insight into the effects of interruptions on creative thinking. Drawing on the recent observation that processing disfluency could elevate the construal level that people use to mentally represent objects and conceive ideas, which in turn facilitates

creative cognition, we suggest that intermittent low-cognitively demanding interruptions can enhance creative thinking. However, if interruptions impose significant cognitive load on the individual, creative thinking will be impaired. Results from a preliminary experiment confirm our propositions.

Theoretical Foundation

Effects of Interruptions

Interruptions are events unrelated to a focal task that disrupt an individual's cognitive focus on the focal task (Corragio 1990; Fisher 1998). Both an individual's internal mental operations and external environments can produce interruptions. Internal interruptions are often referred to as mind wandering, spontaneous cognitive events, daydreaming, stimulus independent thoughts and intrusive thoughts (Antrobus et al. 1966; Gold and Reilly 1985; Klos and Singer 1981). However except for people with serious concentration issues, the majority interruptions arise without following individuals' discretion. External interruptions occur in certain form of randomly occurring, brief notification from the external environment, which are becoming increasingly common for people in modern society. For instance, office workers face frequent interruptions from emails, phone calls and visits from co-workers (Jackson et al. 2001). The advent of modern communication technologies has multiplied the chance for individuals to be interrupted when they are trying to concentrate on a task. People receive notifications from various sources, including their friends and push message service providers.

The cost of interruptions is high. Cognitive processing of the focal task and the interruption is often drawn from the common pool of cognitive resources (Norman and Bobrow 1975). Irrelevant interruptions may drain the cognitive resources, leaving limited cognitive resources available for the focal task. Indeed, most concerns on the impacts of the intermittent interruptions are related to the resultant cognitive exhaustion, which can lead to performance degradation.

On the other hand, interruptions can lead to positive outcomes. The Zeigarnik effect is perhaps the most well-known consequence of interruptions (Zeigarnik 1938). It suggests that when interrupted, people tend to experience "intrusive thoughts about an objective that was once pursued and left incomplete" and will show greater motivation for and better memory of the interrupted task. Interruptions may also produce better outcomes by promoting a more productive use of time, giving extra time for ideas to mature, or encouraging healthy breaks from complex tasks (Madjar and Shalley 2008). Of particular relevance to our focus on creativity, research has documented a self-initiated break can improve creativity performance because it allows the mental operation of incubation to occur whereas external interruptions forcing one to suspend the focal task hurt creativity (Beefink et al. 2008; Madjar and Shalley 2008).

Various IT and social media applications have driven the external interruptions to an unprecedentedly high level. These intermittent technological interruptions fragment people's thinking process, leading to disfluent processing of the focal task. However, the investigation of the consequences of such disfluent cognitive processing induced by interruptions is limited in the extant literature. This research pursues this direction and specifically focuses on the effects of interruptions on creative thinking.

Processing disfluency is a metacognitive experience of ease or difficulty associated with a cognitive process and often perceived as a lack of "the subjective experience of ease or speed in processing information" (Oppenheimer 2008). An important consequence of processing disfluency is a heightened construal level and the associated abstract thinking (Alter and Oppenheimer 2008).

Construal level theory (CLT) (Trope and Liberman 2003) suggests that people may mentally represent objects and tasks at different levels of abstraction: a low level of mental representation is more concrete whereby people focus on specific and contextualized information, whereas a higher level of mental representation is more abstract whereby people emphasize on general and decontextualized information. The construal level that people use to mentally represent objects and events is malleable and often affected by environmental stimuli. For instance, a temporal distant (close) event will invoke a high (low) construal level. Recently, research has documented that disfluent information processing a person experiences would result in a systematic upward shift to the high construal level. For instance, Alter and Oppenheimer (2008) presented participants with city names (e.g., New York) in either hard-to-read (i.e., disfluent) or easy-to-read (i.e., fluent) fonts and asked them to evaluate how far away the city was relative to their current location and to describe the city. Participants who saw the disfluent fonts judged the city

to be farther away and described it using more abstract terms than those who saw fluent fonts, indicating that disfluent stimuli elicited a high construal level and activated more abstract thinking. Relatedly, Liu (2008) explicitly shows that interruptions induce a high construal level. She suggests that, by default, people tend to engage in concrete and bottom-up cognitive processing, a key characteristic of low construal level mental state. At the low construal level, one processes the information at hand concretely in a piecemeal manner, focusing on and attending to the data in detail. However, when interrupted, one will engage in a top-down, high-construal processing.

