Unexpected Distractions: Stimulation or Disruption to Creativity

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Unexpected Distractions: Stimulation or Disruption for Creativity

A dissertation presented

by

Wannawiruch Wiruchnipawan

to

The Department of Business Studies

in partial fulfillment of the requirements

for the degree of

Doctor of Philosophy

in the subject of

Organizational Behavior

Harvard University

Cambridge, Massachusetts

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Unexpected Distrac
tions: Stimulation or Disruption for Creativity

Abstract

This dissertation examines when and how unexpected distractions stimulate or disrupt the creative process. Specifically, I argue that these distractions could introduce useful information and initiate a cognitive break that stimulates a fresh look at the creative task while allowing unconscious thought to process acquired information. Unexpected distractions are, however, disruptive once the new information, relevant or not to the creative task, prompts cognitive overload—the moment in which required cognitive resources exceed available cognitive resources for information processing. The creative process implicates two cognitive sub-processes, divergent thinking and convergent thinking, which influence the novelty and feasibility of the creative product, respectively. Divergent thinking, which is the process of generating new ideas, likely reaps the aforementioned benefits of unexpected distractions, but only until cognitive overload occurs, after which point additional distractions disrupt the forming of new ideas. On the other hand, convergent thinking, the process of deriving the best idea, should suffer from any level of distractions. First, the convergent process profits less from the unconscious associative processing of acquired information. Second, convergent thinking demands information that is directly related to the selected idea or the context in which that idea will be implemented, rendering information transmitted by unexpected distractions mostly irrelevant. Irrelevant information is particularly cognitively taxing and prone to cause cognitive overload. In the lab and online, I found an inverted u-shaped relationship between the frequency of unexpected distractions and the output of

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divergent thinking (operationalized as the novelty of generated ideas) and a negative relationship between the frequency of unexpected distractions and the output of convergent thinking (operationalized as the feasibility of selected ideas). I also found support for the first relationship and partial support for the second relationship using field data from an IT company in Thailand for which I developed measures for evaluating novelty and feasibility in software work. I discuss the implications of these findings for the literature on creativity, cognitive processing, and group brainstorming.
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Introduction

Individuals are surrounded, voluntarily or not, by a multitude of distractions in the workplace (Cellier & Eyrolle, 1992; Kirmeyer, 1988). Distractions may present themselves in various forms, all siphoning some level of attention from the task at hand (Jett & George, 2003). Extra conveniences that are integrated into the modern work environment, such as open office spaces, real-time communication devices, and the Internet, often increase office distractions. These conveniences ease access to other people’s expertise and knowledge, thereby facilitating creative collaboration, yet they may exact a cost on employees’ concentration on the task at hand. An open office layout, for instance, encourages instant brainstorming and question asking, but it could also distract employees from their own work. Or members of a virtual team located in different geographical locations can promptly bounce off and test creative ideas with one another via Internet-enabled messaging systems, but they risk interrupting those on the other end of the line.

Creativity is defined the production of new and useful products and services (Amabile, Conti, Coon, Lazenby, & Herron, 1996; Kampaillis & Valtanen, 2010; Shalley & Gilson, 2004). It is essential to the modern work environment because of its role in begetting organizational innovation and a competitive advantage (Nonaka, 1991; Scott & Bruce, 1994; Simonton, 2000). The creative process is not a simple cognitive process. It entails complex cognitive processing (Amabile, Goldfarb, & Brackfield, 1990) and sustained focus and effort (Amabile, 1996; Newell, Shaw, & Simon, 1958), which render creative tasks particularly vulnerable to all sorts of distractions.

Scholars and practitioners have condemned distractions as disruptive to work patterns, periods of reflection, and work progress (Berger & Merrit, 1998; Mintzberg, 1990; Oldham, Kulik, & Stepina, 1991, Thomas & Ayres, 1998), especially work that requires
sustained focus and effort (Jett & George, 2003), such as creative work. Nonetheless, not all
distractions are disruptive. Expected distractions, such as coffee breaks, web surfing, or
scheduled meetings, are planned and often institutionalized. Distractions of this sort
generally have a positive connotation; they are likely arranged and timed not to disrupt the
work flow while allowing for a cognitive break, which could alleviate fatigue and boredom
(Csikszentmihalyi, 1975; Henning, Sauter, Salvendy, & Krieg, 1989). Indeed, scholars have
associated task autonomy, or freedom and discretion in conducting a task (Breaugh, 1985;
Individuals with task autonomy could plan some distractions in their task to refresh and
boost creativity. How well individuals do so, however, depends on their personal disposition,
experience, skill, and the task at hand. For example, individuals with low self-control perform
worse in a creative task when given task autonomy (Chang, Huang, & Choi, 2012). That is,
how expected distractions affect creativity is likely endogenous to the individual.

Akin to expected distractions, unexpected distractions, which are the focus of this
dissertation, consume time, but they can be quite disruptive. Unexpected distractions are
unplanned and sometimes unwanted. In his TED Talk, Jason Fried (2013), a software
entrepreneur and founder of a well-known American web application company, testified to
the disruptive nature of unexpected distractions. Specifically, Fried acquitted self-initiated
distractions such as Facebook and Twitter from upsetting the workflow but singled out M&M,
which stands for unplanned interruptions by managers and meetings, as the reason “why
work doesn’t happen at work.” Indeed, unexpected distractions, such as unanticipated
phone calls, impromptu meetings, or surprise office visits, can prompt a temporary halt of
attention from the task at hand, compromising work progress (Grove, 1983; Perlow, 1999).
Experimentally manipulated unexpected distractions in the form of interrupting tasks have
been found to hurt decision-making performance on complex intellectual tasks arguably due
to information overload (Spier, Valacich, & Vessey, 1999). In addition, being unexpectedly
distracted could trigger negative emotional responses (Zijlstra, Roe, Leonora, & Krediet,
1999) and an overwhelming sense of not having adequate time to do all the work, known as
“time famine” (Perlow, 1999), likely hurting work performance.

That said, unexpected distractions have their own merits. They can cognitively
stimulate the creative process in various ways, depending on whether their content is related
to the task at hand. When unexpected distractions introduce new cognitive inputs that are
relevant to the task at hand, even slightly, there are three channels through which they might
promote creativity. First, the relevant cognitive inputs could transmit useful information, such
as the supervisor’s real-time feedback, which might otherwise be inaccessible through more
established channels (e.g., scheduled meetings and reports; Kotter, 1982). Real-time
feedback provides a checkpoint that encourages desirable behaviors, discourages
undesirable ones, and promotes fluency and quality of creative idea generation (Jung,
Schneider, & Valacich, 2010), and if it is informational as opposed to controlling (Deci &
Ryan, 1985), it replenishes the sense of competence, renews the task focus, and clarifies
the task goal, facilitating creative performance (Amabile, 1988; Bailyn, 1985).

Second, the new information may broaden the repertoire of ideas from which
individuals draw their ideas to make creative connections. Because creative ideas arise from
non-obvious associations of existing ideas to solve a particular problem (Baughman &
Mumford, 1995; Chua & Iyengar, 2008), information expansion boosts creativity as it
increases the type and the quality of cognitive inputs that may be recombined to produce
creative ideas.

Third, exposure to familiar sensory stimuli and task-related information could improve
memory and idea retrieval and recombination. For example, olfactory stimuli have been
shown to improve performance in memory retrieval exercises (Cann & Ross, 1989).
Retrieval of stored knowledge may facilitate recombination of the knowledge to produce creative ideas. A neuroimaging study also showed that certain areas in the brain regions responsible for memory retrieval, semantic integration, and attentional processes had increased neural activity in participants who were exposed to related ideas of others prior to an idea generation session (Fink et al., 2010). However, further investigation is required to support a direct link between activations of the brain areas involved in creative endeavors to the operating of these brain areas.

Unexpected distractions can also augment the creative process even if their content is completely unrelated to the creative task at hand. Imagine a fire alarm that requires everyone to exit the building or a surprise happy-birthday phone call from a distant relative, both hauling individuals momentarily away from their tasks. There are two ways in which these types of unexpected distractions may improve creativity. First, a period of distraction shifts individuals' focus temporarily away from the primary task, which could give them a novel look at the task once it is resumed. In particular, a period of distraction may lead to “set shifting,” in which individuals are no longer stuck trying to solve a creative problem using the wrong cues, heuristics, or information or are fixated on certain unfruitful methods of problem solving (Schooler & Melcher, 1995). The cognitive break initiated by unexpected distractions can cause ineffective approaches to become less accessible and sometimes forgotten, prepping for a new, unbiased start.

Second, the unconscious mind actively works to arrive at creative outcomes while individuals are being distracted from the unfinished task. The period in which the unconscious mind takes over the matter is called the “incubation period,” during which individuals are engaged in different types of task-unrelated thought and are not aware of the working of their unconscious thought toward the unfinished task (see Ritter & Dijksterhuis, 2014, for a review of the incubation period). Various studies have shown that participants
excelled in creative performance when they were granted an incubation period compared to a control condition (e.g., Baird et al., 2012; Dijksterhuis & Meurs, 2006). The incubation effects have been hypothesized to promote creativity via boosts in unconscious associative processing of acquired information, such as making unobvious connections between existing ideas to produce creative ideas (Baird et al., 2012). Incubation also activates the brain networks that have been observed to interact prior to successfully solving insight problems (Kounios et al., 2008; Kounios et al., 2006). Further empirical evidence has yet to be found.

Unexpected distractions may, nonetheless, be cognitively disruptive to the creative process when additional distractions prompt cognitive overload, which undermines performance of the primary task (Fox, Park, & Lang, 2007). Cognitive overload, the cognitive state in which the required cognitive resources exceed the available cognitive resources (Lang, 2000), occurs because individuals have limited cognitive resources to process new information using active or working memory (Baddeley, 1999; Duncan, 1999; Miller, 1956). Indeed, complex information or information that requires higher-level cognitive processing, such as the creative process (Amabile et al., 1990), takes up more cognitive resources than simple information that requires simple cognitive processing (Fox et al., 2007; Wood, 1986).

Taken together, the impact of unexpected distractions on creative tasks is likely ambiguous. These distractions steal time and stir mixed emotions, yet the overall impact hinges on how well individuals process the new cognitive inputs introduced by these distractions. Specifically, unexpected distractions should cognitively stimulate the creative process when additional information is well processed and should spark new ideas while leaving the primary task in the hands of the unconscious mind. These distractions could, however, undermine the creative process once the train of thought collapses due to the deluge of new information.
No research to date has investigated the effects of unexpected distractions on creativity. This dissertation looks at the processing of new information brought about by these distractions in hopes of disambiguating their effects on creativity. The theoretically derived ambiguity may arise from the treatment of the creative process as a single uniform process yielding one final creative product. Instead, the creative process comprises different cognitive sub-processes, which jointly mold the final creative product (see Lubart, 2001, for a review of the creative process). Arguably, how unexpected distractions influence the creative product depends on how well the information is processed during the distraction period. Because different cognitive sub-processes differentially impact individuals’ ability to process incoming information, the cognitive sub-process in which they are engaged while being unexpectedly distracted should determine the effects of unexpected distractions on creativity.

To identify when unexpected distractions are cognitively stimulating or disruptive to the creative process, I divide the process into two cognitive sub-processes—divergent thinking and convergent thinking, both of which are implicated in creative thinking (Cropley, 2006; Lubart, 2001). Divergent thinking is the process of generating many novel ideas (Guilford, 1967; Khandwalla, 1993; Runco, 1991), whereas convergent thinking is the process of deriving the single best idea (Cropley, 2006). This dichotomy is helpful because divergent thinking and convergent thinking differ in the types of information each seeks and the aspects of creative product each influences. By examining the impact of unexpected distractions on the corresponding aspect of the creative process, I aim to shed some light on when and how unexpected distractions stimulate or disrupt the creative process.

I argue that individuals should reap the aforementioned benefits of unexpected distractions while engaging in divergent thinking for two main reasons. First, because divergent thinking calls for a variety of cognitive inputs to generate new ideas (Amabile,
new, related information introduced by unexpected distractions is likely well received, processed, and utilized. This type of information can provide useful real-time feedback, can serve as additional raw materials for idea combination, can improve focus, or can facilitate the retrieval and recombination of stored knowledge, potentiating new thinking. Second, the goal of divergent thinking is consistent with the working of the unconscious mind during the distraction periods—to associate ideas and make unobvious connections among acquired pieces of information to generate new ideas. Even if the information introduced by unexpected distractions is unrelated to the creative task at hand, being distracted offers a fresh new look at the task once it has been resumed and a period during which unconscious processes tackle the task.

More frequent unexpected distractions, nonetheless, turn benefits into drawbacks following cognitive overload. Because individuals have limited cognitive resources to process incoming information (Baddeley, 1999; Duncan, 1999; Miller, 1956), cognitive overload marks a point when the train of thought is broken and cognitive resources are depleted (Lang, 2000). Exposure to additional information, both related and unrelated to the task at hand, is disruptive to the formation of new ideas, hurting divergent thinking. Because the quality of divergent thinking is reflected in the fluency and novelty of ideas generated (Amabile, 1996; Cropley, 2006; Newell et al., 1958), too many unexpected distractions over an episode of concentration on a creative task may compromise these aspects of the creative product. Thus, I predict curvilinear (inverted u-shaped) relationships between the frequency of unexpected distractions and the number of ideas generated and between the frequency of unexpected distractions and the novelty of ideas generated. These relationships should be positive up to a certain point (where cognitive overload occurs), beyond which the relationships turn negative.
On the other hand, when individuals engage in convergent thinking or the process of selecting and contextualizing the selected idea (Cropley, 2006), unexpected distractions should reduce the feasibility or usefulness of the selected idea for two main reasons. First, the convergent process requires information that is highly specific to that idea or domain-specific information such as set criteria or facts against which a pool of novel ideas can be evaluated (Amabile, 1996). The information introduced by unexpected distractions is likely less useful for convergent thinking. Indeed, new information that is unrelated to the idea being evaluated and refined is particularly cognitively taxing to process (Fox et al., 2007; Lang, 2000; Speier et al., 1999). Even infrequent distractions are a probable cause for cognitive overload as they divert cognitive resources away from convergent thinking.

Second, the goal of convergent thinking is inconsistent with the working of the unconscious mind during the distraction period. In particular, unconscious processes facilitate the organization and polarization of loosely connected ideas to form new ideas (Dijksterhuis & Meurs, 2006; Dijksterhuis & Nordgren, 2006; Zhong, Dijksterhuis, & Galinsky, 2008), whereas convergent thinking calls for an evaluative judgment that narrows the playing field down to one idea that works best. Because the quality of convergent thinking is shown in the feasibility of the selected idea (Amabile, 1996; Cropley, 2006; Newell et al., 1958), I predict a negative relationship between the frequency of unexpected distractions and the feasibility of the selected idea.

This dissertation makes three key contributions. First, by identifying the boundary conditions and proposing the underlying mechanisms of the unexpected distractions-creativity relationship, this research sheds light onto the widely studied but still elusive creative process (George, 2007; Guilford, 1950). This study is the first to examine the differential impacts of unexpected distractions on the fluency and novelty versus the feasibility of creative outputs. This framework offers an effective way to conceptualize and
operationalize the cognitive process to disambiguate the probable mixed effects of unexpected distractions on creativity.

Second, the research illustrates how information processing, a fundamental cognitive process in creative thinking, is key to determining when and how exposure to unexpected distractions are cognitively stimulating or disruptive to the creative process. Specifically, I theorize that cognitive overload, the moment at which information breaks the train of thought, is the tipping point beyond which more distractions compromise rather than facilitate the formation of new ideas during divergent thinking and is the reason that additional unexpected distractions hurt rather than help the selection and refining of the best idea during convergent thinking.

Third, most prior studies on unexpected distractions and task performance were conducted in a lab setting with simple task assignments (e.g., signal detection) as opposed to complex creative task assignments, so it is unclear how the effects will unfold with complex creative tasks in real-world settings. By examining the unexpected distractions-creativity relationship in online, lab, and field settings, this study is able to simultaneously maintain internal and external validity and establish causality.

In the next section, I review relevant work on the creative process and the different types of distractions. I specify the scope of this dissertation by defining unexpected distractions and zeroing in on factors related to information processing as channels through which these distractions stimulate or disrupt creativity. I propose that cognitive overload is the point beyond which exposure to unexpected distractions undermines divergent thinking and convergent thinking, impairing the fluency, novelty, and feasibility of the creative product.
Theory Development

Work Interruptions

Interruptions are ubiquitous in the workplace. They come frequently in many forms, thereby interrupting the flow of work, especially work that demands sustained focus and effort, such as creative work (Amabile, 1996; Newell et al., 1958). This dissertation aims to examine how a certain type of work interruptions—unexpected distractions—affects creative performance.

According to Jett and George (2003), there are four types of work interruptions. The first type is called *intrusions*. Intrusions are unanticipated encounters initiated by another person, such as unscheduled client calls or spontaneous office visits. The second type is known as *breaks*. These are self-initiated recesses from the current task, such as water cooler or bathroom breaks. These two types of interruptions are directed at the interrupted individual but differentiated by the source of interruption—another individual or the self.

The third type of interruption occurs when externally stimulated activities interfere with concentration, such as loud conversations in the hallway. These activities are called *distractions*. They are not directed at but still interrupt the focal individual. Random sensory stimuli, such as fire alarms or puffs of strange odors pulling the individual away from the current task, fall into this category. The fourth type is known as *discrepancies*, which are perceived inconsistencies between expectations and reality, for example, a sudden realization that a deadline has passed. This last type of interruption is more psychological than physical. The new psychological state disrupts the flow of the current task but may or may not bar the interrupted individual from resuming the task. The definition of unexpected
distractions, which are the focus of this dissertation, overlaps in part with Jett and George’s (2003) categorization. The overlap is explained in the following section.

What Counts as an Unexpected Distraction?

Unexpected distractions are characterized by an element of surprise. They are not planned ahead of time; hence, their timing cannot be predicted. These distractions could be voluntary or involuntary or wanted or unwanted by the unexpectedly distracted individual (the focal individual). Scheduled meetings that the focal individual is reluctant about but has to attend are not unexpected distractions because the focal individual is aware that they will take place at a set time. On the other hand, the supervisor’s stopping by for a quick check-in while the focal individual is working is an unexpected distraction, providing that the supervisor comes unannounced. Giving rise to their unexpected nature, these distractions are usually externally initiated as opposed to being initiated by the focal individual. In addition, these distractions may or may not be directed at the focal individual and their content may or may not be related to the task at hand. A random street drilling that has nothing to do with the current task and a surprise supervisor’s visit that provides direct feedback on the task are both considered unexpected distractions as long as they momentarily siphon attention away from the task.

As defined, unexpected distractions encompass intrusions, distractions, and discrepancies per Jett and George’s (2003) categorization, given that these types of interruption are unexpected and temporarily preoccupy the focal individual. Breaks are internally initiated and likely anticipated; thus, they are not unexpected distractions. Exceptions may exist for breaks resulting from urges beyond the control of the individual, for example, an uncontrollable urge to eat or an insurmountable urge to use the restroom that
compels a temporarily pause on the task. These exceptional breaks are unexpected
distractions.

This dissertation investigates the proximate impacts that the short-term, not long-
term, exposure to unexpected distractions exerts on the task at hand. Specifically, I look at
instances in which the focal individual resumes the task after each distraction period to study
the effects of these distractions on the work outputs produced over these interrupted
periods.

**Ambiguous Effects of Unexpected Distractions on Creativity**

Because creativity is key to the success of modern organizations, which are teeming
with unexpected distractions, I focus on the effects of these distractions on this special type
of complex task. The effects that unexpected distractions have on creative tasks are likely
ambiguous due to two main reasons: creative tasks are not simple, and unexpected
distractions are not planned.

First, unlike simple tasks, which involve an unsophisticated processing of information
or an execution of standard procedures, creative tasks require a manipulation of knowledge
and sophisticated thinking. When tasks are routine and tedious, distractions are mostly
beneficial. Previous studies have found that an interrupting task or background noise could
relieve boredom (Oldham, Cummings, Mischel, Schmidtke, & Zhou, 1995; Speier et al.,
1999; Zijlstra et al., 1999) and reduce decision-making time without sacrificing task accuracy
(Zijlstra et al., 1999). In fact, they achieve these positive impacts by arousing attention and
filtering out task-irrelevant information (Sanders & Baron, 1975).

