Interruptions in online training and their effects on learning

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Abstract

Purpose – The purpose of this paper is to identify the types of interruptions learners experience during online training and their effects on learning.

Design/methodology/approach – An internet-based survey was distributed to individuals who experienced interruptions during e-learning to uncover common characteristics. A conceptual framework relating interruption characteristics to self-regulatory facets of learning is discussed.

Findings – The study reveals that e-learners experience computer malfunctions, supervisors and family/friends as common sources of interruptions. The survey also reveals that interruptions are occasionally self-generated.

Originality/value – This paper synthesizes the interruption and self-regulated learning literatures and provides a framework for understanding how interruptions affect online learning. This framework can be used by practitioners and scholars for future research and testing interrupted e-learning.

Keywords Employee learning, E-learning, Training and development

Paper type General review

The studies of interruptions and their effect on performance have become a very popular topic among various scientific communities, as well as the popular press, because of the vast amount of multi-tasking and work fragmentation that is occurring in the workplace. Interruptions are typically defined as uncontrollable, unpredictable events that produce information overload (Cohen, 1980), "require immediate attention" and "insist on action" (Covey, 1989, pp. 150-152). In 2005, the information technology research firm Basex estimated that interruptions create an economic cost of $588bn a year (Spira and Feintuch, 2005). Research conducted by Mark *et al.* (2005) found workers taking an average of 25 min to return to their primary task after experiencing an interruption, and in a study conducted by O'Conaill and Frohlich (1995), workers who were interrupted did not resume to their primary task 41 per cent of the time. Past research has generally concluded that interruptions can be very disruptive to work.

Researchers in training and development have also begun to investigate the disruptive nature of interruptions, as employees consistently cite interruptions as a primary reason why they fail to complete training. Interruptions not only shift focus and attention away from the training, but depending on the type of interruption, employees sometimes have no choice but to abort their training altogether to respond to the interruption. For example, time constraints and workplace interruptions have been reported as common reasons for why workers are unable to complete e-learning in one attempt (Baldwin-Evans, 2004). However, even though interruptions have commonly been reported as interfering with the completion of e-learning, the field has yet to identify the prevalence and types of interruptions that occur during e-learning or to elucidate the effects of interruptions on learning and performance. Accordingly, descriptive research in this area is a logical step toward defining the content domain and establishing a foundation to guide future research and practice in this area.

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The goal of the current paper is to advance understanding about interruptions that can occur during e-learning and their effects on learning and performance. A review of the literature on interruptions is followed by a typological examination of the interruption characteristics that are relevant to e-learning. The goal of the typology is to delineate the characteristics or dimensions that distinguish among different types of interruptions that can arise during e-learning. The typology is an important first step in building a theoretical foundation that can be used to guide future research in this area, particularly research aimed at understanding how interruption dynamics impact learning processes and performance during e-learning. Following the typology, the results of a study designed to gather descriptive data on the prevalence of different types of interruptions experienced during e-learning are discussed. The findings of the study are used to further refine the typology and to identify potential avenues of future research.

Overview

As noted earlier, interruptions are typically defined as uncontrollable, unpredictable events that produce information overload (Cohen, 1980), "require immediate attention" and "insist on action" (Covey, 1989, pp. 150-152). Most research studying the impact of interruptions stems from the domains of aviation, medicine, marketing, military and driving, in which interruptions have been posited to have important consequences. For example, interruptions experienced by pilots during preflight checklists have been blamed for multiple aviation crashes (National Transportation Safety Board, 1969, 1988), and interruptions have been related to emergency room events (Chisholm *et al.*, 2000, 2001) and nursing errors (Tucker and Spear, 2006).

Domains such as human–computer interaction and consumer decision-making have also found that interruptions routinely disrupt people each day in their professional and personal lives. This has lead researchers to investigate the disruptiveness of interruptions based on the types of characteristics they possess (Speier *et al.*, 1999, 2003) and the underlying mechanisms that disrupt completion of a primary task (Edwards and Gronlund, 1998; Oulasvirta and Saariluoma, 2004; Monk *et al.*, 2004).

The attentional demands of interruptions experienced during e-learning however are likely different than those found with work performance errors, consumer decisions or driving. E-learning requires sustained periods of attention from learners, but attentional resources are likely to be depleted more rapidly because of the cognitive tax that comes along with actively encoding and conceptualizing new information. Therefore, interrupted e-learning should sooner diminish the availability of cognitive resources than interruptions experienced during common activities.