One key feature of high construal level is abstract thinking whereby the individual can more easily relate to remote items or distant concepts and conceive ideas divergently (Friedman et al. 2003). On contrary, individuals at a lower construal level will be more likely to restrain themselves to items that are directly and concretely related. There is evidence that thinking abstractly and divergently can promote creativity.

Creativity

It is generally believed that, to be creative, one must “think outside the box” and engage in divergent thinking (Guilford 1967; Runco 2010; Simonton 1999). Divergent thinking requires that individuals deviate from some easily accessible conceptual associations within a domain and construct associations between previously unassociated cognitive elements (Bailin 1987; Guilford 1950; Ward and Wickes 2009). The resulting unusual mental associations serve as the basis for novel ideas (Langley and Jones 1988).

Research has accumulated extensive evidence showing that a high construal level contributes to divergent thinking, leading to enhanced creativity. When solving a problem requiring creativity, people who form a high construal mental representation of the problem components can think abstractly and are less likely to fixate (Smith 1995). Consequently, they are able to overcome the constraints of those conceptual associations that are easily accessible and establish unusual mental associations among diverse and remote concepts. In contrast, people at a low construal level tend to think concretely and common associates related to the problem become overaccessible, rendering them less likely to deviate from usual solutions and generate novel ideas (Förster et al. 2004). For instance, Förster et al. (2004) find that a high level abstract mental representation elicited by a distant temporal perspective facilitates performance on the subsequent creativity tasks such as listing creative reasons why people should greet someone and generating creative ways to improve one’s room.

Recent research has indicated that environmental distractions and chaos can induce a high construal mental state, which in turn promotes creativity. For instance, Mehta et al. (2012) document that a moderate background noise leads to a high construal level of abstracting thinking and consequently enhances individuals’ performance on a series of creative tasks such as brainstorming ideas for a new type of mattress or enumerating uncommon uses for a common object. They reason that the noisy environment interrupts people’s thinking process, shifting their construal level upward and making them think abstractly instead of concretely, which in turn drive them to generate more creative ideas. Relatedly, Vohs et al. (2013) observe that environmental disorderliness stimulates creativity, leading people to generate more novel alternative uses for ping-pong balls and prefer a novel product option over the traditional one.

However, creativity tasks require adequate cognitive resources. When one’s cognitive resources are depleted, information processing is impaired and creativity performance may decline. Prior research shows that depletion of cognitive resources may decrease individual’s creativity performance. In his studies on human creativity, Carruthers (2002) demonstrates that the same cognitive resources are essentially shared by creative thinking and problem-solving. Studies on brain-imaging have also revealed that the brain area responsible for attentional processes is also responsible for creative thinking (Fink et al. 2010). In situations when an interruption task or event consumes too much cognitive resources, a person will choose to reduce the extent of information processing and thus not be able to think creatively (Woodman et al. 1993).

Hypotheses

Our general view is that whether an external interruption would promote or hurt creative thinking will depend on its cognitive resource requirements.

When an external interruption forces one to suspend the focal task and respond to the interruption, one's train of thoughts is fragmented, resulting the focal task to be processed in a disfluent manner. Because processing disfluency can shift the construal level upward (Liu 2008) and induce abstract thinking that benefits creative cognition (Mehta et al. 2012), an interruption can potentially enhance one's creativity performance. But whether such an enhancing effect can occur or not will be contingent on the requirement of cognitive resources of the interruption. If the interruption is just a brief one that does not demand considerable cognitive resources, an abstract mental state and sufficient cognitive resources will facilitate the individual to recruit remote associates in thinking, increasing the probability that new conceptual combinations are formed, which constitutes the basis of creative thinking. However, if the interruption imposes excessive processing load, the cognitive resource available for the focal task will be limited, leading to reduced processing of the focal task. Although the individual is still in an abstract mental state as the consequence of being interrupted, the positive effect of this abstractness is likely to be counteracted by the reduced information processing that is simultaneously induced by the interruption. This reduced processing can prevent one from establishing remote associations that are necessary for creativity.