Second, unlike expected interruptions, unexpected distractions cannot be
anticipated. Expected interruptions such as breaks generally generate more positives than
negatives and are often institutionalized as part of the workday (Roy, 1959). Individuals need occasional respites from the task to alleviate boredom (Fisherl, 1993) and rejuvenate physical and mental energy, especially for monotonous, routine, or tedious tasks (Csikszentmihalyi, 1975; Henning et al., 1989). The downsides are quite straightforward; taking breaks reduces the available time for work, and long interruptions may induce the forgetting of task-relevant knowledge, which takes time to retrieve. It is, however, endogenous to the individuals (e.g., characteristics, knowledge, organization skills), the expected interruption (e.g., when, how frequent, how long), and the task (boring or exciting), whether the positives will outweigh the negatives or vice versa. For example, freedom in deciding when and how to work improves creative performance only for those with prior task-relevant experience who are presumably adept at managing their time and the task (Chang et al., 2012). Or, because these interruptions are planned in advance, individual differences in the ability to plan ahead could determine how well the individuals mentally wrap the unfinished task to tend to incoming interruptions.

On the other hand, creative tasks, which are complex and require sustained focus and effort (Amabile, 1996; Newell et al., 1958), likely suffer from the untimely halt in attention caused by unexpected distractions. This unexpected halt in attention is detrimental to the workflow (Coates, 1990; Vernon, 1990), progress (Grove, 1983; Mintzbert, 1990; Perlow, 1999), and performance (Speier et al., 1999). The positive effects of relieved boredom and aroused attention go against the negative effects of severed focus and effort. Indeed, how the focal individual responds to these distractions is shaped by his or her ability to handle the emotional and cognitive reactions that result from being unexpectedly distracted. The focal individual does not plan these distractions, so spontaneously taking time away from the current task to attend to them likely compromises his or her task performance.

Because creativity requires a manipulation of knowledge, information processing is
central to creative performance. Depending on how well the focal individual can process these distractions in the service of creativity, tending unexpected distractions should, therefore, stimulate the creative process far beyond merely providing relaxation and relieving boredom. How exactly these distractions benefit creative performance via improved information processing depends on whether their content or occurrence is considered.

The Content of Distractions

As the focal individual processes the content of unexpected distractions, he or she gathers new information, which may or may not be directly related to the creative task at hand. There are three main channels through which the new information can boost creative performance.

First, unexpected distractions that introduce task-related feedback; for example, the supervisor may show up unannounced to check on work progress and may deliver the kind of information inaccessible through more conventional means, such as scheduled weekly meetings (Kotter, 1982; Kelley & Sutton, 1997). Real-time feedback is valuable as an immediate checkpoint for the current work, a positive reinforcement for high performers, and a negative reinforcement for low performers. Such feedback is essential for creativity. Apart from material resources (Katz & Allen, 1988), individuals also need access to other people’s expertise as informational inputs for creative endeavors (Mumford, Scott, Gaddis, & Strange, 2002). A computer-mediated idea generation system that provides real-time performance feedback, for example, has been shown to enhance the fluency and quality of creative idea generation (Jung et al., 2010).

Additionally, real-time feedback may serve as a synergistic extrinsic motivator, a type
of extrinsic motivator that works with intrinsic motivators to promote creativity (Amabile, 1996). If informational as opposed to controlling (Deci & Ryan, 1985), the feedback could replenish the sense of competence and renew the focus toward completing the task. The feedback could then act as a form of reward, such as recognition of the focal individual’s competence, engagement, and achievement in the task, which could enhance creative performance (Eisenberger & Armeli, 1997).

Task-related immediate feedback can also clarify the goal of the creative task, which helps to define problems (Getzels & Csikszentmihalyi, 1976) and facilitates creative thinking (Amabile, 1988; Bailyn, 1985). Having a clear goal enhances creativity as it increases focus and effort by providing clear targets toward which individuals can direct their energies (Shalley & Gilson, 2004). Specifically, receiving feedback concerning their progress toward the creative goal informs what is needed and valued to be creative. When individuals know what it means to be creative, they are more likely to be creative (e.g., Manske & Davis, 1968; Speller & Schumacher, 1975). In sum, real-time feedback supplies new information that serves as a checkpoint, guideline, and benchmark on the task, all of which enable the focal individual to motivate and improve his or her creative performance.

Second, even if it is not directly related to the creative task, the information brought in by unexpected distractions could expand the repertoire of information on which the individual may draw as creative inputs. Creative ideas arise not out of thin air but from non-obvious associations and recombination of existing information to solve a particular problem (Baughman & Mumford, 1995; Chua & Iyengar, 2008). The new information increases the type and quantity of information that could be recombined to produce creative ideas. Unexpected distractions may open up unprecedented angles to the task, novel ways in which existing ideas coalesce into creative solutions, or simply new ideas. For instance, an idea to integrate a pleasant smell into a new line of clothing may only dawn on a fashion
designer seeking to creatively tailor the customer’s experience after his or her colleague stops by to chat about the new fragrance. The fashion designer might originally be too focused on the use of visuals to capitalize on scents. In this case, the unexpected chat initiated by his or her colleague sets him or her free from an old perspective while introducing a new way of tackling the task at hand.

Relatedly, the literature on group brainstorming argues that idea sharing or idea exchange during group brainstorming is a cognitive stimulation for idea generation (Dugosh & Paulus, 2005; Dugosh, Paulus, Roland, & Yang, 2000; Paulus & Brown, 2007; Paulus & Nijstad, 2003). Specifically, being exposed to other people’s related ideas could enhance idea generation by activating previously inactive categories of ideas (Brown, Tumeo, Larey, & Paulus, 1998) and spawning related subcategories (Larey & Paulus, 1999), increasing resources for idea combinations.

Being unexpectedly interrupted could transpire in group brainstorming via the practice of turn taking—not talking when someone else talks. In a classic group brainstorming session in which the brainstormers delay criticism and generate as many new ideas as possible by taking turns presenting their ideas (Osborn, 1963), the brainstormers constantly process other people’s presented ideas as part of their creative endeavors. Processing other people’s ideas adds diverse information yet risks interrupting the flow of one’s own ideas. The train of thought may be cut short and ideas not fully developed when one’s turn ends (Paulus, Putman, Dugosh, Dzindolet, & Coskun, 2002). Although predetermined, turns cannot be fully anticipated in a brainstorming session without a strict turn-taking protocol, allowing someone else to suddenly interject. In fact, taking turns in group brainstorming is akin to being unexpectedly distracted from the current task because attention needs to be allocated to new information, temporarily pausing one’s own thought for the aforementioned creativity-stimulating effects to be realized (Brown et al., 1998) or
strengthened (Dugosh et al., 2000; Paulus & Yang, 2000). The group brainstorming literature, however, shows mixed effects. In many cases, brainstorming in a group situation leads to lower, not higher, levels of creativity compared to individual idea generation. In a later section, I revisit this point when I discuss production blocking in group brainstorming, which helps explain why frequent unexpected distractions could hurt the creative process.

Third, besides introducing new information as raw materials for creative associations, unexpected distractions could facilitate the retrieval and recombination of already existing information, two vital processes in creative idea generation (Paulus & Brown, 2007). Indeed, familiar sensory cues may trigger the retrieval of recently stored knowledge or distant memory. In many experiments, participants were able to recognize faces of strangers previously presented to them when the faces were presented at a later time with the same odor they were coupled with in the first presentation session (e.g., Cann & Ross, 1989). Abundant evidence also shows that individuals are more likely to recall details of past memories, especially autobiographical memories, when associated with familiar sensory memory cues in visual, olfactory, verbal, or textural forms (e.g., Herz, 2004; Herz & Cupchik, 1995; Rubin, Groth, & Goldsmith, 1984). Unexpected sensory stimuli such as a surprise sighting of acquainted faces or a fleeting puff of a familiar odor can evoke near or distant stored knowledge that may serve as inputs for the creative task at hand.

Exposure to external stimuli could also enhance creative idea generation at the brain level. A recent neuroscience study found that exposure to the task-related ideas of other people enhanced novelty in an idea generation exercise during a functional magnetic resonance imaging (fMRI) recording. Specifically, participants were asked to generate alternative uses for everyday objects. Participants who were exposed to other people’s related ideas before generating their own ideas were able to achieve higher originality in their ideas than those who were not (Fink et al., 2010). Importantly, performance
improvement was associated with increased neural activities of a complex and widespread neural network involving right-hemispheric temporo-parietal, medial frontal, and posterior cingulate cortices, which are responsible for memory retrieval, semantic integration, and attentional processes. The neural activities in these brain regions suggest that being exposed to other people’s related ideas could serve as memory cues that enhance focus and enable efficient retrieval and recombination of existing information. However, more empirical evidence using additional brain measurements is needed to confirm that the activation of brain regions associated with certain processes indicates that those processes were actually operating.

The Occurrence of Distractions

Oftentimes, unexpected distractions may interrupt work without transmitting any usable information. Imagine an untimely street drilling or a sudden power outage that forces everyone to momentarily stop working. Given that these happenstances do not have any connection to stored knowledge nor do they evoke any past memories, their content may not be readily useful for the creative task at hand. Nonetheless, content aside, their mere occurrence could still enhance the creative process via two main channels. First, the momentary shift of attention away from the creative task at hand can give the focal individual a fresh new look at the task, potentiating creative thinking (e.g., Csikszentmihalyi, 1996; Ghiselin, 1952). This phenomenon is termed “set shifting.” Schooler and Melcher (1995) explain this phenomenon by arguing that by taking time off from the task, the wrong cues, the wrong heuristics, and/or the wrong information become less obvious or forgotten altogether. The focal individual can thereby refresh the outlook toward the task, can become
less fixated on the old way of problem solving, can become more resistant to psychological biases such as recency or primary effects, and can potentially resume the task with more effective strategies.

This particular effect of being unexpectedly distracted is similar to the aforementioned role of unexpected distractions in introducing new information that opens up new perspectives on the task; however, the mechanisms are different because in this case whether the content of the distractions is related to the task is irrelevant. It is rather their occurrence that leads the focal individual to soften the emphasis on or even forget the less effective way of tackling the task. When the wrong way becomes less obvious, the focal individual is receptive to a new, unbiased start that could facilitate creative thinking.

Second, it is the working of the unconscious mind during the distraction period that propels the task without the focal individual’s awareness. This period is called the “incubation period,” during which the individual is engaged in different types of task-unrelated thought and is not aware of the working of his or her unconscious thought toward the unfinished task (see Ritter & Dijksterhuis, 2014, for a review of the incubation period). The incubation period has long been identified as part of the creative process. Specifically, creative outcomes emerge from a process whereby a conscious thought is followed by a period in which the problem is set aside and not consciously worked on (Wallas, 1926). It is not merely the absence of the conscious thought or the phenomenon of set shifting that drives the incubation effects, but unconscious processes also have to be at play (Dijksterhuis & Meurs, 2006; Ritter & Dijksterhuis, 2014). In particular, during incubation the mind is free to wander—to be engaged in internally generated thought that occupies the attention but is unrelated to the overt goal of the current task (Baird et al., 2012; Mason et al., 2007; Smallwood & Schooler, 2006)—while unconscious processes advance on the task. As such, unexpected distractions whose content is unrelated or only remotely related
to the task are more likely than those with related content to induce mind wandering and thus produce the incubation effects. For example, an interrupting incubation activity of a dissimilar nature to the current task has been found to be more effective in improving creative thinking. In a study by Gilhooly, Georgiou, and Devery (2013), incubation activities that involved spatial skills (but not verbal skills) were shown to enhance verbal fluency and verbal-rated creativity of a verbal creative task, and the incubation activities that involved verbal skills (but not spatial skills) were shown to benefit spatial-task fluency and spatial-rated creativity of a spatial creative task.

Many scholars have attempted to identify how exactly the unconscious process of mind wandering operates to potentiate creative thinking, yet the mechanism is still elusive (e.g., Dijksterhuis & Meurs, 2006; Smith & Blankenship, 1989; Yaniv & Meyer, 1987). There exists a number of possibilities. One possibility is that unconscious processes organize, polarize, and weight disorderly information until equilibrium is reached and the solution pops into consciousness (Bos, Dijksterhuis, & van Baaren, 2011; Usher, Russo, Weyers, Brauner, & Zakay, 2011). Specifically, the unconscious mind is able to close in on the correct answer before the answer is accessible to consciousness (Bowers, Regehr, Balthazard, & Parker, 1990), to digest a large amount of information to form an implicit positive or negative attitude toward a target (Betsch, Plessner, Schwieren, & Gütig, 2001), to follow arithmetic rules (Ric & Muller, 2012; Sklar et al., 2012), and, according to brain scans in a neuroscience study, to continue to process information after initial encoding (Creswell, Bursley, & Satpute, 2013). All of these processes could be in the service of creativity outside the awareness of the focal individual.

Another possibility is that mind wandering increases unconscious associative processing of information (Baird et al., 2012; Dijksterhuis & Nordgren, 2006; Ritter & Dijksterhuis, 2014). Specifically, a series of experiments by Dijksterhuis and Meur (2006)
showed that participants were better at deviating from obvious cues, retrieving relatively inaccessible information, and making unobvious connections between ideas when they were given an opportunity for mind wandering. Such improvements in the associative processing of information contribute to divergent thinking.

This mechanism also resonates with the process of spreading activation, which Yaniv and Meyer (1987) use to explain how unsuccessful retrievals of stored knowledge prime the unconscious mind to be more susceptible to sensory inputs at a later time. In particular, the focal individual is likely more adept at unconsciously associating new sensory information while being unexpectedly distracted from the unfinished creative task at hand. New information may in fact not come from proximal distractions because such sensitization to sensory inputs, both semantic memory and episodic memory, could last for quite some time. Neuroimaging work also reveals preliminary evidence that mind wandering causes interactions between the executive and the default networks (Christoff, Gordon, Smallwood, Smith, & Schooler, 2009), which are brain areas observed to interact prior to successful solution to insight problems (Kounios et al., 2008; Kounios et al., 2006). The findings suggest that mind wandering gives rise to a situation in which these brain networks are activated and mutually contribute to associative processing, thus facilitating creative thinking. Further neurocognitive investigations of these brain activations during the incubation period are needed to validate a direct link between mind wandering and associative processing.

It is important to note that the creative benefits of set shifting and incubation rely on an assumption that distraction periods are temporary. In other words, the focal individual temporarily takes time off from the unfinished creative task to attend to incoming unexpected distractions and later resumes the task. For set shifting, the focal individual is able to return to the task with a fresh perspective and away from inappropriate anchors after setting the
task aside for a period of time. Similarly, for the incubation effects to be realized, the focal individual needs to have already established a creative task goal—a goal to find creative solutions for a specific problem—before being unexpectedly distracted from the task. The literature on the working of unconscious processes attests to this argument. In a study by Gallate, Wong, Ellwood, Roring, and Snyder (2012) and in another by Zhong et al. (2008), participants were either informed or not informed that they would soon be returning to finish the original creative task before being distracted to complete another task. Results showed that those who were informed about the return scored significantly higher in their post-distraction performance on the creative task. In other words, the unconscious mind works on the unfinished task only if the focal individual has set his or her intention to do so before the beginning of the distraction period. Besides creative task goals, this assumption also holds true for decision-making goals. In a study by Bos, Dijksterhuis, and Baaren (2008), a distraction period improved participants’ decisions only when they expected to make a decision after the distraction period.

The above describes the various ways by which the content and occurrence of unexpected distractions facilitate information processing, thus improving creative performance beyond relieving exhaustion and boredom. The focal individual, however, requires cognitive resources to process the new information introduced by these distractions. Because cognitive resources are limited, unexpected distractions that occur too frequently may hurt rather than help the cognitive process. The downside of unexpected distractions is addressed in the next section.

The Breakdown of the Information Processing System: Cognitive Overload

Unexpected distractions take time away from the task at hand. Reduced time may
cause an overwhelming sense of urgency, stress, and frustration, which compromise task performance (see Jett & George, 2003). In addition to the straightforward loss of available time, the negative effects of unexpected distractions arise from the failure of the information processing system to effectively process and utilize the introduced information, rendering new information disruptive rather than stimulating the creative process. Such failure is marked by the occurrence of cognitive overload, the cognitive state at which required cognitive resources exceed available cognitive resources and the train of thought is broken (Lang, 2000; Miller, 1956). Cognitive resources are the working memory or the temporary attention-demanding storage used to retain new information (Wickens, 1999). With insufficient cognitive resources to process incoming information, performance of a task involving information processing decreases with more information (Fox et al., 2004; Lang, 2000; Lang, Potter, & Bolls, 1999). Because the creative process implicates cognitive processing and manipulating information to form and evaluate new ideas (e.g., Finke, Ward, & Smith, 1992), it should suffer from the shortage of cognitive resources once cognitive overload strikes.

Cognitive overload occurs because, according to the limited capacity theory (Lang, 2000), the focal individual has limited cognitive resources to process incoming information. In other words, the focal individual can process only so much information over an episode of concentration—a cognitive episode that ends once the concentration breaks down. Once unexpectedly distracted, the focal individual may process the stimulus, determine its relevance to the task, and either ignore or pursue the lead. If the latter, the focal individual shifts his or her attention toward the stimulus, unaware of the working of his or her unconscious mind toward the unfinished task. All of these processes tax cognitive resources as some form of information is being processed. As such, too frequent distractions flood the information processing system with excessive information per cognitive episode, thereby
compromising cognitive performance.

Following cognitive overload, cognitive resources may shift from a complex activity to a simpler activity, hurting performance of the complex activity while facilitating that of the simple activity. Specifically, Fox et al. (2007) found that, once incoming information for a primary recognition task became so complex that cognitive overload was reached, marked by the decline in performance of the primary task, performance of a secondary signal detection task rose. They attributed the findings to an automatic shift in cognitive resources from the increasingly cognitively demanding primary task to the simpler secondary task. As for a creative task, too much new information could cause a similar shift in cognitive resources from making novel and unobvious connections of ideas to making unoriginal and obvious connections of ideas. Indeed, generating novel ideas could be painstaking as there are no precedents or standards to follow. Because what makes the creative process successful is the quality with which the process is executed (Newell et al., 1962; Weisberg, 1986, 1993), a compromised information processing system due to cognitive overload may induce production of less creative ideas. Put differently, cognitive overload could encourage the easy and less creative way out (making unoriginal connections between ideas) when the hard and less comfortable way (making original connections between ideas) becomes too cognitively exhausting.

Additionally, cognitive interference could accelerate cognitive overload. Cognitive interference occurs when secondary activities (i.e., unexpected distractions) tap into the same type of cognitive resources that are being used by a primary task (Gillie & Broadbent, 1989; Hirst & Kalmar, 1987; Wickens, 1999). For example, performance of unrehearsed word recall tasks can be compromised by distractions from phonological stimuli because they both involve similar processing of linguistic information (Gillie & Broadbent, 1989). Hearing others’ related ideas might hinder generation of one’s own ideas as both aim to
answer the same question using a similar processing system (Pinsonneault, Barki, Gallupe, & Hoppen, 1999). Indeed, cognitive overload marks the point at which cognitive interference becomes too great and begins to lower the performance of a primary task.

As noted, there is evidence that group brainstorming produces mixed effects on creative performance. The occurrence of cognitive overload may to an extent explain production losses of group brainstorming (e.g., Diehl & Stroebe, 1987; Mullen, Johnson, & Salas, 1991; Stroebe & Diehl, 1994). A significant portion of production losses of group, compared to individual, brainstorming results from the so-called production blocking (Diehl & Stroebe, 1987; Lamm & Trommsdorff, 1973). The primary cause of production blocking is the fact that individual brainstormers have less time to present their ideas to the group because of turn taking. Besides limited time, there is also a cognitive explanation for production blocking. Specifically, being exposed to a multitude of others’ ideas while waiting for one’s own turn is similar to being unexpectedly distracted with new information. Waiting too long and being cut off by unexpected interjections may lead to cognitive overload, which disrupts the ability to form new ideas. In addition, the findings that the use of brainwriting, in which ideas are shared in writing (Greene, 1987; VanGundy, 1988), is more effective than the classic brainstorming technique in which ideas are verbally shared (Paulus & Yang, 2000) can be explained by the limited cognitive capacity theory (Lang, 2000). With limited cognitive resources, brainstormers could benefit from a lapse of time with minimal distractions after being exposed to others’ related ideas.