Given how important cognitive resources are for learning, the issue of how attention and memory are affected by interruptions during e-learning has been of interest to training and development researchers. To better understand how and why interruptions impact memory and attention requires using a battery of learning measurements that test for knowledge transfer and impacted learning processes (i.e. metacognition, motivation and affect). Currently, more empirical and theoretical work has been carried out to understand the relationship between interruptions and working memory instead of long-term memory, and learning is often measured using multiple-choice exams, which test memory recognition (rote retention) rather than free recall. It is likely that these tests are not rigorous enough to know the true effects of interruptions. Indeed, studies of interrupted online training that test learning using rote retention methods often show that treatment and control groups differ only slightly in learning test scores and have low effect sizes (Conard and Marsh, 2014; Hembrooke and Gay, 2003). Although the evidence indicates that interruptions are mainly

disruptive to e-learning, having more studies and theoretical work that examine how a variety of interruption characteristics influence self-regulatory learning processes and effect adaptive uses of training knowledge would prove valuable.

Numerous lines of research have studied the interruptive effects of texting, cell phone use and social media on learning (Chen and Yan, 2016), though there is an endless array of interruptions that can occur during e-learning. Further, it is unclear whether certain interruption categories (e.g. interpersonal interruptions) follow the same pattern as other types of interruptions (e.g. technical disruptions) on learning processes and performance outcomes. However, it is futile to focus simply on comparing the effects of one interruption to another. Rather, what is needed is an understanding of the different types of interruptions that can arise during e-learning and the key dimensions or characteristics that distinguish among these types. Such a typology will allow future research to examine the implications of these interruption dynamics on learning. In the following section, a typology is presented that outlines the characteristics that distinguish among the different types of interruptions that can occur during e-learning and a discussion of the self-regulatory learning processes involved.

A typology of interruptions during online training

Prior research suggests that interruptions generally vary across three main dimensions: temporal factors, content and urgency (Gillie and Broadbent, 1989; Speier *et al.*, 2003; Zijlstra *et al.*, 1999). In the sections that follow, it is discussed how specific interruption characteristics within each of these dimensions may manifest in the types of interruptions observed during e-learning (Table I). In addition, these characteristics are used to distinguish among the different types of interruptions that may occur during e-learning and begin to explore the potential implications of these interruption characteristics for learning.

Table I. Definition and examples of interruption features

Interruption feature	Definition	Example
Temporal		
Frequency	Number of interruptions that occur during training	Consistency within a given training module, as well as between training modules
Duration	Span of time an interruption takes (i.e. the time that an interruption starts to when it ends)	Seconds, days, weeks, etc.
Timing	Point in time an interruption occurs	Beginning, middle, and end of training module/ skill acquisition
Content		
Relevance	Similarity between the interruption task and primary task	Similarities in information content, task modality, presentation format
Complexity	Level of information processing	Interrelated information, greater information cues
Urgency		
Synchronicity	Transmission of interruption	Synchronous interruptions (i.e. face-to-face conversation and telephone rings). Asynchronous interruptions (i.e. voicemail and email)
Source/Importance	Status of the individual who generates the interruption. Consequence of not responding to interruption	Coworker, supervisor, client, family member, friend

In particular, the different interruption characteristics are linked to the cognitive, motivational and affective processes that are critical for successful learning (Table II).

Temporal characteristics: frequency, duration and timing

Frequency. Temporal factors include the frequency, duration and timing of an interruption. Frequency refers to the number of interruptions that occur during the completion of a primary task. Interruption frequency may pertain to interruptions that consistently occur within a given training module, as well as between training modules, and does not preclude the range of interruption types that may be experienced consecutively across training.

Duration. The duration of an interruption refers to the span of time an interruption lasts (i.e. the time that an interruption starts to when it ends). In e-learning, the duration of an interruption may last anywhere from seconds to days or even longer. For example, technical disruptions that occur during training, such as low bandwidth issues, tend to have short duration periods which result in a short delay as training content is loaded. However, face-to-face interruptions from a supervisor or coworker can involve significantly longer durations.