H1: Interruptions of low cognitive resource requirements will enhance creative thinking.

H2: Interruptions of high cognitive resource requirements will impair creative thinking.

Because the beneficial effect of low cognitively demanding interruptions on creativity is elicited by their fragmenting of one's thought process, we further propose processing disfluency as the underlying cognitive mechanism. On the other hand, although processing disfluency is also induced by high cognitively demanding interruptions, it will not promote creative thinking due to the simultaneous cognitive exhaustion.

H3: Processing disfluency mediates the effect of low cognitively demanding interruptions on creativity thinking.

Research Methodology

A set of experiments to test our hypotheses are designed. We have started one and are still in the process of data collection. This paper presents the preliminary results based on the data collected.

Design, Stimuli, Materials, and Procedure

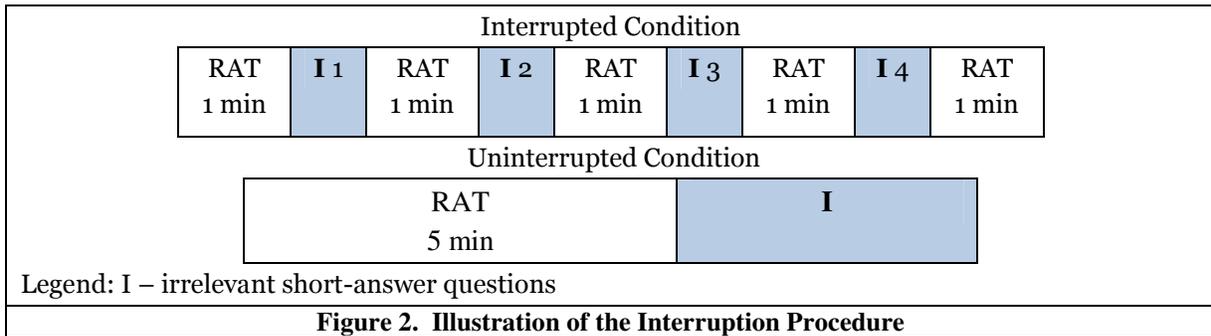
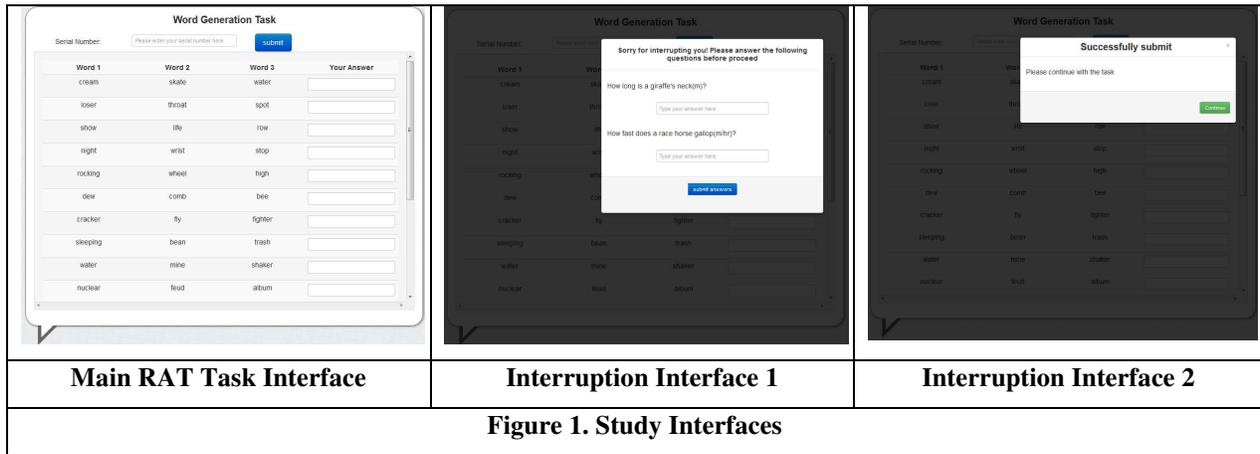
The experiment involved a 2 x 2 between subject design (interruption: present while subjects working on the main task vs. present after subjects finish the main task; interruption type: low cognitive resource requirements vs. high cognitive resource requirements). 43 university students participated in the study in exchange for \$4.