Another way in which demanding distractions may hasten cognitive overload is by compromising the working of the unconscious mind. A meta-analytic review by Sio and Ormerod (2009) reveals that the incubation effects are reduced when interruptions in the form of interpolated tasks are demanding as opposed to undemanding or no task at all. Indeed, demanding interruptions require attention and impose cognitive load on the
information processing system. The overwhelmed information processing system discourages mind wandering (Mason et al., 2007; Smallwood, Nind, & O’Connor, 2009), thereby diminishing the incubation effects. In sum, when cognitive overload is reached, the focal individual unsuccessfully gropes for cognitive resources to process the new information transmitted by unexpected distractions, the processing of which disrupts the working of the unconscious mind on the creative task.

No research to date has investigated the effects of unexpected distractions on creativity. The overall effects of unexpected distractions on creativity result from the competing positive effects, derived from the content or the occurrence of the distractions, and the negative effects from the ensuing cognitive overload. The overall effects are likely contingent on how well the focal individual processes the new cognitive inputs from these distractions. Specifically, unexpected distractions should cognitively stimulate the creative process when additional information provides useful information or sparks new ideas while leaving the unfinished creative task to the unconscious mind. These distractions could, however, impair the creative process once the train of thought collapses due to cognitive overload.

Additionally, the overall effects are likely ambiguous, providing that the creative process is treated as one unifying process yielding one final creative product. The creative process in fact consists of multiple cognitive sub-processes, each possessing a unique information processing style and differentially responding to incoming information. Which sub-process the focal individual engages in as unexpected distractions take place should determine the effects of those distractions on his or her creative performance. To disambiguate the overall effects, I take a closer look at the creative process to identify where in the process the positives dominate the negatives and vice versa.
The Creative Process

The so-called creative process is the sequence of thoughts and actions that produces a creative product (Lubart, 2001). Scholars have proffered various models to understand the process, ranging from Wallas’s (1926) classic four-stage model to the more recent integrative view that emphasizes the multiple cognitive sub-processes implicated simultaneously and cyclically to achieve the final product (Lubart, 1994; Ochse, 1990; Sternberg, 1999; Sternberg & Lubart, 1995; see Lubart, 2001, for a review of the creative process).

The various models differ in the proposed sequence of thoughts and actions. The classic four-stage model, for example, delineates preparation (preliminarily analyzing a problem, defining the problem, and gathering information and skills to solve the problem), incubation (subconsciously working on the problem, making associations of ideas, and rejecting those that do not work), illumination (suddenly realizing a promising solution), and verification (evaluating, refining, and developing the solution) as the sequential steps individuals go through to generate a creative output. There have been some modifications to the classic model in response to empirical findings. For example, by asking artists and scientists to think aloud as they engaged in their creative work, Patrick (1935, 1937, 1938) contended that individuals could engage in multiple stages at once or return to the earlier stages before their work is finished. Similarly, Amabile (1988) proposed the componential model of creativity to describe the most logical phases in which the creative process unfolds—including problem or task identification (identifying a problem), preparation (building up or reactivating information to solve the problem), response generation (generating possible solutions), response validation and communication (testing solutions
against set criteria)—and emphasized that these phases could be iterative and cyclical and were by no means sequential.

In fact, the above models and several others—e.g., the creative cognition’s generative and exploratory processes (Finke et al., 1992; Ward, 2001), the ideation and evaluation cycles (Basadur, 1995), the primary and secondary processes in the psychodynamic approach (Kris, 1952; Kubie, 1958; Suler, 1980), the chance-based theories of blind variation and selective retention (Campbell, 1960; Simonton, 1988)—encompass essentially two sub-processes in which information is processed in two distinct fashions. Specifically, the first sub-process—variously referred to as incubation and illumination, response generation, generative process, ideation, primary process, and blind variation in the respective aforementioned models—operates on a liberal and unstructured recombination of existing information to generate novel ideas. The second sub-process—variously referred to as verification, response evaluation and communication, exploratory process, evaluation, secondary process, and selective retention in the respective aforementioned models—selects a promising idea and fine-tunes it based on specific factual knowledge and criteria.

Based on their differences in information processing, the two sub-processes can be categorized as a divergent thinking process and a convergent thinking process, respectively (discussed in detail below). Which of the two sub-processes is intercepted by unexpected distractions should determine how these distractions would affect the creative output. In particular, the effects of these distractions will be reflected in the aspect of the creative output influenced by the implicated sub-process—the many novel ideas generated during divergent thinking and the workable idea refined during convergent thinking. By identifying the specific sub-process being intercepted, this framework should be able to disambiguate the effects of unexpected distractions on creativity.
Divergent Thinking.

Divergent thinking is the process of brainstorming or generating many new ideas (Guilford, 1967; Khandwalla, 1993; Runco, 1991). It is a creativity-relevant process involving the operation of creativity heuristics in which unobvious associations between available ideas are explored to form novel ideas (Amabile, 1996). I argue that this process is likely to reap the aforementioned benefits of unexpected distractions rather than suffer from their potential drawbacks due to two main reasons.

First, content-wise, divergent thinking engages an information-processing system that receives new information from the environment, thereby internalizing unexpected distractions as resources for the production of new ideas (Amabile, 1996; Cropley, 2006). An unexpected TV commercial for soap may, for instance, help a researcher think outside the box while attempting to come up with original titles for his project on morality and physical cleaning. Additionally, because the divergent process seeks a variety of broad information as cognitive inputs, the focal individual engaging in divergent thinking is likely on the lookout for potentially useful new information to expand his or her perspectives rather than in lockdown to work with existing information. The new information is hence welcome and likely to be effectively processed and utilized in the production of novel ideas during divergent thinking. As mentioned earlier, the new information, even if remotely related to the creative task at hand, could provide useful direct feedback on the task, could serve as additional raw materials for idea generation, or could improve focus and facilitate the retrieval of relevant memories for idea combination, all improving the fluency and novelty of idea generation. Consistently, previous studies on such topics as group brainstorming (e.g., Dugosh & Paulus, 2005) and neuroscience (e.g., Fink et al., 2010) that found exposure to new information advantageous to creative performance investigated the creative aspects specifically influenced by divergent thinking. Those aspects are the fluency and novelty of
ideas generated.

Second, content aside, divergent thinking can profit from the mere occurrence of unexpected distractions. Even if these distractions are unrelated to the creative task at hand, taking a temporary break from the task can lead to set shifting, which broadens the perspectives on the task, contributing to more novel associations of ideas. The goal of divergent thinking also coincides with the working of the unconscious mind while the focal individual is distracted—to make unobvious connections among acquired pieces of information for novel idea generation. In fact, unconscious processes have been found to outperform conscious processes in tasks involving associating ideas and combining ideas in unprecedented fashions such as idea generation tasks (Dijksterhuis & Meurs, 2006) and the Unusual Uses Task (UUT) (Baird et al., 2012), all implicating divergent thinking.

Nonetheless, as noted, the focal individual can process only so much new information per cognitive episode due to his or her limited cognitive resources. Divergent thinking should thus benefit from unexpected distractions up until cognitive overload strikes. At that point, the information processing system falters, and additional distractions hurt rather than help. Because divergent thinking produces many new ideas, affecting both the number and the novelty of ideas generated, I hypothesize the following (Figures 1 and 2 graphically illustrate Hypotheses 1a and 1b, respectively):

**Hypothesis 1a.** There is a curvilinear relationship (inverted u-shaped) between the frequency of unexpected distractions and the number of outputs from a creative task that involves divergent thinking. The relationship is positive with low frequency up to a certain point, beyond which the relationship is negative.
**Hypothesis 1b.** There is a curvilinear relationship (inverted u-shaped) between the frequency of unexpected distractions and the novelty of the outputs from a creative task that involves divergent thinking. The relationship is positive with low frequency up to a certain point, beyond which the relationship is negative.
Convergent Thinking.

Convergent thinking is the process of deriving the single best idea (Cropley, 2006). Specifically, convergent thinking tests the appropriateness and feasibility of novel ideas and selects and refines the best idea to be feasible, appropriate, and implementable. In doing so, individuals need specific knowledge and criteria and domain-specific information to ground and guide the process of evaluation and refinement of ideas (Amabile, 1996). I argue that unexpected distractions should reduce the feasibility or usefulness of the best idea due to two main reasons.

First, content-wise, convergent thinking is neither open nor receptive to the information introduced by unexpected distractions. Even small unexpected distractions could prompt cognitive overload, undermining the benefits while accentuating the drawbacks of
these distractions, because the transmitted information, if not directly related to the focal idea, is likely irrelevant for convergent thinking. For instance, after the researcher zeroes in on one original idea inspired by the soap commercial, he or she likely focuses on how to verbalize the idea as the title of his or her project, thereby entering a lockdown mode, shutting himself or herself off from more commercials. Moreover, previous research has shown that unrelated information is particularly cognitively taxing and prone to initiate cognitive overload (Fox et al., 2007; Lang, 2000). Specifically, experimental subjects had difficulty processing and recalling the content of commercials with many unrelated edits and cuts compared to related ones (Lang, 2000). The convergent process is unlikely to leverage the new information introduced by unexpected distractions because the process evaluates and narrows down the playing field, thus calling for very specific information. Exposure to unexpected distractions should, therefore, cause cognitive overload that undermines the convergent process.

Second, the effects of set shifting and incubation are not aligned with the goal of convergent thinking—to select and contextualize the preferred idea. Set shifting is unlikely beneficial because the focal individual needs to consciously process acquired information to make an informed decision rather than seek additional perspectives or angles. Because convergent thinking is a process that is conscious and evaluative (Dijksterhuis & Meurs, 2006), the focal individual is less likely to benefit from the unconscious processing of information. In other words, to evaluate, select, and refine the best idea, the focal individual needs to carefully peruse relevant information instead of unconsciously exploring possibilities.

In sum, the convergent process tends to be undercut by cognitive overload rather than enhanced by the content or occurrence of unexpected distractions. Because convergent thinking shapes the feasibility or usefulness of the selected idea, I hypothesize
the following (Figure 3 graphically illustrates Hypothesis 2):

**Hypothesis 2.** There is a negative relationship between the frequency of unexpected distractions and the feasibility of the outputs of a creative task that involves convergent thinking.

Figure 3: Graphical Illustration of Hypothesis 2
The Present Studies

I conducted a series of six studies—in the lab, online, and in the field—to investigate when and how unexpected distractions may stimulate or disrupt divergent thinking and convergent thinking in the creative process. I employed a multi-method design to enhance internal and external validity and to establish causality in the hypothesized relationships.

The first four studies were intended to collectively test Hypotheses 1a, 1b, and 2 in the lab and online. For these studies, I created a cover story (see Appendix A) about a new startup planning to launch a new product, berry-flavored vitamin water, to the Boston market and 25 statements (see Appendix B) related to the startup, its marketing campaign for the new product, the new product, and the Boston market. The cover story gave information about the startup, its marketing expert who was responsible for coming up with creative (novel and feasible) ideas for the marketing campaign, and its goal of popularizing the new product in two months’ time. Some of the 25 statements were selected for use as unexpected distractions in experiments in Studies 2, 3, and 4.

Specifically, Study 1: Pretesting of Interruption Materials Online I evaluated the 25 statements on how much their content would help generate novel or feasible ideas for the marketing campaign. I tested Hypotheses 1a and 1b in Study 2: Testing Divergent Thinking in Lab, Study 3: Testing Divergent Thinking Online, and Study 4: Testing Divergent Thinking & Convergent Thinking in Lab using an idea generation task that asked participants to come up with as many novel ideas as possible for the marketing campaign. I also tested Hypothesis 2 in Study 4 using an idea elaboration task that asked participants to select the most promising idea among those they had generated during idea generation and elaborated on how to put that idea into effect. A subset of the 25 statements that scored high on their helpfulness for generating novel and feasible ideas in Study 1 were used as
unexpected distractions in the form of pop-up messages during the idea generation and idea elaboration tasks.

In addition, in Study 6: Testing Divergent Thinking & Convergent Thinking in the Field, I tested Hypotheses 1b and 2 at an IT company in Bangkok, Thailand, with actual programmers as participants and actual software work as creative outputs, using the measures for novelty and utility of software work that I had developed in Study 5: Piloting in the Field. I triangulated the results from all of the studies to verify the hypotheses.

Study 1: Pretesting of Interruption Materials Online

This study was the first in a series of four studies intended to collectively test Hypotheses 1a, 1b, and 2 in the lab and online. It evaluated the 25 statements on how much their content would help generate novel or feasible ideas for the marketing campaign. I selected the statements with the highest scores to use as unexpected distractions in Studies 2, 3, and 4.

Participants and procedure.

Seventy-four online participants were recruited via Amazon Mechanical Turk (MTurk) with the criteria that they lived in the United States, were fluent in English, and were over 18 years of age. Participants answered a 10-minute online survey for a flat compensation of $0.50. Participants were 50% female, on average 33.92 years old, 95.95% U.S. citizens, 79.73% White, 6.76% Asian, 8.11% Latino, and 5.41% Black. For education, 16.22% had a high school degree, 27.03% had some college education, 48.65% had a college degree, 5.41% had a master’s degree, and 2.70% had a professional degree.

Participants read the cover story and the 25 statements. After reading each
statement, they rated how much it would help the marketing expert come up with novel or feasible ideas for the marketing campaign for the new product on a seven-point Likert scale anchored at 1 (not at all) and 7 (very much). Participants then answered some demographic questions before being thanked and paid for their time.

**Measures.**

**Novelty.** I obtained the novelty scores for each statement from the ratings for the following: “How much will this statement help the marketing expert come up with novel (new, original, unprecedented) ideas for the marketing campaign for the new product?”

**Feasibility.** I obtained the feasibility scores for each statement from the ratings for the following: “How much will this statement help the marketing expert come up with feasible (practical, implementable, appropriate) ideas for the marketing campaign for the new product?”

**Results.**

Table 1 shows the descriptive statistics of the 25 statements in the order presented to participants. (See Appendix B for the 25 statements.) Out of 25, I selected 15 (marked with one asterisk), 15 (marked with one asterisk), and 20 (marked with one or two asterisks) statements with the highest scores on novelty and/or feasibility to use as interruption materials in Studies 2, 3, and 4, respectively. The highest scores on novelty and/or feasibility are identified by the highest scores on novelty, feasibility, and combined novelty and feasibility. Examples of selected statements are as follows:

- “We are proud to say that our vitamin water is 100% natural, with absolutely no artificial ingredients.”
- “According to a recent local poll, Bostonians are increasingly becoming health and environment conscious.”
“Fiber in berries can aid in weight loss and lower blood pressure and cholesterol.”

Table 1: Descriptive statistics of the novelty and feasibility scores of 25 statements

<table>
<thead>
<tr>
<th>Statement</th>
<th>Novelty</th>
<th>Feasibility</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Std. Dev.</td>
</tr>
<tr>
<td>1*</td>
<td>4.38</td>
<td>1.64</td>
</tr>
<tr>
<td>2*</td>
<td>4.81</td>
<td>1.64</td>
</tr>
<tr>
<td>3*</td>
<td>4.50</td>
<td>1.72</td>
</tr>
<tr>
<td>4**</td>
<td>4.05</td>
<td>1.62</td>
</tr>
<tr>
<td>5**</td>
<td>4.20</td>
<td>1.68</td>
</tr>
<tr>
<td>6</td>
<td>3.35</td>
<td>1.63</td>
</tr>
<tr>
<td>7*</td>
<td>4.92</td>
<td>1.49</td>
</tr>
<tr>
<td>8*</td>
<td>4.62</td>
<td>1.72</td>
</tr>
<tr>
<td>9</td>
<td>2.96</td>
<td>1.97</td>
</tr>
<tr>
<td>10</td>
<td>3.49</td>
<td>1.62</td>
</tr>
<tr>
<td>11*</td>
<td>4.80</td>
<td>1.31</td>
</tr>
<tr>
<td>12*</td>
<td>4.57</td>
<td>1.48</td>
</tr>
<tr>
<td>13**</td>
<td>4.00</td>
<td>1.75</td>
</tr>
<tr>
<td>14</td>
<td>3.55</td>
<td>1.83</td>
</tr>
<tr>
<td>15**</td>
<td>3.85</td>
<td>1.62</td>
</tr>
<tr>
<td>16*</td>
<td>4.61</td>
<td>1.60</td>
</tr>
<tr>
<td>17*</td>
<td>4.89</td>
<td>1.62</td>
</tr>
<tr>
<td>18**</td>
<td>4.15</td>
<td>1.66</td>
</tr>
<tr>
<td>19*</td>
<td>4.95</td>
<td>1.74</td>
</tr>
<tr>
<td>20*</td>
<td>4.95</td>
<td>1.43</td>
</tr>
<tr>
<td>21*</td>
<td>4.68</td>
<td>1.52</td>
</tr>
<tr>
<td>22</td>
<td>3.41</td>
<td>1.92</td>
</tr>
<tr>
<td>23*</td>
<td>4.69</td>
<td>1.40</td>
</tr>
<tr>
<td>24*</td>
<td>4.35</td>
<td>1.68</td>
</tr>
<tr>
<td>25*</td>
<td>4.55</td>
<td>1.60</td>
</tr>
</tbody>
</table>

Discussion.

I designed the 25 statements to be related to the startup, the marketing campaign, the new product, and/or the Boston market. All of the statements (except Number 15) selected for use as unexpected distractions in later studies (15, 15, and 20 statements selected for use in Studies 2, 3, and 4, respectively) received average ratings of 4 or higher on the 1-7 scale for novelty and feasibility. This means that they would be helpful for generating novel and/or feasible ideas for the marketing campaign. In the next three studies,
I presented the selected statements as pop-up messages that participants encountered during their task assignment. Specifically, a message would pop up at a prearranged interval that participants could not predict and would temporarily prevent them from performing the task assignment.

**Study 2: Testing Divergent Thinking in Lab**

This study tested the curvilinear effects of unexpected distractions on creative outcomes during divergent thinking (Hypotheses 1a and 1b).

**Participants and procedure.**

I recruited 55 participants via a Harvard Business School participant pool with the criteria that they were fluent in English, were over 18 years of age, and were familiar with business and/or marketing concepts. Participants participated in a 20-minute lab experiment, titled “New Marketing Campaign,” for a flat compensation of $20. Participants were 45.45% female, on average 23.82 years old, 96.36% U.S. citizens, 45.45% White, 14.55% Asian, 12.73% Latino, 12.73% Multi-racial, 12.73% Black, and 1.82% Other. For education, 1.82% had a high school degree, 63.64% had some college education, 23.64% and a college degree, and 10.91% had a master’s degree.

Participants each sat in front of a computer terminal and followed the on-screen instructions to begin the experiment. They first read the cover story used in Study 1 before being asked to assume the role of the marketing expert at the startup who was responsible for coming up with creative (novel and feasible) ideas for the marketing campaign to popularize the new product within two months after the official launch. Participants then began a 10-minute idea generation task (a form of divergent thinking), where they were
asked to “generate as many novel ideas for the marketing campaign as possible while deferring any judgment on the feasibility of the ideas.” Participants were not instructed to ignore feasibility but instead were asked to defer any evaluation of feasibility for the time being to let the ideas flow during divergent thinking.

**Manipulations.** Prior to the task, participants were randomly assigned to one of four conditions. These conditions varied the frequency of unexpected distractions presented to participants as incoming messages from their colleagues at the startup during the 10-minute task. The total of 10 minutes excluded the time spent reading any incoming messages. The four conditions were: zero interruptions in 10 minutes (control), five interruptions in 10 minutes, 10 interruptions in 10 minutes, and 15 interruptions in 10 minutes. These incoming messages were the statements in Study 1 with highest scores on novelty and/or feasibility. Participants were informed about possible incoming messages and instructed to read each message carefully before clicking “ok” to resume the task.

I specified the intervals at which unexpected distractions occurred so that participants could not predict when a message would pop up. Specifically, in the five interruptions in 10 minutes condition, participants received a message after 1, 3, 6, 8, and 9 minutes into the task, excluding the time they spent reading each message. The first message popped up after 1 minute since they began the task. The second message popped up 2 minutes after they finished reading the first message. The third message popped up 3 minutes after they finished reading the second message. The fourth message popped up 2 minutes after they finished reading the third message. The fifth message popped up 1 minute after they finished reading the fourth message. In the 10 interruptions in 10 minutes condition, participants received a message twice as frequently as in the five interruptions in 10 minutes condition. In the 15 interruptions in 10 minutes condition, I inserted an additional message between two alternate messages. See Table 2 for how many seconds elapsed
since the start of the task until the nth message popped up across conditions.