Timing. Researchers have also considered the differential effects of interruption timing, in consideration of whether an interruption is more disruptive depending on the point in time it occurs (i.e. the beginning, middle, or end of a task) (Miyata and Norman, 1986; Monk *et al.*, 2002, 2004). With respect to learning, the timing of an interruption characterizes not only the stage of overall training at which an interruption occurs, such as at the beginning, middle or end of the training, but also the phase of the training content, such as at the beginning, middle or end of a learning concept. Therefore, timing in training settings can be considered from both a macro (i.e. overall point in training) and a micro perspective (i.e. stage of conceptual learning).

Implications of temporal characteristics for learning. There exist cognitive, motivational and affective theoretical explanations for why interruptions that vary across temporal characteristics may have differential effects on learning and performance. For example, an interruption that causes a trainee to spend a long time away from training (interruption duration) will require a reassessment of goal progress and perhaps a revised training

Table II.
Effect of interruption on learning process pathway

Process pathway	Projected effects
Cognitive	1. Interruptions create an excess amount of information to be processed resulting in cognitive load or information overload
	2. Interruptions disrupt the encoding of information
	3. Training content decays in short term working memory as the duration of the interruption increases and rehearsal of the information is prevented
Motivation	1. Interruptions may challenge trainees' self-efficacy levels and perceived capability to effectively progress through training
	2. Interruptions increase discrepancies between intended and actual behavior and delay of goal attainment
Affect	1. Uncontrollable and unpredictable interruptions produce information overload and induce stress, causing cognitive fatigue and requiring additional effort
	2. Moderate levels of arousal (experienced from an interruption) may improve performance on training task, whereas extreme high or low levels of arousal may disrupt performance levels
	3. High levels of stress may shift focus away from training toward negative thoughts about performance on the training or the interruption task

agenda. From a motivational standpoint, trainees are likely to reallocate their persistence and effort levels depending on whether they believe they can achieve their training goals. Thus, goal prioritization, self-efficacy and effort regulation play crucial roles in managing the influence of interruptions during training.

From a cognitive perspective, each time an interruption occurs, primary task goals are suspended and to retrieve them an individual often needs to reprocess some of the primary task's information. This process can be effortful and increase cognitive load given the processing of additional information cues from an interruption, as well as reprocessing information from the primary task (Kahneman, 1973). This in turn gradually depletes cognitive resources needed for successful performance of the primary task. Additionally, the longer the duration of an interruption, the more likely it is that an individual will forget his/her primary task goals and his/her position in the subtask sequence, and experience greater difficulty in returning to the primary task (Burmistrov and Leonova, 1996; Monk *et al.*, 2004).

Researchers have also examined the extent to which users experience frustration, boredom and annoyance upon being interrupted during task completion (Bailey *et al.*, 2000). Thus, from an affective perspective, trainees may experience a loss of control and delay of goal achievement, which results in a negative reaction toward their e-learning experience. According to the cognitive interference perspective (Kanfer and Ackerman, 1990), negative learning/performance effects tend to occur when individuals are unable to control their stress levels (Kanfer and Ackerman, 1990; Kanfer and Heggestad, 1999; Kanfer *et al.*, 1994). This view suggests that learning is likely undermined when arousal levels are high, primarily because learners are unable to focus on training because of negative thoughts about their performance on the interruption or the training itself.

Content characteristics: relevance and complexity

Relevance. Content factors include the relevance and complexity of an interruption. Relevance refers to the similarity between an interruption task and primary task, in terms of presentation format (Czerwinski *et al.*, 1991), task modality (Latorella, 1998), content (Speier *et al.*, 1999; Edwards, Li and Lee, 2002) and similarity in actual type of cognitive processing (Gillie and Broadbent, 1989).

Complexity. Interruption complexity refers to the number of informational cues that are processed from an interruption. An interruption is deemed high or low in complexity based on the number of mental operations involved in managing it (Cades *et al.*, 2008).