The focal task was Remote Associates Test (Mednick 1962). It is a classic tool to quantitatively measure one's creativity potential. In the test, subjects are presented with a set of three stimuli words. The three words in each set appear unrelated to each other yet are in some way linked to a fourth unreported target word. The tested person needs to determine the target word. For instance, for the set of words "Shelf", "Read", and "End", the target word would be "Book". The total number of target words generated reflects the individual's creative thinking. To score high in RAT, one must engage in divergent thinking to identify uncommon associations that stimulus words may have instead of focusing on the most common and familiar associations of those words. Thus, RAT has been repeatedly used in creativity studies as a reliable indicator of one's cognitive creative thinking (e.g., Gino and Wiltermuth 2014; Mehta et al. 2012). In our experiment, we presented subjects with 20 sets of words. Figure 1 shows the interface of RAT task.

We developed two sets of short-answer questions as interruptions of differential cognitive resource requirements. The low cognitively demanding interruptions were general knowledge questions which required no in-depth thinking to solve (e.g., "Which country in the world has the largest number of people?" and "Name one country in European Union."). Answers to these questions can be retrieved easily from memory rather than constructed (Cheema and Patrick 2012). The high cognitively demanding interruptions were cognitive estimation questions which may require respondents to engage in deeper processing and consume more cognitive resources (e.g., "How long is a giraffe's neck?" and "How fast

does a race horse gallop?”). Both sets of questions were developed based on Alelrod and Millis (1994) and Cheema and Patrick (2012).

Subjects working on the RAT main task were either interrupted or un-interrupted. Those who were assigned to the interrupted condition experienced 4 interruptions. In each interruption, a dialog message box popped up, asking subjects to answer 2 irrelevant interruption questions (Figure 1). Subjects needed to answer both questions before they could continue with the focal RAT task. In total, subjects had to answer 8 (2x4) interruption questions. Subjects were given 5 minutes to complete the RAT. 4 interruptions popped up in an interval of 1 minute (±5 seconds depending on local system refreshing speed). Thus subjects had 1 minute to focus on RAT before encountering an interruption. After the fourth interruption, they still had 1 minute for RAT before the system stopped them. The timer would pause when subjects were answering the irrelevant interruption questions, and resume when they came back to the RAT task. In the un-interrupted conditions, subjects focused on the RAT task continuously without encountering any interruptions. The system stopped them after 5 minutes and directed to the 8 irrelevant questions. Figure 2 illustrates the interruption procedures.



Research Variables

Creativity performance was measured with participants’ RAT scores. The scales used to measure processing disfluency and a set of control variables are shown in Table 1.

Variable	Scale
Processing disfluency (Mehta et al. 2012)	How distracting did you find the short-answer questions during the word-generation task? (1= completely not distracting; 7 = very distracting)
	How well were you able to concentrate on the word-generation task? (1= completely unable to concentrate; 7 = fully concentrate)
	To what extent did you feel your thinking for the word-generation task was interrupted by the short-answer questions? (1= seriously interrupted; 7 = not interrupted at all)
Perceived	The word-generation task (the interrupting short-answer questions) were