Table 2: Timing of unexpected distractions: How many seconds lapsed since the beginning of the task until the nth message popped up across three conditions

<table>
<thead>
<tr>
<th>Incoming Message</th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5 interruptions in 10 minutes</td>
</tr>
<tr>
<td>1st</td>
<td>60</td>
</tr>
<tr>
<td>2nd</td>
<td>180</td>
</tr>
<tr>
<td>3rd</td>
<td>360</td>
</tr>
<tr>
<td>4th</td>
<td>480</td>
</tr>
<tr>
<td>5th</td>
<td>540</td>
</tr>
<tr>
<td>6th</td>
<td></td>
</tr>
<tr>
<td>7th</td>
<td></td>
</tr>
<tr>
<td>8th</td>
<td></td>
</tr>
<tr>
<td>9th</td>
<td></td>
</tr>
<tr>
<td>10th</td>
<td></td>
</tr>
<tr>
<td>11th</td>
<td></td>
</tr>
<tr>
<td>12th</td>
<td></td>
</tr>
<tr>
<td>13th</td>
<td></td>
</tr>
<tr>
<td>14th</td>
<td></td>
</tr>
<tr>
<td>15th</td>
<td></td>
</tr>
</tbody>
</table>

I presented the 15 selected statements in a fixed sequence. To ensure that participants across conditions (except the control condition) were exposed to both statements with relatively higher scores and those with relatively lower scores on novelty and/or feasibility, the sequence alternated between statements with the highest and the lowest scores among the selected statements. In particular, the first, third, fifth, etc., messages had the first, second, third, etc., highest scores, respectively. The second, fourth, sixth, etc., messages had the first, second, third, etc., lowest scores, respectively.

To keep constant the total time across conditions, participants saw a 10-minute countdown timer during the task; the 10 minutes excluded the time they spend reading the pop-up messages. Participants could no longer work on the task after the 10 minutes lapsed. After completing the task, participants answered a manipulation check question.
about how many incoming messages (0, 5, 10, or 15) they had received during the idea generation task. They then answered a question about their business and marketing background and some demographic questions before being thanked and paid for their participation.

**Manipulation check.** To determine whether the manipulations that varied the frequency at which participants encountered unexpected distractions across conditions worked as intended, I asked participants to report how many messages popped up during their 10-minute idea generation task. Participants did so by choosing whether there were 0, 5, 10, or 15 messages. A Chi-square test of independence indicated that participants were able to cognitively register the pop-up messages. Pearson chi 2(9) = 90.64, p < 0.001.

**Measures.**

**Per-minute frequency of unexpected distractions.** I computed the frequency at which each participant encountered unexpected distractions by dividing the number of interruption messages in his or her experimental condition by 10 minutes.

**Number of ideas.** This is the number of ideas each participant generated during the idea generation task. Two raters with a background in business and marketing evaluated all generated ideas on how much each idea was novel and feasible, using Berry’s (2012) novelty and feasibility scale, which captures the two main components of creativity. Specifically, the raters independently rated each idea on a seven-point Likert scale anchored at 1 (not at all) and 7 (extremely) to determine how much it was (a) novel, (b) new, and (c) original (all capturing novelty) as well as (d) useful, (e) effective, and (f) helpful (all capturing feasibility). Both raters were informed about the goal of the startup and the marketing campaign and were blind to the identities of participants.

**Novelty.** The first three items in Berry’s (2012) novelty and feasibility scale capture
novelty. Inter-rater reliabilities using intra-class correlation (ICC) were 0.76, 0.75, and 0.76, respectively. These reliabilities were higher than 0.70 and thus acceptable, so I averaged the two raters. The Cronbach’s alpha for the three items was 0.99, so I averaged them to form a novelty score for each idea. The ICC for novelty was 0.47 ($p < 0.001$), so I averaged the novelty scores across ideas from the same participant to compute a novelty score for each participant.

**Feasibility.** The last three items in Berry’s (2012) novelty and feasibility scale capture feasibility. Inter-rater reliabilities using ICC were 0.70, 0.74, and 0.71, respectively. These reliabilities were higher than 0.70 and thus acceptable, so I averaged the two raters. The Cronbach’s alpha for the three items was 0.97, so I averaged them to form a feasibility score for each idea. The ICC for feasibility was 0.12 ($p < 0.001$), so I averaged the feasibility scores across ideas from the same participant to compute a feasibility score for each participant.

**Control variables.** Even with random assignments, I accounted for a variety of aspects around participants to rule out possibilities that any of them might influence performance on idea generation. Specifically, I controlled for their business and marketing backgrounds and their demographic profiles, including age, gender (male or female), education level (high school degree, some college, college degree, or master’s degree and higher), and race (Black, Asian, Latino, Native American, Multi-Racial, White, or other). I also controlled for which of two experimental sessions they participated in.

Given the time limit, the number of ideas generated could be influenced by the novelty and feasibility of those ideas; thus, I controlled for novelty and feasibility when regressing on the number of ideas generated. This is a classic tradeoff between quality and quantity. Participants might not be able to write as many ideas were they to strive to make each idea very novel and/or feasible. In addition, when regressing on novelty, I controlled for
the number of ideas generated and feasibility to eliminate omitted variable bias. Specifically, exposure to unexpected distractions might influence the novelty of ideas generated through the number and/or feasibility of ideas generated. To elaborate, participants might be under time and distraction pressure to generate as many ideas as possible at the cost of originality of those ideas. Further, although participants were explicitly told to set aside their concerns for feasibility during idea generation, how novel they made their ideas could still be confined by the ultimate goal of putting those ideas to practical use in the marketing campaign. This rationale is consistent with a view that novelty and feasibility interact to produce creativity (George, 2007; Litchfield, 2008; Plucker, Beghetto, & Dow, 2004; Runco & Charles, 1993). Specifically, creative ideas are novel ideas that are bounded by a consideration of their feasibility (Guilford, 1950).

Results.

Table 3 provides the means and standard deviations of the number, novelty, and feasibility of ideas generated by condition.

Table 3: Means and (standard deviations) of number, novelty, and feasibility of ideas generated by condition

<table>
<thead>
<tr>
<th>Variable</th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0 interruption in 10 minutes (N=14)</td>
</tr>
<tr>
<td>Number of ideas</td>
<td>11.64(8.21)</td>
</tr>
<tr>
<td>Novelty</td>
<td>2.59(0.98)</td>
</tr>
<tr>
<td>Feasibility</td>
<td>3.44(0.79)</td>
</tr>
</tbody>
</table>

To gain an initial understanding of the data prior to inserting any control variables, I conducted analyses of variance to determine if there was any significant difference in the number, novelty, and feasibility of ideas generated across the four conditions.
An analysis of variance (ANOVA) on number of ideas generated indicated no significant difference across conditions, $F(3,51) = 0.78$, $p = 0.5104$. Although the number of ideas generated exhibited an inverted u-shaped relationship with the frequency of unexpected distractions, peaking in the five interruptions in 10 minutes condition, the pattern did not reach any statistical significance. I also ran a pairwise Sidak posthoc analysis to determine whether there was any significant difference between any two conditions and found none. See a scatter plot of the number of ideas generated across the four conditions in Figure 4.

![Figure 4: Scatter plot of the number of ideas generated by condition](image)

An ANOVA on novelty showed a significant difference across the four conditions, $F(3,51) = 8.28$, $p < 0.001$. The novelty of ideas generated exhibited an inverted u-shaped relationship with the frequency of unexpected distractions. Sidak posthoc analysis indicated
that on average the ideas generated by participants who encountered five unexpected distractions in 10 minutes were more novel than those generated by participants who did not encounter any unexpected distractions ($p < 0.01$), who encountered 10 distractions in 10 minutes ($p < 0.001$), and who encountered 15 unexpected distractions in 10 minutes ($p < 0.001$). The novelty of ideas generated was statistically equivalent across the zero, 10, and 15 interruptions in 10 minutes conditions. These results showed preliminary support for Hypothesis 1b. See a scatter plot of the novelty scores across the four conditions in Figure 5.

![Figure 5: Scatter plot of the novelty scores by condition](image)

An ANOVA on feasibility showed that there was no significant difference across the four conditions, $F(3,51) = 1.67$, $p = 0.1843$. Although the feasibility of ideas generated exhibited an inverted u-shaped relationship with the frequency of unexpected distractions,
peaking in the five interruptions in 10 minutes condition, the pattern did not reach any statistical significance. I also ran a pairwise Sidak posthoc analysis to determine whether there was any significant difference between any two conditions and found none.

Participants’ demographic characteristics and business and marketing backgrounds were statistically equivalent across the four conditions.

**Testing Hypotheses 1a & 1b using regression analyses.** Table 4 presents the regression results.

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Key predictors</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frequency</td>
<td>-5.83 (6.21)</td>
<td>1.49 (0.93)</td>
<td>1.75 (0.86)*</td>
</tr>
<tr>
<td>(Frequency)^2</td>
<td>3.63 (4.03)</td>
<td>-1.30 (0.59)*</td>
<td>-1.45 (0.55)*</td>
</tr>
<tr>
<td><strong>Control variables</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of ideas</td>
<td>-0.28 (1.06)</td>
<td>0.01 (0.02)</td>
<td>0.01 (0.02)</td>
</tr>
<tr>
<td>Novelty</td>
<td>-</td>
<td>-0.01 (0.29)</td>
<td>-0.03 (0.26)</td>
</tr>
<tr>
<td>Feasibility</td>
<td>0.94 (1.86)</td>
<td>0.08 (0.29)</td>
<td>-0.03 (0.26)</td>
</tr>
<tr>
<td>Bus/Mkt Background</td>
<td>0.17 (0.68)</td>
<td>-0.15 (0.10)</td>
<td>-0.17 (0.10)+</td>
</tr>
<tr>
<td><strong>Overall R-Square</strong></td>
<td>0.288</td>
<td>0.4391</td>
<td>0.4075</td>
</tr>
<tr>
<td>R-Square Change</td>
<td>-</td>
<td>-</td>
<td>-0.0316</td>
</tr>
</tbody>
</table>

*p<0.10,  *p<0.05,  **p<0.01,  ***p<0.001; standard errors are in parentheses; Frequency is per-minute frequency of unexpected distractions; other controls include participant’s gender, age, education and race dummies, and session dummies; race dummies are dropped in Model 3.

I conducted regression analyses to test Hypotheses 1a and 1b. First, to test the curvilinear effects of the frequency of unexpected distractions on the number of ideas generated, in Model 1, I regressed the number of ideas on per-minute frequency of unexpected distractions, per-minute frequency of unexpected distractions squared, and the controls. The results showed non-significant relationships between per-minute frequency of unexpected distractions and number of ideas (β = -5.83, p = 0.354) and between per-minute
frequency of unexpected distractions squared and number of ideas ($\beta = 3.63, p = 0.373$). Hypothesis 1a was not supported.

Next, to test the curvilinear effects of the frequency of unexpected distractions on the novelty of ideas generated, in Model 2, I regressed novelty on per-minute frequency of unexpected distractions, per-minute frequency of unexpected distractions squared, and the controls. The results showed a positive but non-significant relationship between per-minute frequency of unexpected distractions and novelty ($\beta = 1.49, p = 0.119$), and a negative and significant relationship between per-minute frequency of unexpected distractions squared and novelty ($\beta = -1.30, p < 0.05$). I speculated that the non-significant effect of per-minute frequency of unexpected distractions on novelty might result from the low power of the model—55 participants with an array of variables and the effect was almost marginally significant—so, in Model 3, I removed the race dummies, which were not significant in Model 2, from the controls.

In Model 3, the results showed a positive and significant relationship between per-minute frequency of unexpected distractions and novelty ($\beta = 1.75, p < 0.05$) and a negative and significant relationship between per-minute frequency of unexpected distractions squared and novelty ($\beta = -1.45, p < 0.05$). Hypothesis 1b was supported.

**Discussion.**

This study reveals empirical support for Hypotheses 1b but not 1a. Specifically, there was an inverted u-shaped relationship between the frequency of unexpected distractions and the novelty but not the number of ideas generated during the idea generation task. Indeed, idea generation invokes divergent thinking (Guilford, 1967; Khandwalla, 1993; Runco, 1991) to brainstorm as many novel ideas as possible. Sidak posthoc analysis points out that, in this particular context, participants were able to produce ideas that were the most
novel when they encountered five unexpected distractions in 10 minutes (0.5 unexpected
distraction per minute), compared to zero, 10, or 15 unexpected distractions in 10 minutes.
This curvilinear relationship was, however, significant only after I removed some insignificant
controls to increase the degrees of freedom in the regression model. For robustness check, I
moved to conduct a similar study online with a bigger sample size to see if the findings
would replicate.

Study 3: Testing Divergent Thinking Online

Like Study 2, this study was intended to test Hypotheses 1a and 1b. I increased the
sample size to raise the power of the testing model.

Participants and procedure.
I recruited 102 online participants via MTurk with the criteria that they lived in the
U.S., were over 18 years of age, were fluent in English, and were familiar with business
and/or marketing concepts. Participants went through the same study design as in Study 2
but at the convenience of their own computer terminals. They were compensated a constant
rate of $0.75 for 20 minutes of their time. Participants were 45.10% female, on average
33.41 years old, 96.08% U.S. citizens, 69.61% White, 8.82% Asian, 6.86% Latino, 4.90%
Multi-racial, 8.82% Black, and 0.98% Other. For education, 10.78% had a high school
degree, 39.22% had some college education, 43.14% had a college degree, 5.88% had a
master’s degree, and 0.98% had a professional degree.

Manipulation check. To determine whether the manipulations that varied the
frequency at which participants encountered unexpected distractions across conditions
worked as intended, I asked participants to report how many incoming messages popped up
during their 10-minute idea generation task. Participants did so by choosing whether there were zero, five, 10, or 15 messages. A Chi-square test of independence indicated that participants were able to cognitively register the pop-up messages. Pearson chi 2(9) = 152.26, p < 0.001.

**Measures.**

The variables were the same as in Study 2. However, this study was conducted in a single online session; hence, I did not control for which session participants participated in.

**Novelty.** The first three items in Berry’s (2012) novelty and feasibility scale capture novelty. Inter-rater reliabilities using ICC were 0.75, 0.72, and 0.73, respectively. These reliabilities were higher than 0.70 and thus acceptable, so I averaged the two raters. The Cronbach’s alpha for the three items was 0.95, so I averaged them to form a novelty score for each idea. The ICC for novelty was 0.50 (p < 0.001), so I averaged the novelty scores across ideas from the same participant to compute a novelty score for each participant.

**Feasibility.** The last three items in Berry’s (2012) novelty and feasibility scale capture feasibility. Inter-rater reliabilities using ICC were 0.75, 0.74, and 0.80 for the fourth, fifth, and sixth items, respectively. These reliabilities were higher than 0.70 and thus acceptable, so I averaged the two raters. The Cronbach’s alpha for the three items was 0.91, so I averaged them to form a feasibility score for each idea. The ICC for feasibility was 0.41 (p < 0.001), so I averaged the feasibility scores across ideas from the same participant to compute a feasibility score for each participant.

**Results.**

Table 5 provides the means and standard deviations of the number, novelty, and feasibility of ideas generated across the four conditions.
Table 5: Means and (standard deviations) of number, novelty, and feasibility of ideas generated by condition

<table>
<thead>
<tr>
<th>Variable</th>
<th>Condition</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0 interruption in 10 minutes (N=25)</td>
<td>5 interruptions in 10 minutes (N=25)</td>
<td>10 interruptions in 10 minutes (N=28)</td>
<td>15 interruptions in 10 minutes (N=24)</td>
<td></td>
</tr>
<tr>
<td>Number of ideas</td>
<td>7.88(3.95)</td>
<td>8.68(3.67)</td>
<td>10.43(3.91)</td>
<td>9.71(3.70)</td>
<td></td>
</tr>
<tr>
<td>Novelty</td>
<td>2.53(0.69)</td>
<td>3.12(0.59)</td>
<td>2.50(0.31)</td>
<td>2.22(0.42)</td>
<td></td>
</tr>
<tr>
<td>Feasibility</td>
<td>4.00(0.58)</td>
<td>3.94(0.46)</td>
<td>3.80(0.58)</td>
<td>3.67(0.60)</td>
<td></td>
</tr>
</tbody>
</table>

To gain an initial understanding of the data prior to inserting any control variables, I conducted analyses of variance to determine whether there was any significant difference in the number, novelty, and feasibility of ideas generated across the four conditions.

An ANOVA on the number of ideas generated indicated a marginally significant difference across conditions, $F(3,98) = 2.26, p < 0.10$. Although the number of ideas generated exhibited an inverted u-shaped relationship with the frequency of unexpected distractions, peaking in the 10 interruptions in 10 minutes condition, the pattern only reached marginal statistical significance. I also ran a pairwise Sidak posthoc analysis to determine whether there was any significant difference between any two conditions and found only a marginally significant difference between the number of ideas generated in the zero interruptions in 10 minutes and the 10 interruptions in 10 minutes conditions ($p < 0.10$). See a scatter plot of the number of ideas across the four conditions in Figure 6.
An ANOVA on novelty showed a significant difference across the four conditions, $F(3,98) = 13.02, p < 0.001$. The novelty of ideas generated exhibited an inverted u-shaped relationship with the frequency of unexpected distractions. Sidak posthoc analysis indicated that on average the ideas generated by participants who encountered five unexpected distractions in 10 minutes were more novel than those generated by participants who did not encounter any unexpected distractions ($p < 0.001$), who encountered 10 unexpected distractions in 10 minutes ($p < 0.001$), and who encountered 15 unexpected distractions in 10 minutes ($p < 0.001$). The novelty of feasibility generated was statistically equivalent across the zero, 10, and 15 interruptions in 10 minutes conditions. These results, consistent with those in Study 2, showed preliminary support for Hypothesis 1b. See a scatter plot of the novelty scores across the four conditions in Figure 7.
An ANOVA on feasibility showed that there was no significant difference across the four conditions, $F(3,98) = 1.73, p = 0.1658$. I also ran a pairwise Sidak posthoc analysis to determine whether there was any significant difference between any two conditions and found none.

Participants’ demographic characteristics and business and marketing backgrounds were statistically equivalent across the four conditions.

*Testing Hypotheses 1a & 1b using regression analyses.* Table 6 presents the regression results.
Table 6: Regression results (N=102)

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of ideas</td>
<td>Novelty</td>
<td>Novelty</td>
</tr>
<tr>
<td>Key predictors</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frequency</td>
<td>4.91(2.56)+</td>
<td>1.09(0.34)**</td>
<td>1.02(0.35)**</td>
</tr>
<tr>
<td>(Frequency)^2</td>
<td>-2.48(1.70)</td>
<td>-0.87(0.21)***</td>
<td>0.80(0.22)***</td>
</tr>
<tr>
<td>Control variables</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of ideas</td>
<td>-</td>
<td>-0.02(0.01)</td>
<td>-0.01(0.01)</td>
</tr>
<tr>
<td>Novelty</td>
<td>-1.15(0.78)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Feasibility</td>
<td>0.64(0.74)</td>
<td>0.17(0.10)+</td>
<td>0.22(0.10)*</td>
</tr>
<tr>
<td>Bus/Mkt Background</td>
<td>0.58(0.26)*</td>
<td>-0.02(0.04)</td>
<td>-0.03(0.04)</td>
</tr>
<tr>
<td>Overall R-Square</td>
<td>0.2374</td>
<td>0.4164</td>
<td>0.3233</td>
</tr>
<tr>
<td>R-Square Change</td>
<td>-</td>
<td>-</td>
<td>-0.0931*</td>
</tr>
</tbody>
</table>

*p<0.10, **p<0.05, ***p<0.001; standard errors are in parentheses; Frequency is per-minute frequency of unexpected distractions; other controls include participant's gender, age, education and race dummies, and session dummies; race dummies are dropped in Model 3.

I conducted regression analyses with the same model specifications as in Study 2 to test Hypotheses 1a and 1b. First, to test the curvilinear effects of the frequency of unexpected distractions on the number of ideas generated, in Model 1, I regressed the number of ideas on per-minute frequency of unexpected distractions, per-minute frequency of unexpected distractions squared, and the controls. The results showed a marginally positive relationship between per-minute frequency of unexpected distractions and the number of ideas ($\beta = 4.91, p < 0.10$) and a non-significant relationship between per-minute frequency of unexpected distractions squared and the number of ideas ($\beta = -2.48, p = 0.148$). Consistent with Study 2, Hypothesis 1a was not supported.