Implications of content characteristics for learning. Given that individuals have limited cognitive resources for processing information (Kahneman, 1973), greater complexity levels increasingly tax mental load and bring individuals to their capacity quickly. Past research has demonstrated that when individuals process two tasks of similar content, they experience information interference. In this case, the two sources of content become conceptually blended or distorted because of the difficulty involved with differentiating between them in working memory (Anderson and Milson, 1989; Norman, 1981). This in turn results in information overload, which depletes available resources for processing information and successfully performing either task (Kinsbourne, 1981, 1982; Navon, 1984; Edwards and Gronlund, 1998; Speier *et al.*, 1999). On the other hand, greater diversity in information content also requires individuals to process more information cues which can challenge the limited cognitive capacity resources they possess (Speier *et al.*, 1999). Cognitive load theory (Sweller, 1988) discusses that as cognitive load increases because of distracting stimuli, attentional resources are reduced, making it more difficult to process and retain information. As a result, learning is less likely to occur. Thus, prior research suggests

that interruptions that are both highly relevant and irrelevant can be detrimental to e-learning in terms of format, content, modality or cognitive processing.

From an affective and motivational perspective, as individuals experience stress via the overloading of their cognitive resources, they cope by altering their processing strategy. Thus, individuals' goals and attitudinal states may change because of the demands of the situation and result in reallocation of effort. According to Cohen's cognitive fatigue model (Cohen, 1980), as individuals experience information overload, levels of anxiety, tension and anger also increase (O'Connell *et al.*, 1976), which result in greater effort, fatigue and dissatisfaction (Beehr *et al.*, 1976; Caplan and Jones, 1975). Thus, interruptions that are very complex or irrelevant should further undermine learning through these affective and motivational pathways.

Urgency characteristics: synchronicity, source and importance

Synchronicity. The third dimension, urgency, refers to the extent to which the trainee can negotiate their response to an interruption and decide when to attend to the interruption task. For example, interruption synchronicity refers to the synchronization or timing at which an interruption is experienced. Synchronous interruptions occur in real-time, such that the trainee is faced with an interruption in the present moment and an immediate response from the trainee is typically expected. In contrast, asynchronous interruptions often do not require an immediate response.

Source and importance. The source of an interruption refers to the status of the individual who generates the interruption and his/her importance to one's professional or personal life. Interruptions can be generated by a variety of sources, such as technology, peers, coworkers, clients, family/friends and supervisors. The source of an interruption influences an individual's evaluation of the cost-benefit tradeoff of not responding to an interruption and the perceived urgency of the required response (e.g. interruption from one's boss versus one's colleague).

Implications of urgency characteristics for learning. McFarlane (2002) discusses that while there is no ideal method to interrupt users in tasks across all performance measures, he found that when interruptions were not urgent, overall user performance was best when individuals could negotiate the urgency of their response. This is because it allowed individuals to thoughtfully manage the interruption in relation to fulfillment of their primary task requirements.

It is important to consider how urgency characteristics elicit affective responses in users, which can promote or inhibit the level at which individuals effectively learn and achieve their goals. Some research has showed that interruptions that are perceived as uncontrollable and unpredictable produce high levels of arousal, leading to psychological and physiological problems for individuals, such that they feel incapable of performing effectively (Zijlstra *et al.*, 1999; Bailey *et al.*, 2001). Individuals who experience greater levels of stress and anxiety may engage in off-task, negative thinking about their learning capabilities and as a result, perform poorly at learning new tasks.

A different perspective suggests that interruptions that increase arousal to a certain point can serve to promote learning. According to this view, the range over which performance improves with increasing arousal varies with task complexity. Whereas high levels of arousal on a complex learning task is likely to inhibit a learner's ability to cognitively master new concepts, a simpler learning task coupled with arousal can narrow attention on the dominant and relevant cues of the task to raise performance levels (Speier *et al.*, 2003).

Finally, activity regulation theory (Hacker, 1978, 1986) explains that in the execution of goal-directed activity, individuals engage in goal-attainment strategies and self-monitoring of goal progress. They will revise their strategies if they experience a discrepancy in goal attainment (Frese and Zapf, 1994; Roe, 1988). Thus, if trainees are interrupted by their supervisor during training, the urgency with which they comply to the request will have consequences on their learning and performance goals during training. For example, a shift in performance and learning goals may cause trainees to reduce their effort and progress through training at a suboptimal performance standard to complete their training at a faster rate.

Summary

In summary, a typology has been presented that highlights the distinguishing characteristics of interruptions. The typology highlights temporal, content and urgency characteristics as the three key conceptual dimensions that distinguish among different types of interruptions and their effects on learning. As discussed at the beginning of this paper, little descriptive knowledge exists regarding the types of interruptions e-learners experience. Therefore, the typology described above was used to design a survey that would provide insight into the types of interruptions e-learners experienced and to refine the conceptual framework. More specifically, the survey assessed both the temporal (e.g. frequency, duration and timing) and urgency (e.g. synchronicity and source) characteristics of interruptions reported by a sample of e-learners. Although the survey did not directly assess interruption content characteristics, it assessed the length of an interruption and the lag time to resume training, which provides an indirect indication of specific content features, such as complexity. In the next section, the survey methodology is discussed and the findings from the survey are presented.