difficulty of RAT & interruption questions	<ul style="list-style-type: none"> • difficult (1= strongly disagree; 7 = strongly agree) • challenging (1= strongly disagree; 7 = strongly agree) • tricky (1= strongly disagree; 7 = strongly agree) • not easy to solve (1= strongly disagree; 7 = strongly agree)
Involvement in RAT & interruption questions	How much effort have you put in the word-generation task (the interrupting short-answer questions?) (1= no effort at all; 7 = a lot of effort)
	How much thought did you give to the word-generation task (the interrupting short-answer questions)? (1= not much thought at all; 7 = a lot of thoughts)
	How involved were you in completing the word-generation task (the interrupting short-answer questions)? (1 = I wasn't involved at all; 7 = I was completely involved)
Personal creativity (Gough 1979)	<p>In real life, I am ... (1= strongly disagree; 7 = strongly agree)</p> <ul style="list-style-type: none"> • a person with a lot of new ideas • a person who appreciates new products • a person with a wide range of interests • a person who is resourceful
Multi-tasking habits	<p>When I use laptops/PCs, I usually... (1= strongly disagree; 7 = strongly agree)</p> <ul style="list-style-type: none"> • do more than one task concurrently • have my social network accounts logged in • switch back and forth between multiple tasks

Table 1. Variable Instruments

Preliminary Results

Manipulation Checks

Subjects from un-interrupted group reported not having seen any interruptions when doing RAT, while all subjected from the interrupted conditions reported encountering more than one dialogs coming out, indicating that subjects perceived the interruptions as designed.

Manipulation check of subjects' perceived difficulty of the interruptions across the two interruption types confirms that subjects in the cognitive estimation condition perceived the interrupting questions to impose more cognitive load than those in the general knowledge condition ($M_{CE} = 4.36$, $M_{GK} = 3.04$, $t = 2.56$, $p = 0.01$).

Results and Interpretations

Since subjects in the un-interrupted condition who were directed to work on either cognitive estimation or general knowledge questions after completing RAT did not differ in the number of words generated ($M_{GK} = 6.55$, $M_{CE} = 6.86$), we averaged subjects' RAT scores to form the RAT scores for un-interrupted condition. Thus, we transformed the analysis into a 3 level one-way ANCOVA test (interruption: low cognitive resource requirements vs. high cognitive resource vs. no-interruption). Table 2 presents the RAT scores across treatment conditions.

	Interruption Treatments		
	Interruptions - General Knowledge	Interruptions - Cognitive Estimation	No-interruptions
RAT score	10.82 (n = 11)	4.64 (n = 11)	6.62 (n = 21)

Table 2. Summary of RAT Scores across Conditions

As expected, the ANCOVA analysis with interruption type as predictor, RAT performance as dependent variable, and all control variables as covariates reveals a significant effect of interruption type on RAT score ($F = 3.89$, $p = 0.03$). Contrast analyses shows that subjects who experienced frequent low cognitively demanding interruptions (i.e., general knowledge questions) generated more words ($M = 10.82$) than those who encountered no interruptions ($M = 6.62$, $t = 2.82$, $p < 0.01$) and those who experienced frequent high cognitively demanding interruptions (i.e., cognitive estimations) ($M = 4.64$, $t =$

4.86, $p < 0.001$). The difference between the latter two was marginally significant ($t = 1.83$, $p = 0.08$). These results lend support for H1 and H2.

We followed Baron and Kenny's approach (1986) to test the mediation effect of processing disfluency on the relationship between low-cognitive demanding interruptions and creativity performance. All mediation criteria were met. Regression analyses yielded that, (1) interruptions (absent vs. present) had a positive effect on processing disfluency ($t = 10.37$, $p < 0.001$), (2) interruptions had a positive effect on creativity performance ($t = 2.81$, $p = 0.008$), (3) processing disfluency had a positive effect on creativity performance ($t = 3.39$, $p = 0.002$), (4) when creativity performance was regressed on both interruptions and processing disfluency, the effect of interruptions became insignificant ($t = -0.364$, $p = 0.73$) and only a marginal significant effect of processing disfluency emerged ($t = 1.89$, $p = 0.07$). These results are consistent with our theorizing that processing disfluency was responsible for the heightened creativity, lending support for H3.

Discussions

Summary and Future Research Agenda

In this research, we show that one's creative thinking could profit from intermittent interruptions of low-cognitive resource requirements. However, when encountering interruptions that consumed excessive cognitive resources, one's creativity was hindered. We also demonstrate that the processing disfluency caused by the distractions was the underlying cognitive mechanism leading to enhanced creativity.

Much work is in the pipeline to strengthen the robustness of our theorizing. First, we are still collecting data with the current experimental setting. We speculate the marginal mediation effect of processing disfluency was due to the relatively small sample size and expect that a significant effect would emerge when more data are obtained.