Next, to test the curvilinear effects of the frequency of unexpected distractions on the novelty of ideas, in Model 2, I regressed novelty on per-minute frequency of unexpected distractions, per-minute frequency of unexpected distractions squared, and the controls. The results showed a positive and significant relationship between per-minute frequency of unexpected distractions and novelty ($\beta = 1.09, p < 0.01$) and a negative and significant
relationship between per-minute frequency of unexpected distractions squared and novelty ($\beta = -0.87, p < 0.001$). For comparability to Study 2, I ran another model, Model 3, without the race dummies as the control. The results showed a positive and significant relationship between per-minute frequency of unexpected distractions and novelty ($\beta = 1.02, p < 0.01$) and a negative and significant relationship between per-minute frequency of unexpected distractions squared and novelty ($\beta = -0.80, p < 0.001$). These results, consistent with those in Study 2, supported Hypothesis 1b.

**Discussion.**

Like Study 2, this study provides support for Hypotheses 1b but not 1a. Specifically, there was an inverted u-shaped relationship between the frequency of unexpected distractions and novelty but not the number of ideas generated during idea generation. In addition, consistent with Study 2, Sidak posthoc analysis suggests that, in this particular context, participants were able to create ideas that were most novel when they encountered five, compared to zero, 10, or 15, unexpected distractions in 10 minutes. With a bigger sample size than the previous study, the curvilinear relationship between the frequency of unexpected distractions and the novelty of ideas generated was significant with or without the race dummies as controls. This relationship proved to be robust.

In the next lab study, I added an idea elaboration task, which implicates convergent thinking, to the current study design to test the hypothesized negative relationship between the frequency of unexpected distractions and the feasibility of creative outcomes from convergent thinking.
Study 4: Testing Divergent Thinking & Convergent Thinking in Lab

This study tested Hypotheses 1a, 1b, and 2 in the lab.

Participants and procedure.

I recruited 55 participants via the Harvard Business School participant pool with the criteria that they were fluent in English, were over 18 years of age, and were familiar with business and/or marketing concepts. They were compensated a flat rate of $20 for 30 minutes of their time. Participants were 45.45% female, on average 25.27 years old, 96.36% U.S. citizens, 40.00% White, 23.64% Asian, 3.64% Latino, 10.91% Multi-racial, and 21.82% Black. For education, 1.82% had some high school education, 1.82% had a high school degree, 40.00% had some college education, 32.73% had a college degree, 20.00% had a master’s degree, 1.82% had a professional degree, and 1.82% had a doctoral degree.

Participants went through a similar but longer study design as in Studies 1 and 2. Specifically, they read the same cover story and completed the same idea generation task before moving on to a 10-minute idea elaboration task (a form of convergent thinking). For this task, participants were asked to select one idea among those they had generated during the idea generation task that they thought had the highest potential to be feasible, appropriate, and useful for the marketing campaign and then to elaborate on how to make that idea feasible, appropriate, and useful. They were also reminded of the goal of the campaign to “attract many customers in a short period of time.”

Manipulations. Prior to each task, participants were randomly assigned to one of three conditions. These conditions varied in the frequency of unexpected distractions presented to participants in the form of pop-up messages from their colleagues at the startup during the 10-minute (excluding the time spent reading the messages) task time. The
three conditions were zero interruptions in 10 minutes (control), five interruptions in 10 minutes, and 10 interruptions in 10 minutes. The pop-up messages were taken from 20 of the statements in Study 1 with the highest scores on novelty and/or feasibility. The first 10 statements were used during the idea generation task, and the latter 10 were used during the idea elaboration task. Participants were informed about possible incoming messages and instructed to read each message carefully before clicking “ok” to resume the task.

There were only three conditions (not 4) in this study because I inferred from the results of Studies 2 and 3 that peak performance in terms of the novelty of ideas generated was in the five interruptions in 10 minutes condition, and the performance in the 10 interruptions in 10 minutes condition did not significantly differ from the performance in the 15 interruptions in 10 minutes condition. The conditions to which each participant was assigned for the first and second tasks were independent. There were therefore a total of 3X3 = 9 assignment combinations. The intervals at which unexpected distractions occurred and the sequences of the messages were the same as in Studies 2 and 3.

Following each task, participants answered a manipulation question of how many incoming messages (zero, five, 10, or 15) they encountered during the 10-minute task time. Lastly, participants answered a question about their business and marketing background and some demographic questions before being thanked and paid for their participation.

**Manipulation check: Idea generation task.** To determine whether the manipulations that varied the frequency at which participants encountered unexpected distractions during the idea generation task across conditions worked as intended, I asked participants to report the number—zero, five, 10, or 15—of incoming messages during their 10-minute idea generation task. A Chi-square test of independence indicated that participants were able to cognitively register the pop-up messages, Pearson chi 2(4) = 60.47, p < 0.001.
**Manipulation check: Idea elaboration task.** To determine whether the manipulations that varied the frequency at which participants encountered unexpected distractions during the idea elaboration task across conditions worked as intended, I asked participants to report the number—zero, five, 10, or 15—of incoming messages during their 10-minute idea elaboration task. A Chi-square test of independence indicated that participants were able to cognitively register the pop-up messages, Pearson chi $2(4) = 77.89$, $p < 0.001$.

**Measures.**

**Per-minute frequency of unexpected distractions during idea generation task.** I computed the frequency at which each participant encountered unexpected distractions during the idea generation task by dividing the number of interruption messages in his or her experimental condition by 10 minutes.

**Per-minute frequency of unexpected distractions during idea elaboration task.** I computed the frequency at which each participant encountered unexpected distractions during the idea elaboration task by dividing the number of interruption messages in his or her experimental condition by 10 minutes.

**Number of ideas generated.** This is the number of ideas each participant generated during the idea generation task. The same two raters as in Studies 2 and 3 evaluated all generated ideas during the idea generation task using Berry's (2012) novelty and feasibility scale, which captures the two main components of creativity. Specifically, the raters independently rated on a seven-point Likert scale anchored at 1 (not at all) and 7 (extremely) how much each idea was (a) novel, (b) new, and (c) original (all capturing novelty) as well as (d) useful, (e) effective, and (f) helpful (all capturing feasibility). Both raters were informed of the goal of the startup and the campaign but were blind to the
identities of participants.

**Novelty of ideas generated.** The first three items in Berry’s (2012) novelty and feasibility scale capture novelty. Inter-rater reliabilities using ICC were 0.80, 0.76, and 0.77, respectively. These reliabilities were higher than 0.70 and thus acceptable, so I averaged the two raters. The Cronbach’s alpha for the three items was 0.97, so I averaged them to form a novelty score for each idea. The ICC for novelty was 0.36 ($p < 0.001$), so I averaged the novelty scores across ideas from the same participant to compute a novelty score for each participant.

**Feasibility of ideas generated.** The last three items in Berry’s (2012) novelty and feasibility scale capture feasibility. Inter-rater reliabilities using ICC were 0.72, 0.78, and 0.77, respectively. These reliabilities were higher than 0.70 and thus acceptable, so I averaged the two raters. The Cronbach’s alpha for the three items was 0.96, so I averaged them to form a feasibility score for each idea. The ICC for feasibility was 0.25 ($p < 0.001$), so I averaged the feasibility scores across ideas from the same participant to compute a feasibility score for each participant.

The same two raters independently evaluated the idea that each participant selected and elaborated on during the idea elaboration task using the same Berry’s (2012) novelty and feasibility scale. Both raters were blind to the identities of participants. They finished with all the ratings for the idea generation task before moving on to the idea elaboration task, so they were unlikely able to match the identities of participants across the two tasks.

**Novelty of idea selected.** Inter-rater reliabilities using ICC were 0.71, 0.76, and 0.76 for the first, second, and third items in the Berry’s (2012) novelty and feasibility scale, respectively. These reliabilities were higher than 0.70 and thus acceptable, so I averaged the two raters. The Cronbach’s alpha for the three items was 0.97, so I averaged them to form a novelty score for each participant.
Feasibility of idea selected. Inter-rater reliabilities using ICC were 0.82, 0.75, and 0.78 for the fourth, fifth, and sixth items in the Berry’s (2012) novelty and feasibility scale, respectively. These reliabilities were higher than 0.70 and thus acceptable, so I averaged the two raters. The Cronbach’s alpha for the three items was 0.92, so I averaged them to form a feasibility score for each participant.

Control variables. To test Hypotheses 1a and 1b (involving divergent thinking), I included the same controls as in Study 3. As for Hypothesis 2 (involving convergent thinking), I controlled for the novelty of the idea selected in addition to participants’ demographics and business and marketing background and the session dummies when regressing on feasibility of idea selected. I did this to isolate the effects of unexpected distractions on the feasibility of the selected idea.

Results.

Table 7 provides the means and standard deviations of the number, novelty, and feasibility of ideas generated during the idea generation task across the three conditions.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Variable</th>
<th>Number</th>
<th>Novelty</th>
<th>Feasibility</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0 interruption in 10 minutes</td>
<td>10.50(7.63)</td>
<td>3.41(0.59)</td>
<td>4.60(0.71)</td>
</tr>
<tr>
<td>(N=18)</td>
<td>5 interruptions in 10 minutes</td>
<td>10.31(4.29)</td>
<td>3.94(0.70)</td>
<td>4.84(0.56)</td>
</tr>
<tr>
<td></td>
<td>10 interruptions in 10 minutes</td>
<td>10.00(6.32)</td>
<td>3.11(0.78)</td>
<td>4.45(0.56)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(N=19)</td>
<td>(N=19)</td>
<td>(N=18)</td>
</tr>
</tbody>
</table>

Table 8 provides the means and standard deviations of the novelty and feasibility of the idea selected during the idea elaboration task across the three conditions.
Table 8 Means and (standard deviations) of the novelty and feasibility of idea selected during the idea elaboration task by condition.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Condition</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0 interruption in 10 minutes</td>
<td>5 interruptions</td>
<td>10 interruptions</td>
<td></td>
</tr>
<tr>
<td>Novelty</td>
<td></td>
<td>in 10 minutes</td>
<td>in 10 minutes</td>
<td>in 10 minutes</td>
</tr>
<tr>
<td>Feasibility</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.36(1.41)</td>
<td>3.46(0.82)</td>
<td>3.25(0.79)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.14(0.75)</td>
<td>4.33(0.94)</td>
<td>3.57(0.86)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

To gain preliminary understanding of the data before inserting any control variables, I conducted analyses of variance to determine whether there was any significant difference in the number of ideas generated, the novelty of ideas generated, the feasibility of ideas generated, the novelty of idea selected, and the feasibility of idea selected across conditions.

An ANOVA on the number of ideas generated indicated no difference across the three conditions during idea generation, $F(2,52) = 0.03$, $p = 0.9705$. I also ran a pairwise Sidak posthoc analysis to determine whether there was any significant difference between any two conditions and found none. See a scatter plot of the number of ideas generated across the three conditions in Figure 8.
An ANOVA on novelty of ideas generated showed a significant difference across the three conditions during idea generation, $F(2,52) = 6.78, p < 0.01$. The novelty of ideas generated exhibited an inverted u-shaped relationship with the frequency of unexpected distractions. Sidak posthoc analysis indicated that on average the ideas generated by participants who encountered five unexpected distractions in 10 minutes were marginally more novel than those generated by participants who did not encounter any unexpected distractions ($p < 0.10$) and who encountered 10 distractions in 10 minutes ($p < 0.01$). The novelty of ideas generated was statistically equivalent between the zero and 10 interruptions in 10 minutes conditions. These results, consistent with those in Studies 2 and 3, showed preliminary support for Hypothesis 1b. See a scatter plot of the novelty of ideas generated across the three conditions in Figure 9.
Figure 9: Scatter plot of the novelty of ideas generated by condition

An ANOVA on feasibility of ideas generated showed that there was no significant difference across the three conditions during idea generation, $F(2,52) = 1.95$, $p = 0.1527$. I also ran a pairwise Sidak posthoc analysis to determine if there was any significant difference between any two conditions and found none.

Participants’ demographic characteristics and business and marketing backgrounds were statistically equivalent across the three conditions during idea generation.

An ANOVA on novelty of idea selected showed that there was no significant difference across the three conditions during idea elaboration, $F(2,52) = 0.18$, $p = 0.8326$. I also ran a pairwise Sidak posthoc analysis to determine if there was any significant difference between any two conditions and found none.

An ANOVA on feasibility of idea selected showed a significant difference across the three conditions during idea elaboration, $F(2,52) = 15.75$, $p < 0.001$. The feasibility of idea
selected exhibited a negative relationship with the frequency of unexpected distractions. Sidak posthoc analysis indicated that on average the ideas generated by participants who encountered no unexpected distractions were marginally more novel than those generated by participants who encountered five unexpected distractions ($p < 0.05$) or 10 distractions in 10 minutes ($p < 0.001$). Also, the feasibility of the idea selected in the five interruptions in 10 minutes condition was higher than in the 10 interruptions in 10 minutes condition ($p < 0.05$). These results showed preliminary support for Hypothesis 2. See a scatter plot of the feasibility of ideas generated across the three conditions in Figure 10.

![Figure 10: Scatter plot of the feasibility of idea selected by condition](image)

Participants' demographic characteristics and business and marketing backgrounds were statistically equivalent across the three conditions during idea elaboration.

**Testing Hypotheses 1a, 1b, and 2 using regression analyses.** Table 9 presents
the regression results.

Table 9: Regression results (N=55)

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of ideas</td>
<td>Novelty</td>
<td>Feasibility</td>
<td>Feasibility</td>
</tr>
<tr>
<td>Key predictors</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frequency</td>
<td>4.68(11.62)</td>
<td>2.50(0.72)**</td>
<td>-0.90(0.45)+</td>
<td>-1.34(0.28)**</td>
</tr>
<tr>
<td>(Frequency)^2</td>
<td>-7.42(12.01)</td>
<td>-3.04(0.70)**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control variables</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of ideas</td>
<td>-</td>
<td>-0.01(0.01)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Novelty</td>
<td>-1.56(2.36)</td>
<td>-</td>
<td>0.42(0.12)**</td>
<td>0.39(0.11)**</td>
</tr>
<tr>
<td>Feasibility</td>
<td>-0.90(2.12)</td>
<td>0.30(0.14)*</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Bus/Mkt Background</td>
<td>0.45(0.60)</td>
<td>-0.03(0.04)</td>
<td>0.12(0.07)+</td>
<td>0.09(0.06)</td>
</tr>
<tr>
<td>Frequency_gen</td>
<td>-</td>
<td>-</td>
<td>0.61(0.54)</td>
<td>0.04(0.31)</td>
</tr>
<tr>
<td>Frequency_gen X</td>
<td>-</td>
<td>-</td>
<td>-0.88(0.69)</td>
<td>-</td>
</tr>
<tr>
<td>Frequency_elab</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Overall R-Square</td>
<td>0.2627</td>
<td>0.7591</td>
<td>0.7185</td>
<td>0.7051</td>
</tr>
<tr>
<td>R-Square Change</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-0.0134</td>
</tr>
</tbody>
</table>

+p<0.10, *p<0.05, **p<0.01, ***p<0.001; standard errors are in parentheses; in Models 1 and 2, Frequency is per-minute frequency of unexpected distractions during idea generation; in Models 3 and 4, Frequency is per-minute frequency of unexpected distractions during idea elaboration; in Model 1, Novelty is novelty of ideas generated and Feasibility is feasibility of ideas generated; in Model 2, Feasibility is feasibility of ideas generated; in Models 3 and 4, Novelty is novelty of idea selected; Frequency_gen is per-minute frequency of unexpected distractions during idea generation; Frequency_elab is per-minute frequency of unexpected distractions during idea elaboration; other controls include participant's gender, age, education and race dummies, and session dummies.

I conducted regression analyses to test Hypotheses 1a, 1b, and 2. First, to test the curvilinear effects of the frequency of unexpected distractions during the idea generation task on the number of ideas generated, in Model 1, I regressed the number of ideas generated on per-minute frequency of unexpected distractions during the idea generation task, per-minute frequency of unexpected distractions during the idea generation task squared, and the controls. The results showed non-significant relationships between per-minute frequency of unexpected distractions during idea generation task and the number of ideas generated ($\beta = 4.68$, $p = 0.690$) and between per-minute frequency of unexpected distractions during the idea generation task squared and number of ideas generated...
(\(\beta = -7.42, p = 0.541\)). Consistent with Studies 2 and 3, Hypothesis 1a was not supported.

Next, to test the curvilinear effects of the frequency of unexpected distractions during the idea generation task on the novelty of ideas generated, in Model 2, I regressed novelty of ideas generated on per-minute frequency of unexpected distractions during the idea generation task, per-minute frequency of unexpected distractions during the idea generation task squared, and the controls. The results showed a positive and significant relationship between per-minute frequency of unexpected distractions during the idea generation task and novelty of ideas generated (\(\beta = 2.50, p < 0.001\)) and a negative and significant relationship between per-minute frequency of unexpected distractions during the idea generation task squared and novelty of ideas generated (\(\beta = -3.04, p < 0.001\)). The results were consistent with those in Studies 2 and 3 and supported Hypothesis 1b.

Next, to test the negative effects of the frequency of unexpected distractions during the idea elaboration task on the feasibility of idea selected, in Model 3, I regressed feasibility of idea selected on per-minute frequency of unexpected distractions during idea elaboration task and the controls. Because participants completed the idea elaboration task after the idea generation task, the condition to which they were assigned for the first task might have influenced the effects of unexpected distractions during the second task on their second task performance. For example, participants who were interrupted 15 times in 10 minutes during the first task might be too weary or distracted to focus on the second task, regardless of how many interruptions they faced during the 10-minute second task. To account for this, I included as regressors per-minute frequency of unexpected distractions during the idea generation task and an interaction term between per-minute frequency of unexpected distractions during the idea generation task and per-minute frequency of unexpected distractions during the idea elaboration task. The results showed a marginally negative relationship between per-minute frequency of unexpected distractions during the idea
elaboration task and feasibility of idea selected ($\beta = -0.90, p < 0.10$).

Because the interaction term was not a significant moderator of the relationship between per-minute frequency of unexpected distractions during the idea elaboration task and feasibility of the idea selected ($\beta = -0.88, p = 0.211$), I removed it in Model 4 to increase the degrees of freedom of the model. The results showed a negative and significant relationship between per-minute frequency of unexpected distractions during the idea elaboration task and feasibility of idea selected ($\beta = -1.34, p < 0.01$), supporting Hypothesis 2.

**Discussion.**

This study supports Hypotheses 1b and 2 but not 1a. As predicted, divergent thinking benefits from the new cognitive inputs introduced by unexpected distractions but only up to a certain frequency of interruptions—0.5 unexpected distraction per minute in this particular context. Convergent thinking, on the other hand, suffers from any frequency of unexpected distractions. Note that only the novelty, not the number, of ideas generated during idea generation, which involves divergent thinking, differed across frequencies of unexpected distractions. The non-significant effect of the frequency of unexpected distractions on the number of ideas generated, consistent across Studies 2-4, was, nonetheless, not surprising. Instructed to “write down as many novel ideas as possible for the marketing campaign,” participants might generally put a higher emphasis on generating “novel” ideas as opposed to “as many ideas as possible” given the tight time limit of 10 minutes. In other words, participants might spent time making each idea for popularizing the new product exceptionally novel at the expense of generating more ideas. Further studies that offer different incentives for the number versus novelty of ideas generated and/or vary the time limit and/or the type of divergent thinking task could test this possibility.
I created the interruption materials for Studies 2, 3, and 4 to be related to the startup, the marketing campaign, the new product, and/or the Boston market. It follows that all of the unexpected distractions participants encountered during their task assignments introduced new cognitive contents that were relevant to the creative task at hand. This is not necessarily the case in the actual workplace where unexpected distractions come in various forms and contents. Some of these real-world distractions might be related to the task at hand while others might not. As long as they can take attention away from the primary task, these distractions should exert the same patterns of effects on the creative process. Nonetheless, as I argue, the channels through which these different types of unexpected distractions may impact the creative outcomes are distinctive. Study 6 tested Hypotheses 1b and 2 in a real-world setting with naturally occurring unexpected distractions that might or might not be relevant to the creative task at hand.