Method

Procedure

To capture information about characteristics of interruptions that occur during e-learning, an internet-based survey was created that was distributed by study response project (Stanton and Weiss, 2002; Wallace, 2004) to working adults in the USA, who had participated in an e-learning within the past year. The sample consisted of 55 individuals who reported experiencing at least one interruption during e-learning conducted within the past year. Each individual could provide information on up to five interruptions, from which 172 observations were gathered (i.e. interruptions) nested within these 55 individuals. The age of participants ranged from 21 to 67, with an average age of 39. The education profile of participants was as follows: high school (6 per cent); associates degree (10 per cent); some college, no degree (13 per cent); 4 year college degree (37 per cent); some graduate school, no degree (6 per cent); masters degree (25 per cent); and PhD, MD, JD or other advanced degree (3 per cent); 60 per cent of the participants were male.

The development of the survey was guided by the interruption typology framework as outlined above. The survey began by asking participants whether they had experienced an interruption(s) during their past year of e-learning. If they responded in the affirmative, participants were then asked to continue with the survey and to recall the most recent e-learning in which they experienced an interruption. Participants were then asked about each interruption they experienced (maximum of five). In particular, participants were asked about the timing of the interruption (beginning, middle, or end of training) and the source of the interruption (technical/computer difficulty, face to face communication with another person, phone-call/e-mail/text message, or other). Upon selecting one of the answer choices

regarding the source of the interruption, the question was branched to obtain further information about the characteristics of the interruption. For example, selecting the technical/computer difficulty answer choice branched into answer choices: frozen computer screen, dropped connection, error message or other malfunction. Similarly, if participants had selected that the interruption involved face-to-face communication with another person, they were then asked whether the person was their coworker, supervisor, client, family/friend or other. The answer choice options of coworker, supervisor, client, family/friend or other were also provided for the interruption of a phone-call/e-mail/text message.

Following these responses, participants were then asked to provide the approximate amount of time an interruption lasted, followed by another question asking the approximate amount of time it took for them to return to their training. These measures provide an indirect assessment of the complexity of the interruption.

Results

In total, 62 per cent of the sample reported participating in their e-learning at their work desk. The remaining 38 per cent of the sample reported participating in a combination of places, including their home, work environment and outside both their home and work environment; 48 per cent of the sample reported participating in their e-learning during regular work hours, 23 per cent reported participating during personal time, and the remaining participants reported using a combination of these methods; 82 per cent of the sample reported that their training was internet/intranet-based, and the remaining sample reported using a combination of e-learning formats, including internet/intranet, CD-ROM, video and podcasts.

Frequency tables of the survey variables are depicted in Table III through Table VIII. Table III shows the frequency of specific interruption sources (e.g. the frequency of specific types of computer malfunctions), whereas Table IV shows interruption sources combined into aggregated categories (e.g. any computer related interruption is considered a computer malfunction). These results reveal that coworkers were the most common source of an interruption (35 per cent), and that most of these interruptions occurred face-to-face rather than through phone, text, or email. The second most common source of interruption came from computer malfunctions (23 per cent), followed by interruptions from supervisors (17 per cent) and then family and friends (16 per cent). The prevalence of family and friends

Table III. Frequency and percentages of interruption sources subcategories

Source type	Frequency	(%)
Phone/text/email client	6	0.03
Phone/text/email supervisor	8	0.05
Error message	8	0.05
Phone/text/email family/friend	10	0.06
FTF supervisor*	14	0.08
FTF family/friend*	16	0.09
Other	17	0.10
Computer froze	17	0.10
Dropped connection	18	0.11
Phone/text/email coworker	18	0.10
FTF coworker*	40	0.23
Total	172	100

Note: *FTF - face-to-face interruption

interrupting participants' e-learning is indicative of the fact that many employees participate in e-learning outside of the workplace (e.g. from home, on the road). Interestingly, an examination of the "other" sources reported by participants revealed a category of interruptions not included in the typology – self-generated interruptions. These interruptions accounted for 11 per cent of all reported interruptions and are characterized by purposeful breaks from the training. In the discussion, the potential implications of these self-generated interruptions are further examined.