Another study is designed to examine creativity with a different task in an attempt to strengthen the reliability of current findings. Subjects will be asked to generate creative use of a common object (e.g., ping-pong balls). We will also measure subjects' processing disfluency and construal level with the objective to establish the interruption – processing disfluency – high construal level – enhanced creativity relationship. Subjects will be either interrupted or not interrupted during the idea generation process. After completing the task, they will complete behavioral identification form (Vallacher and Wegner 1989) to measure their situational construal level as well as indicate processing disfluency they have experienced. With such a design, we expect to provide a more comprehensive and robust explanation of the cognitive mechanism underlying the effect of interruptions on creativity.

We will also examine the long term effects of interruptions in an experiment which grants subjects extra time to focus on the focal task after experiencing intermittent interruptions. The enhanced or impaired creative thinking is a temporal effect that is specifically elicited by the interruption. When the low cognitively demanding interruption is withdrawn, the individual is able to focus on the focal task and a normal concrete processing style is resumed (Liu 2008). Because, compared to abstract thinking, concrete thinking hinders creative cognition, we expect that, over time, the enhancing effect associated with the interruption will be reduced or nullified, leading interrupted ones and uninterrupted ones to perform similarly in the creativity task. However, when the interruption of high cognitive resource requirements is removed, the cognitive resources taken by the interruption will be released and available for the focal task. Such an increased supply of cognitive resources will allow the individual to catch up and the performance gap between individuals distracted by high cognitively demanding interruptions and the uninterrupted ones will shrink.

Experiments extending our propositions of interruptions' creativity-enhancing/impairing effects to product evaluation and choice context are also under design. Prior research suggests that innovative consumers are more likely to adopt novel products (Im et al. 2003). Thus, we expect that when a product evaluation process is suspended by low-cognitively demanding interruptions, consumers will be more likely to choose the innovative product. However, when the cognitive load of the interruptions increases, consumers would prefer the conventional product.

Theoretical Contributions and Practical Implications

ICT-related interruptions are increasingly unavoidable in this digitally wired world. This study contributes to the heated discussion on what they would do to human's cognition. It shows that these interruptions may either enhance or impair creative thinking and when and why such enhancing and impairing effect will occur.

The research contributes to the literature of interruptions. While past research has shown that only self-initiated task switching can improve creativity, we demonstrate that external imposed interruptions could facilitate creative thinking when they demanded low cognitive resources but hindered creative thinking when they required high cognitive resources. Departing the incubation account, we propose a relatively high construal level induced by information processing disfluency associated with interruptions as the underlying cognitive mechanism. The research also enriches the literature of creativity. Adding to the documentation of the positive effect of ambient noise (Mehta et al. 2012) and contextual disorderliness (Vohs et al. 2013) on creative thinking, we identify interruptions associated with ICT use as another important environmental distraction affecting creative cognition. Considering the penetration of ICT into our work and life, we believe this theoretical contribution is valuable.

The research has important practical implications. Interruptions induced by ICT are pervasive in the workplace and educational institutions. The value of creativity is increasingly being recognized in our society (Florida 2002; Madjar and Oldham 2006). Many people rely on creative thinking for personal and corporate success. For instance, students need to brainstorm interesting ideas for essay assignments, researchers need to conceive novel research topics, product developers, fashion designers, and architects need to generate new designs, and executives need to look for creative solutions to business problems. Very often they complete their work on digital devices which at the same time expose them to interruptions originating from their social networks. A deep understanding of the effects of interruptions is critical for people to regulate their use of ICT and design their workflow. As our research findings suggest, when people are engaging in a task requiring creative thinking, they need not try every effort to disconnect themselves from their social networks digitally and it would be alright if someone interrupts them for a light conversation online. This study also sheds important light for companies on how to formulate their ICT use policy and design the computer-based work system. For example, companies may not benefit if they disable online connectivity of their computer-based work systems for employees whose creative thinking matters a lot. We also expect our future research of the effects of interruptions on creative and innovative product evaluation and choice could provide richer implications to e-commerce practitioners.

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