**Study 5: Piloting in the Field**

This study was the first in two field studies I conducted at an IT company in Bangkok, Thailand, with actual employees as participants, actual software tasks as creative outputs, and naturally occurring unexpected distractions. A typical software project at this research site delivered an IT product that satisfied the client’s needs, such as a company’s web platform or an automated human resources’ data-entry system. Management of this company constantly encouraged the programmers to work innovatively (e.g., produce intermediate products that others can conveniently build on, combine existing chunks of coding in novel ways) to save time and effort but without sacrificing the quality (e.g., reliability, stability, traceability) of their work. A typical software project took between three and five weeks to finish.
This study allowed me to familiarize myself with the company, to understand its operations and the types of service it provided, and to design a field study that would test the hypotheses in this context. Specifically, I was able to categorize the software work into a type involving divergent thinking and another involving convergent thinking, both of which strived for creativity. I also developed and validated measures for novelty and feasibility of creative outputs from these two types of software work using Amabile’s (1982) consensual assessment technique.

**A typical software project.**

The management and senior programmers at the research site volunteered to give me information about their company in three semi-structured phone interview sessions. They were Thai natives who had been with the company for more than a decade and were acquainted with their operations of the company and the type of software products it provided. I conducted the phone interviews in Thai while I was located in the United States.

The interviewees walked me through a typical software project. A project manager would meet with a client to gather demands and requirements for a product (e.g., a web interface, a security system, a support system). The manager then delegated the work to his or her team members. The first step in the project was to create a high-level design of the product. This step was called software designing, and it was the process of generating coding structures, plans, or specifications in response to the client’s requirements. The design could be as unconventional as the programmers in charge desired as long as it met the demands of the client. The outputs of this step, usually design templates, would serve as the blueprint for the next step. The next step was software coding, during which codes were written following the blueprint from the software-designing step to constitute the final product. The blueprint served as a guideline in this step, but the programmers in charge
could still innovate their coding routines. For example, they could use different code libraries or combine previous codes in novel ways to minimize the execution time. An analogous example of these two steps can be found in the work of writing. With a specific topic in mind, the writer may start from outlining his or her arguments by paragraphs—that is, what points to get across in the introduction, the body, and the conclusion. The writer then begins to put thoughts into words following the argument outline. Indeed, software designing is akin to the process of outlining the arguments, whereas software coding resembles the heavy lifting process of writing as guided. Both processes could benefit from some creative endeavors as long as the requests are fulfilled.

The interviewees asserted that software designing implicated divergent thinking while software coding involved a great amount of convergent thinking. Specifically, programmers looked for various designs to satisfy the client’s demands in the designing process, and they had abundant leeway in translating the client’s demands into the designs. They were open to new information and ways to cover all the requirements. On the other hand, in software coding, programmers were guided by a specific design to write codes that worked as intended. Although they had room to experiment with various ways of coding to optimize the output, it all converged to what was most useful for the client as opposed to what was possible.

In addition, I worked with the interviewees to create two sets of creativity measures for software work, one for software designing and the other for software coding. We first identified what it meant to be novel and feasible in software designing and software coding. Then, we composed items that would capture these two dimensions in each of the two types of software work. We came up with a total of eight items for each type of software work—four hypothesized to capture novelty and four hypothesized to capture feasibility of the outputs. See Table 10 for these items and their hypothesized domains. I used Amabile’s
(1982) consensual assessment technique to validate these measures. I was also able to test the interviewees’ assertions about software designing’s involving divergent thinking and software coding’s involving convergent thinking using empirical data from this study.

Table 10: Creativity measures for software designing and software coding

<table>
<thead>
<tr>
<th>#</th>
<th>Items for Software Designing</th>
<th>Items for Software Coding</th>
<th>Hypothesized Domain</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Modern, not plain or boring</td>
<td>Easy to debug</td>
<td>Novelty</td>
</tr>
<tr>
<td>2</td>
<td>Unique and original</td>
<td>Making novel use of library code</td>
<td>Novelty</td>
</tr>
<tr>
<td>3</td>
<td>Designed in a way that can be reused, reusable</td>
<td>Making novel use of common code to prevent repetitive coding</td>
<td>Novelty</td>
</tr>
<tr>
<td>4</td>
<td>Employing novel techniques in designing</td>
<td>Employing new coding techniques</td>
<td>Novelty</td>
</tr>
<tr>
<td>5</td>
<td>Failsafe, preventive of possible errors or issues</td>
<td>Foolproof, reliable</td>
<td>Feasibility</td>
</tr>
<tr>
<td>6</td>
<td>Suitable for coding</td>
<td>Failsafe, preventive of possible errors or issues</td>
<td>Feasibility</td>
</tr>
<tr>
<td>7</td>
<td>Cost effective</td>
<td>Capable of self-healing</td>
<td>Feasibility</td>
</tr>
<tr>
<td>8</td>
<td>Capable of self-healing, resilient</td>
<td>Optimized to reduce execution time</td>
<td>Feasibility</td>
</tr>
</tbody>
</table>

Participants and procedure.

A total of 126 programmers at the software company volunteered to participate in this study via email signups. They were all Thai natives, 34.13% female with an average age of 29.25 years and tenure of 4.01 years. Participants were assured confidentiality of their responses by the researcher and the company’s management. They completed a three-minute online survey as soon as possible after their first working session was over (due to any expected distraction or scheduled break).

The survey asked them to report which type of task (software designing or software coding) they were doing during the working session and rate how much each of the six characteristics in Table 11 described their task on a scale of 1 (not at all) to 7 (very much). Note that the first three characteristics define divergent thinking, and the last three describe...
convergent thinking, according to Cropley (2006). However, participants were not informed of the divergent or the convergent nature of these characteristics. I sent out the survey at 7 a.m. on two consecutive days, one per day. Each participant completed the survey only once.

Table 11: Divergent and convergent characteristics

<table>
<thead>
<tr>
<th>#</th>
<th>Characteristics</th>
<th>Divergent or Convergent thinking?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Involves brainstorming of new ideas</td>
<td>Divergent</td>
</tr>
<tr>
<td>2</td>
<td>Open to new information</td>
<td>Divergent</td>
</tr>
<tr>
<td>3</td>
<td>There may be more than one solution or process to achieve the goal</td>
<td>Divergent</td>
</tr>
<tr>
<td>4</td>
<td>Involves going into detail of a chosen idea</td>
<td>Convergent</td>
</tr>
<tr>
<td>5</td>
<td>Focuses on a given problem-solving solution, not opening up to new ideas</td>
<td>Convergent</td>
</tr>
<tr>
<td>6</td>
<td>Follows a predetermined plan of action</td>
<td>Convergent</td>
</tr>
</tbody>
</table>

After rating their task according to the six characteristics, participants were asked to submit their work outputs from that working session to two internal evaluators who would evaluate their work outputs. Participants were not informed about the specific nature of the evaluation nor promised any feedback on their work outputs. I translated all of the study materials from English to Thai and back-translated from Thai to English to ensure conceptual equivalence and comparability (Brislin, 1986).

**Measures.**

**Divergent.** Participants reported how much each of the characteristics in Table 10 described their task on a scale of 1 (not at all) to 7 (very much). The Cronbach’s alpha for the first three characteristics, which denote divergent thinking, was 0.85, so I averaged them to form a divergent score.

**Convergent.** Participants reported how much each of the characteristics in Table 10
described their task on a scale of 1 (not at all) to 7 (very much). The Cronbach’s alpha for the last three characteristics, which denote convergent thinking, was 0.74, so I averaged them to form a convergent score.

Two internal evaluators independently evaluated the novelty and feasibility of participants’ work outputs on a seven-point Likert scale anchored at 1 (not at all) and 7 (very much), using the respective creativity measures I created with the management of the company for either software designing or software coding. These evaluators were senior programmers who worked in the quality control department of the company and volunteered to participate in this study. They had experience in both software designing and software coding and, according to management of the company, possessed the necessary knowledge and skills to evaluate the work outputs. They were blind to the identities of participants.

**Novelty of software designing.** I hypothesized the first four items in the creativity measure for software designing that I had developed with the management of the company to capture novelty in software designing. Inter-rater reliabilities using ICC were 0.75, 0.74, 0.77, and 0.73 for the first, second, third, and fourth items, respectively. These reliabilities were higher than 0.70 and thus acceptable, so I averaged the two raters for each item.

**Feasibility of software designing.** I hypothesized the last four items in the creativity measure for software designing that I had developed with the management of the company to capture feasibility in software designing. Inter-rater reliabilities using ICC were 0.74, 0.79, 0.79, and 0.83 for the first, second, third, and fourth items, respectively. These reliabilities were higher than 0.70 and thus acceptable, so I averaged the two raters for each item.

**Novelty of software coding.** I hypothesized the first four items in the creativity measure for software coding that I had developed with the management of the company to capture novelty in software coding. Inter-rater reliabilities using ICC were 0.80, 0.75, 0.80,
and 0.78 for the first, second, third, and fourth items, respectively. These reliabilities were higher than 0.70 and thus acceptable, so I averaged the two raters for each item.  

**Feasibility of software coding.** I hypothesized the last four items in the creativity measure for software coding that I had developed with the management of the company to capture feasibility in software coding. Inter-rater reliabilities using intra-class correlation (ICC) were 0.80, 0.74, 0.73, and 0.83 for the first, second, third, and fourth items, respectively. These reliabilities were higher than 0.70 and thus acceptable, so I averaged the two raters for each item.

**Results.**  
**Software design as divergent thinking and software coding as convergent thinking.** I conducted a factor analysis on the ratings for the six characteristics according to which one participants described their task. The results with Varimax rotation indicated that the first three characteristics loaded on a single factor—most likely divergent thinking—with an eigenvalue of 1.87 and a Cronbach’s alpha of 0.85. I thus averaged these three characteristics to compute a divergent score. The last three characteristics also loaded on a single factor—most likely convergent thinking—with an eigenvalue of 1.31 and a Cronbach’s alpha of 0.74. I thus averaged the last three characteristics to compute a convergent score.

A t-test showed that software designing had higher divergent scores ($N = 42, M = 4.79$, $SD = 1.14$) than software coding ($N = 84, M = 3.93$, $SD = 1.35$) ($p < 0.01$). In addition, software designing had lower convergent ratings ($N = 42, M = 3.95$, $SD = 0.96$) than software coding ($N = 84, M = 4.52$, $SD = 1.09$) ($p < 0.01$). These results were consistent with the information gathered from the management and senior programmers of the company.

**Creativity measures for software designing and software coding.** I validated the creativity measures that I had developed with the management and senior programmers of
the company using Amabile’s (1982) consensual assessment technique. Factor analysis with Varimax rotation indicated that for software designing Items 1, 2, and 4 loaded on a single factor—arguably capturing novelty—with an eigenvalue of 2.00 and a Cronbach’s alpha of 0.84. Items 3, 5, 6, 7, and 8 loaded on a single factor—arguably capturing feasibility—with an eigenvalue of 2.91 and a Cronbach’s alpha of 0.91. I was able to validate the hypothesized domains for all of the items except Item 4. Specifically, this item, “designed in a way that can be reused, reusable,” captured feasibility, as opposed to novelty, of software designing. Table 12 presents the creative measures for software designing with their hypothesized and validated domains.

Table 12: Creativity measures for software designing with hypothesized and validated domains

<table>
<thead>
<tr>
<th>#</th>
<th>Items</th>
<th>Hypothesized Domain</th>
<th>Validated Domain</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Modern, not plain or boring</td>
<td>Novelty</td>
<td>Novelty</td>
</tr>
<tr>
<td>2</td>
<td>Unique and original</td>
<td>Novelty</td>
<td>Novelty</td>
</tr>
<tr>
<td>3</td>
<td>Designed in a way that can be reused, reusable</td>
<td>Novelty</td>
<td>Feasibility</td>
</tr>
<tr>
<td>4</td>
<td>Employing novel techniques in designing</td>
<td>Novelty</td>
<td>Novelty</td>
</tr>
<tr>
<td>5</td>
<td>Failsafe, preventive of possible errors or issues</td>
<td>Feasibility</td>
<td>Feasibility</td>
</tr>
<tr>
<td>6</td>
<td>Suitable for coding</td>
<td>Feasibility</td>
<td>Feasibility</td>
</tr>
<tr>
<td>7</td>
<td>Cost effective</td>
<td>Feasibility</td>
<td>Feasibility</td>
</tr>
<tr>
<td>8</td>
<td>Capable of self-healing, resilient</td>
<td>Feasibility</td>
<td>Feasibility</td>
</tr>
</tbody>
</table>

For software coding, Items 1, 2, 3, and 4 loaded on a single factor—arguably capturing novelty—with an eigenvalue of 2.25 and a Cronbach’s alpha of 0.85. Items 5, 6, 7, and 8 loaded on a single factor—arguably capturing feasibility—with an eigenvalue of 2.44 and a Cronbach’s alpha of 0.86. I was able to validate the hypothesized domains for all of the items. Table 13 presents creative measures for software designing with their hypothesized and validated domains.
Table 13: Creativity measures for software coding with hypothesized and validated domains

<table>
<thead>
<tr>
<th>#</th>
<th>Items</th>
<th>Hypothesized Domain</th>
<th>Validated Domain</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Easy to debug</td>
<td>Novelty</td>
<td>Novelty</td>
</tr>
<tr>
<td>2</td>
<td>Making novel use of library code</td>
<td>Novelty</td>
<td>Novelty</td>
</tr>
<tr>
<td>3</td>
<td>Making novel use of common code to prevent repetitive coding</td>
<td>Novelty</td>
<td>Novelty</td>
</tr>
<tr>
<td>4</td>
<td>Employing new coding techniques</td>
<td>Novelty</td>
<td>Novelty</td>
</tr>
<tr>
<td>5</td>
<td>Foolproof, reliable</td>
<td>Feasibility</td>
<td>Feasibility</td>
</tr>
<tr>
<td>6</td>
<td>Failsafe, preventive of possible errors or issues</td>
<td>Feasibility</td>
<td>Feasibility</td>
</tr>
<tr>
<td>7</td>
<td>Capable of self-healing</td>
<td>Feasibility</td>
<td>Feasibility</td>
</tr>
<tr>
<td>8</td>
<td>Optimized to reduce execution time</td>
<td>Feasibility</td>
<td>Feasibility</td>
</tr>
</tbody>
</table>

Discussion.

This study shows that, generally, software designing implicates divergent thinking and software coding involves convergent thinking, not vice versa. It also validates the creativity measures that evaluate novelty and feasibility in software designing and software coding. I employed these measures in the next study.

Study 6: Testing Divergent Thinking & Convergent Thinking in the Field

This study tested Hypotheses 1b and 2 in a field setting.

Participants and procedure.

Eighty-three programmers who were responsible for software designing and/or software coding participated in this five-day study in return for $10 if they completed at least three out of five surveys and $5 if they completed one or two surveys. Participants were all Thai natives, 36.14% female with an average age of 29.13 years and tenure of 3.94 years. Participants were asked to complete a total of five surveys, one per day. They were told that the purpose of this research was to understand how the use of time could increase work
effectiveness and were assured confidentiality of their responses by the researcher and the company's management. I sent out a 15-minute online survey at 7 a.m. for five consecutive days. Participants started each survey as soon as possible after their first working session was over (due to any expected distraction or schedule break) and were asked to finish the survey in one sitting. In each survey, participants indicated the type of task (software designing or software coding) they were doing in their first working session, described any unexpected distractions they encountered during the first working session in chronological order, entered the total time of their first working session, answered how much each of six characteristics (the same as in Study 5) defined their work, rated how complex the task was on a scale of 1 (not at all) to 7 (very much), and answered some questions about themselves, the task, and their work at the company. After completing the survey, participants submitted their work outputs from the first working session to be evaluated by the same two internal evaluators as in Study 5, using the creativity measures developed in Study 5. Again, participants were not informed about the specific nature of the evaluation or promised any feedback on their work outputs.

Measures.

**Per-hour frequency of unexpected distractions.** I computed the frequency at which each participant encountered unexpected distractions by dividing the number of reported unexpected distractions by the total hours of his or her first working session.

**Divergent.** Participants reported how much each of the characteristics in Table 10 described their task on a scale of 1 (not at all) to 7 (very much). The Cronbach’s alpha for the first three characteristics, which denote divergent thinking, was 0.91, so I averaged them to form a divergent score.

**Convergent.** Participants reported how much each of the characteristics in Table 10
described their task on a scale of 1 (not at all) to 7 (very much). The Cronbach’s alpha for the last three characteristics, which denote convergent thinking, was 0.76, so I averaged them to form a divergent score.

The same two internal evaluators from Study 5 independently evaluated the novelty and feasibility of participants’ work outputs on a seven-point Likert scale anchored at 1 (not at all) and 7 (very much), using the respective creativity measures developed in Study 5. Both evaluators were blind to the identities of participants.

**Novelty of software designing.** Items 1, 2, and 4 in the creativity measures for software designing (see Table 12) capture novelty in software designing. Inter-rater reliabilities using ICC were 0.77, 0.72, and 0.73, respectively. These reliabilities were higher than 0.70 and thus acceptable, so I averaged the two raters for each item.

**Feasibility of software designing.** Items 3, 5, 6, 7, and 8 in the creativity measures for software designing (see Table 12) capture feasibility in software designing. Inter-rater reliabilities using ICC were 0.76, 0.71, 0.71, 0.78, and 0.83, respectively. These reliabilities were higher than 0.70 and thus acceptable, so I averaged the two raters for each item.

**Novelty of software coding.** The first four items in the creativity measures for software coding (see Table 13) capture novelty in software coding. Inter-rater reliabilities using ICC were 0.70, 0.74, 0.77, and 0.73 for the first, second, third, and fourth items, respectively. These reliabilities were higher than 0.70 and thus acceptable, so I averaged the two raters for each item.

**Feasibility of software coding.** The last four items in the creativity measures for software coding (see Table 13) capture feasibility in software coding. Inter-rater reliabilities using ICC were 0.74, 0.71, 0.70, and 0.72 for the first, second, third, and fourth items, respectively. These reliabilities were higher than 0.70 and thus acceptable, so I averaged the two raters for each item.
Control variables. Following the rationale that novelty and feasibility may be inversely correlated in the judgments of creativity (Runco & Charles, 1993) or that creative ideas are novel ideas that are bounded by a consideration of their feasibility (Guilford, 1950), I controlled for the novelty of work outputs when regressing on the feasibility of those work outputs and vice versa. I also controlled for task complexity and the day on which participants completed the survey, which might have affected task performance.

Results.

Software design as divergent thinking and software coding as convergent thinking. I conducted a factor analysis on the ratings for the six characteristics according to which one participants described their task. The results with Varimax rotation indicated that the first three statements, characterizing divergent thinking, loaded on a single factor with an eigenvalue of 2.21 and a Cronbach’s alpha of 0.91. I thus average these statements to compute a divergent score. The last three statements, characterizing convergent thinking, also loaded on a single factor with an eigenvalue of 1.41 and a Cronbach’s alpha of 0.76. I therefore averaged the last three statements to compute a convergent score. These factor analysis results were consistent with those in Study 5.

A t-test showed that software designing had higher divergent scores \(N = 62, M = 4.68, SD = 0.98\) than software coding \(N = 284, M = 4.17, SD = 1.40\) \((p < 0.01)\). In addition, software designing had lower convergent ratings \(N = 62, M = 3.74, SD = 0.55\) than software coding \(N = 284, M = 4.56, SD = 1.10\) \((p < 0.01)\). These results were consistent with the information gathered from the management and senior programmers of the company and the results in Study 5.

Creativity measures for software designing and software coding. I was able to revalidate the validated creativity measures I had developed with the management and
senior programmers of the company using Amabile’s (1982) consensual assessment technique. Factor analysis with Varimax rotation indicated that for software designing Items 1, 2, and 4 loaded on a single factor, capturing novelty with an eigenvalue of 2.49 and a Cronbach’s alpha of 0.92. Items 3, 5, 6, 7, and 8 loaded on a single factor, capturing feasibility with an eigenvalue of 3.60 and a Cronbach’s alpha of 0.93. See Table 12. These factor analysis results were consistent with those in Study 5.

For software coding, Items 1, 2, 3, and 4 loaded on a single factor, capturing novelty with an eigenvalue of 3.10 and a Cronbach’s alpha of 0.93. Items 5, 6, 7, and 8 loaded on a single factor, capturing feasibility with an eigenvalue of 2.98 and a Cronbach’s alpha of 0.92. I was able to validate the hypothesized domains for all of the items. See Table 13. These factor analysis results were consistent with those in Study 5.