Table V provides frequency statistics for interruption duration (the amount of time an interruption lasted) and Table VI provides statistics for interruption response lag time (the amount of time it took to resume training). Although the responses were open-ended, the data suggest that participants rounded off their responses to these items – as responses of 5, 10, 15 and 60 min emerged frequently from the data. Given this, both variables were classified into categories of short interruption/response lag time (5 min or less), medium interruption/response lag time (6-10 min), large interruption/response lag time (11-59 min) or very large interruption/response lag time (60 min or longer). The table shows that interruptions characterized by a short duration (5 min or less) were most common (41 per cent). However, participants were most likely to report large delays (11-59 min) before resuming training, and 31 per cent of participants indicated a delay of 60 min or more before they could resume training. These findings suggest that even short interruptions can result in significant delays in the completion of e-learning.

Source type	Frequency	(%)
Client	6	0.04
Other	11	0.06
Family/friend	26	0.16
Supervisor	28	0.17
Computer malfunction	37	0.22
Coworker	58	0.35
Total	166	100

Table IV. Frequency and percentages of interruption source primary categories

Time (in minutes)	Frequency	(%)
5 or less	67	0.41
6-10	34	0.21
11-59	35	0.21
60 +	27	0.17
Total	163	100

Table V. Frequency and percentages of interruption duration

Time (in minutes)	Frequency	(%)
5 or less	46	0.28
6-10	25	0.16
11-59	49	0.31
60 +	40	0.25
Total	160	100

Table VI. Frequency and percentages of response lag time

Table VII provides a frequency table of interruption timing (i.e. beginning, middle or end of training) and shows that participants were most likely to be interrupted in the middle of training (50 per cent). On the one hand, these results are encouraging because interruptions that occur at the beginning of training are likely to be most disruptive to learning since this is when cognitive resource demands are greatest. However, interruptions that occur at the middle of training may be more disruptive than those that occur near the end of training, at which point trainees are more likely to have already proceduralized their skills. Finally, Table VIII provides a chart of interruption frequency, which examines the number of interruptions individuals reported experiencing during their training. Although the number of interruptions varied across trainees, it is worthwhile to note that 25 per cent of the trainees reported experiencing six or more interruptions.

Discussion

The goal of this study was to gain a better sense of the prevalence and types of interruptions e-learners experience. The findings of this study indicated that the most frequent interruption participants encountered during their training was from coworkers, which is consistent with prior work in this area (Cellier and Eyrolle, 1992). However, participants also cited computer malfunctions, supervisors, and family/friends as common sources of interruptions. Interestingly, the survey also revealed that interruptions were occasionally self-generated, which is an interruption source that was not originally included in the typology. Respondents reported that they needed to "take a break to rest" or "purposefully decided to complete part of the online training and come back after other activities." Self-generated interruptions counter the traditional definition of an interruption, which states that interruptions are "an externally generated, randomly occurring, discrete event that breaks continuity of cognitive focus on a primary task" (Corragio, 1990, p. 19); however, it is seemingly the case that self-generated interruptions exist more through internal and self-controllable processes. Thus, with this type of interruption, it is relevant to explore what prompts individuals to take a break from training.

Adler and Benbunan-Fich (2013) found that self-generated interruptions can arise from positive and negative feelings of task progress and goal attainment levels. The findings

Table VII. Frequency and percentages of interruption timing

Timing of training	Frequency	(%)
Beginning of Training	45	0.26
Middle of Training	86	0.5
End of Training	41	0.24
Total	172	100

Table VIII. Frequency and percentages of interruption frequency

Frequency count	Frequency	(%)
1	8	0.15
2	13	0.24
3	14	0.25
4	4	0.07
5	2	0.04
More than 5	14	0.25
Total	55	100

from their study indicated that negative feelings triggered more self-generated interruptions than positive feelings and that more self-generated interruptions led to lower accuracy in all performance tasks. Within the boundaries of self-regulated learning, these results suggest that trainees may benefit from various self-regulatory learning strategies to combat feelings of boredom or anxiety, as well as use time management planning to help them maintain on-task attention. Alternatively, self-generated interruptions may serve trainees a way to mentally break from a learning task when they are low on cognitive and motivational resources and are seeking ways to maintain those resources for other tasks. Future work should examine the conditions under which self-generated interruptions are beneficial during e-learning in relation to maintaining motivational, affective, and cognitive process pathways needed for learning.