**Testing Hypothesis 1b.** The outputs of software designing, according to the management and senior programmers of the company, should not be evaluated in terms of quantity. It was the company policy that programmers should strive to produce a software design that addressed the specific needs of the clients with minimal concerns over the number of outputs produced. Hypothesis 1a could thus not be tested in this particular context. I was, however, able to test whether the frequency of unexpected distractions exhibited an inverted u-shaped relationship with the novelty of work outputs from software designing (involving divergent thinking). Figure 11 shows a scatter plot of the frequency of unexpected distractions and the novelty of work outputs from software designing.
Figure 11: Scatter plot of the frequency of unexpected distractions and the novelty of work outputs from software designing.

Not controlling for any other factors, the quadratic prediction line in Figure 8 resembled an inverted u. The three observations on the right, however, seemed to be driving the pattern. I then conducted regression analyses to more rigorously test Hypothesis 1b.

**Using regression analyses.** Table 14 displays the descriptive statistics and correlations among key variables. Table 15 presents the regression results.
Table 14: Descriptive statistics and correlations among key variables (N=62)

<table>
<thead>
<tr>
<th>Variables</th>
<th>Mean</th>
<th>SD</th>
<th>Min</th>
<th>Max</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Novelty of software designing</td>
<td>4.24</td>
<td>2.08</td>
<td>1.00</td>
<td>6.67</td>
<td>(0.92)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feasibility of software designing</td>
<td>4.42</td>
<td>0.99</td>
<td>1.00</td>
<td>6.40</td>
<td>0.48***</td>
<td>(0.93)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Per-hour frequency of unexpected distractions</td>
<td>0.55</td>
<td>0.61</td>
<td>0.00</td>
<td>3</td>
<td>0.03</td>
<td>0.03</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Task complexity</td>
<td>4.44</td>
<td>1.29</td>
<td>1.00</td>
<td>7</td>
<td>0.28*</td>
<td>0.23+</td>
<td>-0.04</td>
<td>1.00</td>
</tr>
</tbody>
</table>

+p<0.10, *p<0.05, **p<0.01, ***p<0.001; there were a total of 28 programmers; internal consistency reliabilities (Cronbach’s alpha) on the diagonal, in parentheses.

Table 15: Regression results (N=62)

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Novelty of software designing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Key predictors</td>
<td></td>
</tr>
<tr>
<td>Per-hour frequency of unexpected distractions</td>
<td>1.26(0.54)*</td>
</tr>
<tr>
<td>(Per-hour frequency of unexpected distractions)^2</td>
<td>-0.64(0.18)**</td>
</tr>
<tr>
<td>Control variables</td>
<td></td>
</tr>
<tr>
<td>Feasibility of software designing</td>
<td>0.03(0.23)</td>
</tr>
<tr>
<td>Complex</td>
<td>0.19(0.14)</td>
</tr>
<tr>
<td>Overall R-Square</td>
<td>0.2636</td>
</tr>
</tbody>
</table>

+p<0.10, *p<0.05, **p<0.01, ***p<0.001; standard errors are in parentheses; other controls include day dummies—which of five days on which participants completed the survey.

To test an inverted u-shaped relationship between the frequency of unexpected distractions and the novelty of the outputs from software designing, I regressed novelty in software designing on per-hour frequency of unexpected distractions, per-hour frequency of unexpected distractions squared, and the controls. I included participant-fixed effects to account for each participant’s individuality that could affect the work outputs and how frequently the participants were unexpectedly distracted. I also clustered the standard errors by participants to correct for interdependence among within-participant observations (Bertrand, Duflo, & Mullainathan, 2004). The results showed a positive relationship between per-hour frequency of unexpected distractions and novelty of software designing.
(β = 1.26, p < 0.05) and a negative relationship between per-hour frequency of unexpected distractions squared and novelty of software designing (β = -0.64, p < 0.001), supporting Hypothesis 1b.

Simple slopes analysis illustrated the curvilinear effects of per-hour frequency of unexpected distractions on novelty of software designing. The results revealed that the slope started off as positive and went from positive to zero at the frequency of 0.5 unexpected distractions per hour and from zero to negative at the frequency of two unexpected distractions per hour. Table 16 presents the simple slopes results.

Table 16: Simple slopes results

<table>
<thead>
<tr>
<th>Per-hour frequency of unexpected distractions</th>
<th>Slope</th>
<th>SE</th>
<th>t</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00</td>
<td>1.26</td>
<td>0.54</td>
<td>2.33</td>
<td>0.020</td>
</tr>
<tr>
<td>0.25</td>
<td>0.93</td>
<td>0.48</td>
<td>1.97</td>
<td>0.049</td>
</tr>
<tr>
<td>0.50</td>
<td>0.61</td>
<td>0.42</td>
<td>1.46</td>
<td>0.145</td>
</tr>
<tr>
<td>0.75</td>
<td>0.29</td>
<td>0.38</td>
<td>0.77</td>
<td>0.441</td>
</tr>
<tr>
<td>1.00</td>
<td>-0.03</td>
<td>0.35</td>
<td>-0.08</td>
<td>0.933</td>
</tr>
<tr>
<td>1.25</td>
<td>-0.35</td>
<td>0.35</td>
<td>-1.00</td>
<td>0.315</td>
</tr>
<tr>
<td>1.50</td>
<td>-0.67</td>
<td>0.37</td>
<td>-1.83</td>
<td>0.067</td>
</tr>
<tr>
<td>1.75</td>
<td>-0.99</td>
<td>0.4</td>
<td>-2.46</td>
<td>0.014</td>
</tr>
<tr>
<td>2.00</td>
<td>-1.32</td>
<td>0.46</td>
<td>-2.89</td>
<td>0.004</td>
</tr>
<tr>
<td>2.25</td>
<td>-1.63</td>
<td>0.52</td>
<td>-3.17</td>
<td>0.002</td>
</tr>
<tr>
<td>2.50</td>
<td>-1.96</td>
<td>0.58</td>
<td>-3.35</td>
<td>0.001</td>
</tr>
<tr>
<td>2.75</td>
<td>-2.28</td>
<td>0.66</td>
<td>-3.47</td>
<td>0.001</td>
</tr>
<tr>
<td>3.00</td>
<td>-2.6</td>
<td>0.73</td>
<td>-3.54</td>
<td>0.000</td>
</tr>
</tbody>
</table>

**Testing Hypothesis 2.** Figure 12 shows a scatter plot of the frequency of unexpected distractions and the feasibility of work outputs from software coding.
Not accounting for any other factors, the linear prediction line in Figure 10 was slightly negatively sloped. I also drew a quadratic prediction line because the frequency of unexpected distractions and the feasibility of work outputs from software coding seemed to have a nonlinear relationship. The quadratic prediction line appeared to go from flat to a negative slope. I then conducted regression analyses to more rigorously test Hypothesis 2.

**Using regression analyses.** Table 17 displays the descriptive statistics and correlations among key variables. Table 18 presents the regression results.
Table 17: Descriptive statistics and correlations among key variables (N=283)

<table>
<thead>
<tr>
<th>Variables</th>
<th>Mean</th>
<th>SD</th>
<th>Min</th>
<th>Max</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Novelty of software designing</td>
<td>4.12</td>
<td>1.39</td>
<td>1.00</td>
<td>7.00</td>
<td>(0.93)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Feasibility of software designing</td>
<td>4.15</td>
<td>1.23</td>
<td>1.00</td>
<td>7.00</td>
<td>0.76***</td>
<td>(0.92)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Per-hour frequency of unexpected distractions</td>
<td>0.54</td>
<td>0.58</td>
<td>0.00</td>
<td>3.50</td>
<td>-0.14*</td>
<td>-0.10+</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>4 Task complexity</td>
<td>4.24</td>
<td>1.18</td>
<td>1.00</td>
<td>7.00</td>
<td>0.39***</td>
<td>0.42***</td>
<td>-0.04</td>
<td>1.00</td>
</tr>
</tbody>
</table>

+p<0.10, *p<0.05, **p<0.01, ***p<0.001; there were a total of 77 programmers; internal consistency reliabilities (Cronbach’s alpha) on the diagonal, in parentheses.

Table 18: Regression results (N=283)

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>1 Feasibility of software coding</th>
<th>2 Feasibility of software coding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Key predictors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Per-hour frequency of unexpected distractions</td>
<td>-0.19(0.12)</td>
<td>0.15(0.24)</td>
</tr>
<tr>
<td>(Per-hour frequency of unexpected distractions)^2</td>
<td>-</td>
<td>-0.17(0.08)*</td>
</tr>
<tr>
<td>Control variables</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Novelty of software coding</td>
<td>0.35(0.12)**</td>
<td>0.37(0.12)**</td>
</tr>
<tr>
<td>Complexity</td>
<td>0.08(0.06)</td>
<td>0.07(0.06)</td>
</tr>
<tr>
<td>Overall R-Square</td>
<td>0.5844</td>
<td>0.5899</td>
</tr>
<tr>
<td>R-Square Change</td>
<td>-</td>
<td>0.0055*</td>
</tr>
</tbody>
</table>

+p<0.10, *p<0.05, **p<0.01, ***p<0.001; standard errors are in parentheses; other controls include day dummies—which of five days on which participants completed the survey.

To test a negative relationship between the frequency of unexpected distractions and the feasibility of the outputs from software coding, in Model 1, I regressed feasibility in software coding on the per-hour frequency of unexpected distractions and the controls. I included participant-fixed effects to account for each participant’s individuality that could affect the work outputs and how frequently participants were unexpectedly distracted and clustered standard errors by participants to correct for interdependence among within-participant observations (Bertrand et al., 2004). The results showed a negative but non-significant relationship between per-hour frequency of unexpected distractions and feasibility.
of software coding ($\beta = -0.19, p = 0.108$). Because the scatter plot demonstrated a potential curvilinear relationship between the frequency of unexpected distractions and the feasibility of the outputs from software coding, in Model 2, I added per-hour frequency of unexpected distractions squared as the regressor. The results showed a non-significant relationship between per-hour frequency of unexpected distractions and feasibility of software coding ($\beta = 0.15, p = 0.552$) and a negative relationship between per-hour frequency of unexpected distractions squared and feasibility of software coding ($\beta = -0.17, p < 0.05$), partially supporting Hypothesis 2. Specifically, simple slopes results revealed that the slope started off as zero before turning negative at the frequency of 1.25 unexpected distractions per hour. Table 19 presents the simple slopes results.

Table 19: Simple slopes results

<table>
<thead>
<tr>
<th>Per-hour frequency of unexpected distractions</th>
<th>Slope</th>
<th>SE</th>
<th>t</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00</td>
<td>0.15</td>
<td>0.24</td>
<td>0.60</td>
<td>0.551</td>
</tr>
<tr>
<td>0.25</td>
<td>0.06</td>
<td>0.21</td>
<td>0.29</td>
<td>0.774</td>
</tr>
<tr>
<td>0.50</td>
<td>-0.03</td>
<td>0.17</td>
<td>-0.16</td>
<td>0.872</td>
</tr>
<tr>
<td>0.75</td>
<td>-0.11</td>
<td>0.14</td>
<td>-0.83</td>
<td>0.405</td>
</tr>
<tr>
<td>1.00</td>
<td>-0.20</td>
<td>0.11</td>
<td>-1.82</td>
<td>0.068</td>
</tr>
<tr>
<td>1.25</td>
<td>-0.29</td>
<td>0.09</td>
<td>-3.03</td>
<td>0.002</td>
</tr>
<tr>
<td>1.50</td>
<td>-0.37</td>
<td>0.10</td>
<td>-3.87</td>
<td>0.000</td>
</tr>
<tr>
<td>1.75</td>
<td>-0.46</td>
<td>0.11</td>
<td>-4</td>
<td>0.000</td>
</tr>
<tr>
<td>2.00</td>
<td>-0.55</td>
<td>0.14</td>
<td>-3.81</td>
<td>0.000</td>
</tr>
<tr>
<td>2.25</td>
<td>-0.63</td>
<td>0.18</td>
<td>-3.57</td>
<td>0.000</td>
</tr>
<tr>
<td>2.50</td>
<td>-0.72</td>
<td>0.21</td>
<td>-3.36</td>
<td>0.001</td>
</tr>
<tr>
<td>2.75</td>
<td>-0.81</td>
<td>0.25</td>
<td>-3.19</td>
<td>0.001</td>
</tr>
<tr>
<td>3.00</td>
<td>-0.89</td>
<td>0.29</td>
<td>-3.06</td>
<td>0.002</td>
</tr>
</tbody>
</table>

Discussion.

Consistent with Study 5, this study confirms that divergent thinking is central to software designing, whereas convergent thinking is essential for software coding. The factor
analysis results also validate the creativity measures for software work developed in Study 5.

Most importantly, this study provides empirical support for Hypothesis 1b and partially for Hypothesis 2. In the real world, where unexpected distractions occur naturally and their content may or may not be related to the creative task at hand, exposure to these distractions is helpful for divergent thinking but only up to the point at which it is too much to take in more information. Note that, from the scatter plot of the frequency of unexpected distractions and the novelty of work outputs from software designing, it could appear that the three rightmost observations were driving the curvilinear effects. This issue is, however, immaterial due to two main reasons. First, there are no methodological grounds to drop those three observations from the data. Second, a more rigorous test of regression in which each participant’s individuality and other factors that could affect the novelty of the outputs from software designing were accounted for justifies the curvilinear relationship.

In addition, the curvilinear, as opposed to linearly negative, relationship between the frequency of unexpected distractions and the feasibility of the outputs from software coding suggests that participants might have a certain level of tolerance toward these distractions before additional information began to hurt. The slope was, in fact, flat before turning negative but never positive. Arguably, unexpected distractions are not helpful for convergent thinking because they are neither likely to bring in useful information nor stimulate the unconscious processes that would facilitate the convergent process, yet it might take a certain frequency of these distractions before the negative effect kicks in.
General Discussion

This dissertation offers three main contributions: two theoretical contributions and one empirical contribution. First, this research disambiguates the effects of unexpected distractions on creativity, ultimately shedding light on the elusive creative process (George, 2007; Guilford, 1950). Specifically, I conceptualize and operationalize the creative process as a composition of two distinct cognitive sub-processes that differ in their information-processing style: divergent thinking and convergent thinking. I examine the differential impacts that varying frequencies of unexpected distractions exert on the novelty and feasibility of the creative outputs from these two sub-processes, respectively.

Divergent thinking refers to the ability to produce novel ideas or solutions to a creative task or problem. Individuals looking to generate new ideas tend to benefit from unexpected distractions as they provide cognitive inputs for idea associations, and their unconscious thought during incubation could assist in the associative processing of acquired information. The results supported Hypothesis 1b but not 1a. Specifically, the originality, but not the number, of ideas produced during a divergent thinking session exhibited an inverted u-shape relationship with the frequency of unexpected distractions. Online, lab, and field participants were able to produce ideas that were more original when they encountered a low frequency of unexpected distractions, but not so with a higher frequency of these distractions. The turning point, I speculate, marks the occurrence of cognitive overload where required cognitive resources for processing information exceed the available cognitive resources in that cognitive episode. Empirical evidence of the occurrence of cognitive overload is, however, needed to validate this speculation.

The lack of support for Hypothesis 1a is, however, not surprising. As noted, having been instructed to “write down as many novel ideas as possible for the marketing campaign”
within a 10-minute time limit, the participants might have placed greater emphasis on generating “novel” ideas than on generating “many” ideas to satisfy the task goal. Future research may vary the time limit, the instruction, or the type of divergent thinking task to test this possibility.

Convergent thinking, on the other hand, selects and fine-tunes the selected idea to be feasible, appropriate, and implementable. In doing so, individuals seek highly specific factual knowledge or set criteria against which they evaluate possible ideas and contextualize the selected idea. They are, I argue, less open or receptive to unexpected distractions, which might not directly relate to the selected idea or the context in which the idea will be implemented. Because unrelated information is particularly cognitively taxing to process (Lang, 2000; Fox et al., 2007), even infrequent unexpected distractions can prompt cognitive overload, compromising the refinement process and thus also the feasibility of the selected idea. Furthermore, the unconscious associative processing of information during the incubation period is likely less helpful for the evaluative and focused process of convergent thinking.

Lab results supported Hypothesis 2, whereas the field results partially supported it. Specifically, the feasibility of the final ideas selected and refined by lab participants was negatively correlated with the frequency of unexpected distractions, which were presented as interrupting messages during a convergent thinking session. In the field, the relationship started off flat before turning negative after a certain frequency. The field results, however, did not undermine the core contribution of this dissertation because, as expected, the field setting involved many factors outside the control of the researcher. There were three main factors involved. First, the software-coding task, although it mostly involved convergent thinking, might have implicated the process of divergent thinking as participating programmers looked for coding ideas and experimented with various ways of coding. This
possibility is preliminarily supported by the divergent thinking characteristics with which participants described their software coding tasks in the field studies. As such, the resultant relationship between the frequency of unexpected distractions and the feasibility of coding outputs might not be strictly negative. Second, participants could have had a certain level of tolerance toward this form of distractions, which they repeatedly encountered. That is, cognitive overload might not have occurred in some participants who were still able to maintain their train of thought, given the frequency of the unexpected distractions they faced, most of which numbered no more than two distractions per hour. Third, some of the distractions might be real-time feedback to the participants’ current work, which would be relevant, helpful, and less likely to cause cognitive overload. This was not the case for lab experiments, because I constructed the interrupting messages to be moderately relevant to the task and not in the form of direct feedback. However, empirical evidence is needed to support the last two possibilities.

Importantly, the curvilinearity of the relationship concerning divergent thinking and the negative relationship concerning convergent thinking jointly denote the second theoretical contribution of this research. Specifically, I hypothesize the breakdown of the information-processing system, determining information overloads—or cognitive overload—as the point beyond which additional unexpected distractions undermine rather than facilitate the creative process.

Cognitive overload may analogously explain how unexpected distractions could compromise the decision-making process. Note that convergent thinking is akin to the process of making a decision on a complex task, because both are knowledge intensive and involve the manipulation of ideas to obtain the best solution (Lim & Ployhart, 2004). Both processes test the possibilities against some sort of criteria or requirements to determine which one may or may not work and then refine the best possibility so that it will work in
practice. As such, unsurprisingly, previous research on the effects of distractions on decision making shows that interrupting activities weakens one’s decision-making performance on complex tasks. For instance, Speier et al. (1999) found in their experiments that interruptions reduced decision-making performance regarding complex tasks, especially when the interrupting tasks were frequent and dissimilar in nature to the primary tasks. They attributed this particular failure of the cognitive system to the flooding of information, calling it “information overload,” which forces cognitive resources to be rationed across different tasks. In addition to causing a reduction in decision quality (Abdel-Khalik, 1973; Chewning & Hanell, 1990; Shields, 1980; Snowball, 1980; Speier et al., 1999), information overload has been shown to increase the time required to make a decision (Shiffman & Griest-Bousquet, 1992) and increase confusion regarding the decision (Cohen, 1980; Jacoby, Speller, & Kohn, 1974a, 1974b; Malhotra, Jain, & Lagakos, 1982).

Information overload, defined as a cognitive state in which the amount of input to a system exceeds its processing capacity (Milford & Perry, 1977), can be regarded as cognitive overload. The system whose capacity is exceeded is, in this case, the information-processing system. When the overload takes place, the information-processing system is compromised, thereby degrading the quality of the relevant processes that rely on the information-processing system, such as the decision-making process or the creative process. Previous studies have operationalized information load with many different areas of focus: the amount of information (e.g., number of cues: Casey, 1980; O’Reilly, 1980), the number of alternative outcomes (Shields, 1980), the diversity of the information (Iselin, 1988), the increase in task complexity (Hart, 1986), and the limited time (Schick, Gordon, & Haka, 1990). Indeed, operationalizing information load as the frequency of unexpected distractions effectively captures all of these aspects of the construct. Unexpected distractions introduce additional information as possible outcomes and cognitive inputs for
the complex creativity task. Looking at the frequency as opposed to the amount or duration of these distractions also points to the relevance of time constraints, indicating that cognitive resources are not infinite but limited per cognitive episode.