Studies have shown that better students take more time to study difficult learning material (Le Ny *et al.*, 1972) and that less able students do not allocate enough study time toward learning complex concepts (Nelson and Leonesio, 1988). These findings are important because e-learners are free to decide the pace and time of their training, and ultimately, are the key presiders of their training. Thus, the quality of the learning experience is in their hands. While the incidence of interruptions can derail and throw training off its course, whether trainees continue their commitment to their learning agenda is an open question. Therefore, when interruptions are in play, it becomes crucial for e-learners to identify in advance the types of learning goals and objectives they want to achieve. In consideration of what they want to get out of their training, they should also create time management plans for resuming training based on the likelihood that they will be disrupted by interruptions. Future research should investigate time management plans and goal structures that optimize for situations of interrupted training and self-regulatory factors that help e-learners remain committed to these plans. Of related importance is to compare the successful retention and transfer of training concepts when the resumption lag periods of these time management plans vary.

In addition to having e-learners create time management plans, prior research in cognitive psychology has demonstrated that there's great value in using memory tests to help students with retrieval and long-term retention of learning content. Known as the testing effect, tests enhance knowledge retention more so than additional study of training content, even when tests are provided without feedback (Roediger and Karpicke, 2006). This phenomenon is also evident in the mind-wandering literature. A recent study found that interspersing periods of online instruction with low-stakes quizzing promoted student attention by discouraging task-irrelevant behavior (mind-wandering) and encouraging task-relevant activities (note-taking), ultimately improving learning (Szpunar *et al.*, 2013). Future studies should examine the effects of memory testing in the context of interrupted e-learning. Memory testing may not only offer cognitive benefits, such as enhanced use of metacognitive learning strategies, sustained learner attention and improved retention of training content, but also increase learner motivation and satisfaction toward e-learning.

In the current study, face-to-face interactions interrupted trainees more frequently than asynchronous forms of communication (e.g. phone, text, email). This suggests that individuals should use self-initiated strategies to manage their physical and social environment to reduce this type of interruption. Regulating one's physical and social environment involves identifying ways to restructure one's training environment to make it more conducive for learning (Zimmerman and Risemberg, 1997). The management of one's study area requires locating a place that is quiet and relatively free of visual and auditory distractions so that one can concentrate. Self-regulated learners can restructure their physical environment to meet their needs by altering their physical surroundings. For

example, organizations have begun to recognize the disturbing effects interruptions have on e-learning, and so it is becoming a norm for organizations to allow e-learners to put up signs, such as: "*Person Learning, Do Not Disturb*", as well as block phone calls, instant messages and e-mail in at least 1- to 2-h intervals of time during training.

Although this study provides useful descriptive data on the types of interruptions experienced by e-learners, there are several limitations that should be noted. First, the sample consisted of a limited number of respondents. However, many of the respondents reported multiple instances of interruptions, thereby increasing the total number of observations. Second, the data was collected through retrospective, self-report procedures. Specifically, the survey required participants to recall details about the most recent interruption (s) they experienced during their e-learning. It is difficult to know at what level of detail individuals can effectively recall past episodes of interruptions. For example, it is likely individuals rounded off the length of time an interruption lasted, as well as the amount of time it took them to return to their training. Although the specific estimates provided by participants may be imprecise, the data provide insight into general trends surrounding issues such as interruption duration and response lag time.

Conclusion

A goal in this paper was to advance an understanding of the interruptions that e-learners experience during their training. To this end, a conceptual framework was presented that delineates core characteristics that distinguish among the different types of interruptions that can occur during e-learning and took the first step in beginning to link these characteristics to critical learning processes. In addition, a sample of e-learners was surveyed to determine whether the types of interruptions they experienced during training aligned with those suggested by the typology. The findings from the study generally provided support for the proposed typology, but also highlighted areas that warrant future research attention (e.g. self-generated interruptions). Although future work is needed to further test and refine the conceptual framework, the typology can serve as a valuable theoretical foundation for future research aimed at examining the effects of different types of interruptions on critical learning processes and outcomes during e-learning.

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