In sum, both the content and occurrence of unexpected distractions benefit divergent thinking, but not convergent thinking, and the benefits turn into drawbacks, once cognitive overload takes place. In addition to the three main ways outlined in the theory development section, another potential method exists through which the occurrence of unexpected distractions may facilitate creative thinking. Specifically, being unexpectedly distracted could help renew the task focus by preventing goal habituation. Research on vigilance decrement supports this possibility. That is, vigilance decrement or a decline in performance of a vigilance task (a task that requires sustained focus and effort over a long period of time) may result from the failure of the cognitive control to maintain goal representations of the task, yet this process could be reversed with short and infrequent distractions (Ariga & Lleras, 2011). Specifically, short and infrequent distractions may prevent the vigilance goal from ever reaching habituation (the state in which goal representations to sustained stimulations diminish and eventually vanish) and enhance focus once the vigilance task is resumed. Goal representations are crucial for the completion of various cognitive tasks, because they contain information that guides the planning and actions needed to deliver specific outcomes (Braver & Cohen, 2000; Paxton, Barch, Racinem, & Braver, 2008); the lack of goal representations brings about inattentional blindness or mindlessness, which could change awareness into disengagement from the task, thus compromising task performance (Mack & Rock, 1998; Strayer & Johnston, 2001). Distraction from a vigilance task could allow for a momentary deactivation of the vigilance goal, thus preventing it from habituating and renewing the focus once the vigilance task is resumed.

Note, however, that this particular explanation of how unexpected distractions could
benefit the creative process is less probable than the other explanations outlined in the theory development section. Specifically, previous studies have never drawn a connection between vigilance tasks (such as signal detection tasks) and creative tasks, because the former are simple and mundane, while the latter are complex and challenging. One may, nevertheless, argue that, because creative tasks are cognitive tasks that entail complex processing of information (Amabile et al., 1990) and sustained focus and effort and perseverance (Amabile, 1996; Newell et al., 1958), they should be subject to goal habituation. If this is true, the effects of short and infrequent unexpected distractions in preventing goal habituation and enhancing focus upon task reactivation should be applicable to creative tasks. This is, however, an empirical question that needs further testing.

As noted, the present research also speaks to the literature on group brainstorming. Brainstorming in a group situation can be regarded as an environment wherein unexpected distractions may affect idea generation. This view is grounded in an argument that unexpected interjections and the practice of turn taking (not speaking while someone else speaks) give rise to unexpected distractions. Note that the content of these distractions are usually related to the ongoing brainstorming task, which may not be the case for other contexts. Indeed, the curvilinear effects of unexpected distractions on divergent thinking resonate with the concepts of cognitively induced production gains and losses in group brainstorming (see Paulus et al., 2002, for a review on production gains and losses in group brainstorming). Specifically, exposure to others’ related ideas could stimulate new thinking by activating related but inactive knowledge and adding new categories of information to the idea generating process (cognitive stimulation). However, constant follow-ups on others’ ideas may disrupt one’s own train of thought, thus undermining the idea-generating process (production blocking). In this regard, the mitigating effects on production losses of solitary brainstorming—separately digesting presented ideas to further develop one’s own ideas
after a group session (Dugosh et al., 2000; Paulus & Yang, 2000)—can be viewed as an opportunity for brainstormers to replenish their cognitive resources to preclude cognitive overload. Individual brainstormers ideally need a moment to themselves, away from additional distractions, to cultivate their own ideas and reap the most benefits from the group brainstorming process. This practice is comparable to identifying the optimal frequency of unexpected distractions for divergent thinking.

Third, the empirics from the various settings (online, lab, and field) in this research augment the credibility of its findings. In particular, this dissertation triangulates the results across six studies to understand the effects of unexpected distractions on creativity. Most previous studies examining the relationship between distractions and work performance are lab studies, and their work has involved simple task assignments (e.g., signal detection) as opposed to complex creativity assignments. Indeed, the lab and online setups of this research in which unexpected distractions were presented at varying frequencies and creative outputs objectively assessed on the relevant dimensions facilitates a test of causality in the hypothesized relationships. The field setting also increases the external validity of the findings. The research site was situated in one of the fastest-growing industries, where creative performance was pursued. All field participants were IT professionals who were actual employees embedded in the modern workplace where unexpected distractions abounded and creativity was evaluated as a key performance index.

**Limitations and Future Research**

The present research has some limitations. First, I rely on field participants’ self-reports to calculate the independent variable. Specifically, participants reported the length of
their first working session, whose end was marked by the occurrence of the first expected
distraction (e.g., a scheduled meeting), and listed all of the unexpected distractions they
encountered during that session. These self-reports could be subject to self-report,
retrospective, and recency biases. For example, participants were exposed to a variety of
distractions so they might only remember the most recent ones. The average length of the
first working session was, however, 2.38 hours (SD=0.94), which should not be too long for
participants to recall. Additionally, because it was the first working session of the day, it is
reasonable to assume that participants were still alert and the events they observed were
still fresh in their memories. To maximize the internal validity of the findings, I asked
participants to complete the online report immediately after their first expected distraction
ended or as soon as possible.

Second, in the lab, I controlled the frequency of the unexpected distractions
participants encountered, but in the field, these distractions occurred naturally, and
participants were left to their own devices to manage their task and time. For instance,
although all participating programmers at the research site worked in open spaces and each
was assigned a fixed workstation, individuals’ past reactions to unexpected distractions
influenced the future occurrences of similar distractions. For example, participants who
became cranky every time a colleague popped in to chat might receive fewer surprising
visits in the future. These happenings were indeed natural in the real-world workplace, and I
was not able to manipulate them without disrupting the flow of their work. Furthermore, more
creative participants might generally be interrupted by others more frequently than less
creative participants. I did not have data on the participants’ overall creativity, so I could not
directly control for it. However, I included participants’ fixed effects in the regression
analyses to account for their individuality (e.g., their overall creativity), which could influence
their work outputs and how frequently they were unexpectedly interrupted. Due to these
possible endogeneity concerns in the field, triangulating field findings with lab and online findings are ever vital in order to test the hypotheses.

Third, most field participants engaging in the divergent task of software designing encountered 0, 1, or 2 unexpected distractions per hour, making it possible that some of them might not have lost their train of thought within their first working session. From Figure 11—the scatter plot of the frequency of unexpected distractions and novelty of work outputs from software designing—the decline in performance began when the frequency of unexpected distractions exceeded 2 distractions per hour, and those observations were likely to drive the curvilinear relationship between the frequency of unexpected distractions and the novelty of work outputs from software designing. To more rigorously test this curvilinear effect, future researchers could consider conducting a field experiment in which the frequency of unexpected distractions is manipulated to vary across conditions and actual work outputs are assessed as dependent variables. Such a field experiment would enhance both the internal and external validity of the findings.

Fourth, according to the empirics in Studies 5 and 6, the field tasks of software designing and software coding mostly implicated the process of divergent thinking and convergent thinking, respectively. By the task nature and goal, software designing involved more divergent thinking than convergent thinking, because participants engaging in software designing looked to innovate coding structures that satisfied the client's requirements. Software coding, on the other hand, involved more convergent thinking than divergent thinking, because participants engaging in software coding focused on writing codes that worked according to the designs. These relationships are, nonetheless, not exclusive. Participants engaging in software designing also had to evaluate the possible structures against the client's demands and converge on a set of final designs before passing them on to the coders. Likewise, participants engaging in software coding could try out different ways
of coding until the best way worked as planned. There could, therefore, be a mix of both cognitive processes in these two different tasks, which, as noted, might explain the partial support for Hypothesis 2 in the field.

More broadly, it is important to note that, while I divide the creative process into divergent thinking and convergent thinking and predict the effects of unexpected distractions on the novelty and feasibility aspects of the creative outputs, the exact way in which novelty and feasibility combine to form judgments of creativity is still unclear and is likely context dependent (Berry, 2012; Litchfield, 2008; Shalley & Zhou, 2008; Zhou & Shalley, 2003). For instance, compared to novelty, feasibility should be a much more prominent aspect of a creative tool design than a creative graphic art design, rendering the process of creating the former more convergent and feasibility focused than divergent or novelty focused. Further research that varies the context in which the creative process takes place (e.g., art versus business) is needed to address how exposure to unexpected distractions affects creative judgments across various contexts.

Fifth, I theorized but did not measure the occurrence of cognitive overload. To validate cognitive overload as the underlying mechanism that explains the turning point of the inverted u-shape relationship between the frequency of unexpected distractions and the novelty of divergent thinking outputs and the negative relationship between the frequency of unexpected distractions and the feasibility of convergent thinking outputs, future research should control for factors in addition to information processing that could influence the effects of unexpected distractions on creativity. One set of potential factors is one’s emotional responses to these distractions. For example, discrepancies—perceived inconsistencies between expectations and reality—which are considered unexpected distractions, usually trigger emotional reactions (Mandler, 1990) and subsequent behavioral responses that are individual- and task-specific (Jett & George, 2003). Specifically,
perceived discrepancies between expectations and reality could instigate either mindful attention and engagement to the task (Langer, 1989b, 1997; Louis & Sutton, 1991), which freshens an exhausted mind (Langer, 1989a) and facilitates adaptation and learning (Okhuysen, 2001), or mindless denial or suppression of the discrepancies from the failure to control intense emotional reactions, leading to unresponsiveness and inadaptation (Perrow, 1984; Weick, 1993). In addition, how the focal individual responds to unexpected distractions depends on his or her willingness and ability to handle emotional reactions and task complexity. For instance, a complex task may drain the cognitive resources required to recognize and mindfully respond to unexpected distractions, thus prompting a decline in task performance. Future research may vary task complexity and control or test for the mediation role of emotional responses to unexpected distractions.

Sixth, future research may test Hypotheses 1a and 1b using different divergent tasks in a controlled lab environment to further validate cognitive overload as the underlying mechanism of the hypothesized relationships. For example, researchers could emphasize the goal of generating as “many” novel ideas as possible in a different divergent task to retest Hypothesis 1a. Or, with divergent tasks of varying complexity, the turning point at which benefits become drawbacks likely shifts because the primary tasks take up different amounts of cognitive resources, thus leaving more or fewer resources remaining for processing the distractions. If the inverted u-shaped pattern persists, the results would provide additional evidence for the occurrence of cognitive overload.

Seventh, it might be helpful to examine what happens at the brain level when cognitive overload occurs. With advanced brain imaging technology, neuroscientists are able to map out activities in different parts of the brain at the onset of or during a certain cognitive process. Future research could, for instance, encourage participants to generate creative ideas while unexpectedly distracting them with varying frequencies of distractions,
all the while scanning their brain activity in an fMRI machine. The findings could help advance our understanding of what happens when a train of thought is broken down. It is possible, for example, that lower frequency of activities in the brain areas responsible for memory retrieval and heightened activities in the brain areas associated with frustration will be observed following cognitive overload, which would explain individuals’ compromised creative performance.

Eighth, the length and complexity of unexpected distractions could influence when the cognitive overload occurs. In this research, I captured the frequency of these distractions but did not have information on how long or how complex they were. Specifically, lab participants were unexpectedly interrupted by pop-up messages whose content was quite straightforward and related to the creative tasks, but I did not measure how long participants spent reading each of these messages. In the field, participants briefly described any unexpected distractions they encountered during their first working session, but their reports did not allow for coding for the complexity or the duration of these distractions. Indeed, longer and more complex distractions are likely to demand more focused attention, potentially hastening cognitive overload. Demanding distractions also reduced mind wandering (Mason et al., 2007; Smallwood et al., 2009), thereby weakening the incubation effects. Consistently, a study on the role of unconscious thought in the creative process suggests that the length of the incubation period matters. Specifically, Yang, Chattopadhyay, Zhang, and Dahl (2012) found that only incubation of a moderate length (3 minutes), as opposed to short or long length (1 or 5 minutes, respectively), allowed unconscious thought to outperform conscious thought on creativity. The optimal length of the incubation period is, however, contingent on the type of task and its complexity (Weisberg, 1999) and could only be determined empirically.

Ninth, future research can inspect the moderating role of the relevance of
unexpected distractions to the task. In this dissertation, I hypothesize separate channels through which the content and the occurrence of unexpected distractions may affect the creative process. Under the assumption that unexpected distractions may or may not be related to the task at hand, I argue that the resultant relationship only depends on which cognitive sub-process—divergent or convergent thinking—is intercepted by the distraction. It is, however, interesting to investigate further the case in which unexpected distractions bear directly on the creative task, such as when there is direct feedback for the task. Because real-time feedback should inform and improve convergent thinking, the effect of their frequency on the feasibility of convergent outputs might as well be an inverted u as opposed to a negative effect. Nonetheless, in the case of divergent thinking, direct feedback to the task, which tends to be focused and evaluative, should not be as helpful in building unobvious connections and potentiating novel ideas, thus lessening their positive impact on the novelty of divergent outputs.

Tenth, it would also be interesting to examine the long-term impact of unexpected distractions on creative performance. The final creative outputs would likely be the increments of the outputs from multiple creative endeavors over several cognitive episodes. Individuals may, nonetheless, get better at multitasking or become more tolerant of a certain type of unexpected distractions after repeated exposure. Individuals could also go back to correct any compromised aspects of the creative outputs after replenishing their cognitive resources. As such, the hypothesized effects of cognitive overload could be mitigated when creative performance is examined in the long run.
Practical Implications

In today’s business environment, individuals are constantly distracted while required to be creative. By identifying how unexpected distractions, which permeate the modern workplace, stimulate or disrupt the creative process, this dissertation suggests ways to take advantage of these distractions. First, individuals should expose themselves to unexpected distractions when they aim to generate novel ideas, as opposed to when they seek specific information to make the final idea feasible, appropriate, and implementable. For instance, an employee could work in a coffee shop or an open space as he or she brainstorms ideas, but in a library as he or she fine tunes the best idea to respond to specific needs. Second, to maximize the benefits of unexpected distractions and preclude cognitive overload, individuals should recognize their cognitive capacity and open up to unexpected distractions only to that capacity. For example, the employee could move to an isolated place as he or she experiences that additional unexpected distractions are becoming less manageable and more disruptive to the idea generation process. One might find it ideal to plan unexpected distractions (making them less unexpected), such as scheduling a daily brainstorming session so individuals can cognitively prepare themselves (e.g., wrap up ongoing trains of thought). Additionally, individuals could implement the aforementioned solitary brainstorming technique to effectively process new information while simultaneously letting their unconscious thought work on the unfinished task. This method, however, requires individuals to identify their cognitive capacity and the type of input they seek during a certain cognitive process.

Overall, individuals could structure the physical and temporal environments of their workplace to manage their exposure to unexpected distractions and capitalize on the creativity-stimulating effects of these distractions. A simple principle is that individuals would
desire a work environment that allows for unexpected distractions when they seek additional inputs for their creative tasks but not such an environment when they need to finish their trains of thought or fine tune their best ideas. The practice of flexible work options under which employees do not have to be in the office to fulfill their work responsibilities is an example of how the work environment could leverage unexpected distractions. In their work in progress, Amabile and Kramer (HBR, July 24, 2013) collected daily electronic diaries from the HR employees of a New York bank and found that employees described the occasional days they worked from home as refreshing and freeing from office distractions, and they cited increased focus and creativity as reasons for higher work progress. Although there might be other forms of unexpected distractions at home (e.g., surprise neighbor visits), working out of the office may reduce certain types of unexpected distractions that occur regularly in the workplace (e.g., unexpected supervisor visits or impromptu meetings). The out-of-office environment could facilitate the creative process as long as employees are able to seek external inputs (e.g., brainstorm ideas with others) when the timing is appropriate. For example, an employee could bounce ideas off others using a virtual communication device before returning to working alone to finish forming new ideas and fine tune the best idea for specific needs.

The emerging phenomenon of “hoffice,” initiated by Christofer Gradin Franzen and Johline Zandra and popularized in the Scandinavian countries, is another example. The term hoffice involves transforming regular homes into free co-working spaces where participants work in synchronized 45-minute shifts. Between shifts, participants get interrupted by an attention-grabbing device such as an alarm clock to take a short break together, during which they, among other things, share what they have accomplished in the previous shift and expected to finish in the next. Under these agreed-upon guidelines, each short break provides an opportunity to brainstorm ideas with others, whereas each 45-minute shift
allows for an uninterrupted time to flesh out and refine ideas. Participants in the hoffice design could improve creativity in this work setting by trying to finish any trains of thought before each break to welcome new information and let the unconscious mind advance to the divergent task during the break, while ruminating on the gathered information during each shift to sharpen convergent thinking.

In sum, both flexible work options and hoffice give room for individuals to structure their physical and temporal work environments in such ways that they can turn unexpected distractions into less unexpected ones to maximize the benefits of these distractions and deter cognitive overload.
Conclusion

Achieving creativity is a perpetual necessity in the workplace, and yet it represents a constant struggle in today’s business environment. Modern organizations offer easy access to resources to stimulate creative collaboration, but these extra conveniences may actually serve as distractions to the creative process. By putting forth a cognitive framework to determine how creativity can be stimulated or disrupted by unexpected distractions, this research offers an effective way to disambiguate the effects of unexpected distractions on creativity, thus advancing the theoretical and empirical understanding of the creative process.
Appendices

Appendix A: Cover story

A consumer-product startup is planning to launch a new product—berry-flavored vitamin water—to the Boston market. The founder is very determined to make this new product a big hit within two months after the official launch date. He has assembled a team of 4 including himself to work on the launch. One of the members is a marketing expert who will play the most crucial role in designing a marketing campaign for this new product.

The first thing the marketing expert needs to do is to propose some creative (novel and feasible) ideas for the marketing campaign. Each idea describes in 1-2 sentences how/where/when the startup could advertise the new product to attract many customers in a short period of time.
Appendix B: 25 statements

| Statement 1: | Fiber in berries can aid in weight loss and lower blood pressure and cholesterol. |
| Statement 2: | Berries contain powerful antioxidants, one of which is Anthocyanins, which helps prevent and manage arthritis and slow age-related memory loss. |
| Statement 3: | Vitamin C is a strong antioxidant in berries. It supports the health of collagen, which helps maintain cartilage stores and aids in joint flexibility. |
| Statement 4: | Women in their 30s are the most health conscious group compared to women in other age ranges or men across all ages. |
| Statement 5: | Men in their 20s are currently the biggest buyers of existing vitamin water in the Boston market. |
| Statement 6: | There are currently five existing major brands of vitamin water in the Boston area. |
| Statement 7: | The existing major brands of vitamin water in the Boston market use plastic bottles whereas we will use recyclable glass. |
| Statement 8: | Our container is 1.5 times smaller than a typical bottle in the Boston market, but 1.8 times cheaper. |
| Statement 9: | We are collecting survey data on the popularity of each of the college basketball teams in Boston. The results will be in next week. |
| Statement 10: | The market shares of the five existing brands of vitamin water in the Boston area are 42%, 29%, 18%, 6%, 3%, and 2%. We are hoping to steal at least 10% in the next quarter. |
| Statement 11: | We are introducing new flavors including goji berry and the mix between blueberry and blackberry and between raspberry and cranberry. |
| Statement 12: | According to a recent local poll, Bostonians are increasingly becoming health and environment conscious. |
| Statement 13: | Boston is a college town where a large percentage of its residents are college and graduate students. |
| Statement 14: | 65% of students in Boston who are not on a meal plan prefer to eat at a restaurant than cooking at home. |
| Statement 15: | The main outlets of the existing five major brands of vitamin water are big supermarkets. |
| Statement 16: | We have confirmed with 3 schools that they will be willing to have our free sample booths during the launch week. |
| Statement 17: | We are planning to distribute 5,000 buy-one-get-one free coupons to students in Boston one week before the launch. |
| Statement 18: | 19% of consumers who buy vitamin water reported buying it with a power bar. |
| Statement 19: | We are proud to say that our vitamin water is 100% natural, with absolutely no artificial ingredients. |
Appendix B (Continued)

Statement 20: Only one of the five existing major brands of vitamin water in the Boston area is a US brand; the other four are foreign brands. Our brand is also a US brand.

Statement 21: During the first month after the launch, consumers of our vitamin water with purchase information may follow a specific link to enter into a raffle for 30 $100 gift cards.

Statement 22: There are more than 550 gas stations in Boston, and about 60% of the Boston residents have access to car.

Statement 23: Our vitamin water has 15% lower sugar per volume compared to competing brands.

Statement 24: According to our latest poll, college students are more eager to use a buy-one-get-one-free coupon than a 50%-discount coupon.

Statement 25: 3 retail stores have confirmed that they will be willing to have our vitamin water on their shelves for a 3-month probation period after the launch.
References


