

## Just more of the same, or different? An integrative theoretical framework for the study of cumulative interruptions at work

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We propose a theoretical framework that explores the accumulation of work interruptions and their effects. Most research studies have dealt with interruptions as isolated phenomena, ignoring the simultaneous or sequential occurrence of interruptions common in everyday life. We fill this gap and provide insight into the process of the accumulation of interruptions by mapping deep-level regulation onto an observable sequence of actions. Furthermore, we explain how cumulative interruptions can lead to qualitatively different effects because of the interaction and joint development of isolated effects, identifying some mediating and moderating factors. In doing so, we disclose the relationships between the effects of single interruptions found in laboratory studies and the impacts on health and well-being of multiple interruptions found in applied research.

**Keywords:** Cumulative work interruptions; Mental process; Effort; Loss of resources; Strain; Performance.

Do you expect to read this article without interruptions? How many times will you be interrupted? By what or by whom? How will these interruptions affect you and your task performance? Will these interruptions affect your performance of later tasks or your mood? Questions like these will be the topic of discussion in this article.

Interruptions are a part of people's daily experience in many work environments. Nearly one-third (28%) of respondents of the third European Survey on Living and Working Conditions, conducted across 15 European countries, indicated that they were interrupted several times a day "in order to take on an unforeseen task" (Paoli & Merlić, 2005, p. 86). A German survey of 20,000 employees showed that the rate of interruptions had doubled in the past 20 years and had become one of the main stressors in work life (BAuA, 2013). Because some interruptions are unavoidable in contemporary work life, it is important to understand the origins, processes, and consequences of interruptions in real-work settings. More than two decades of research has provided important insights into the nature and effects of interruptions (Altmann & Trafton, 2002; Einstein, McDaniel, Williford, Pagan, & Dismukes, 2003; Zijlstra, Roe, Leonora, & Krediet, 1999). For instance, researchers have shown that the consequences

of interruptions can include forgotten intentions, quantitative and qualitative deterioration of performance, time loss, and strain (Bailey & Konstan, 2006; Einstein et al., 2003; Grebner et al., 2003). In some work settings, interruptions even have been discovered to be risky due to enhanced likelihood of errors in very sensitive areas, such as air-traffic control or medication administration in hospitals (e.g., Balas, Scott, & Rogers, 2004; Ho, Nikolic, Waters, & Sarter, 2004). In cross-sectional studies, researchers have established positive relationships between work interruptions and depression, psychosomatic complaints, and burnout among different occupational groups (Grebner et al., 2003; Rout, Cooper, & Rout, 1996; Wülser, 2006). Although interruptions may, under certain conditions, have positive effects (e.g., Zijlstra et al., 1999), most existing research suggests that interruptions have harmful impacts on performance and well-being.

To date, most studies have dealt with interruptions as isolated phenomena, leaving unexplored the simultaneous or sequential occurrence of interruptions that are typical for work life. Thus, the evidence regarding interruptions is fragmentary and incomplete. We do not know how multiple interruptions affect the workflow and performance of people over time, or how they influence

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This research was supported by the Bundesanstalt für Arbeitsschutz und Arbeitsmedizin (Federal Institute for Occupational Safety and Health) [grant number F2220]. Writing this article was facilitated by a stay of the last author at the Research Academy Leipzig in 2012 and 2013.

people's well-being and health. This is an undesirable situation because without a proper understanding of interruptions, we may not be able to take effective measures against their harmful effects, and given the nature of the modern workplace, the rate at which interruptions occur may continue to grow.

The aim of this article is to integrate the current literature and to derive propositions on the effects of accumulating interruptions in real-work contexts. We will develop a theoretical framework that aggregates and extends present knowledge (of laboratory research) on the process and effects of single and isolated interruptions and establishes new angles for applied research in the work context. The framework covers knowledge on (1) single, isolated interruptions and multiple, combined interruptions; (2) interruptions in lab and real-life settings; (3) features of interruptive tasks, including complexity (simple, complex) and time demand (frequency, duration); and (4) the surface- and deep-level aspects of interruptions. The framework also serves as the basis for specific research models that allow for the study of (1) implications of the accumulation of interruptions for task performance and well-being; (2) agency, or more specifically, how people respond to and handle interruptions; and (3) changes over time.

Our integrative framework permits us to explain the expected outcome when single effects of interruptions accumulate. We argue that this is not just a matter of an additive increase, but that it entails a qualitative change in effects that is unobservable in laboratory studies. Next, we point to feedback loops and interactions among the consequences of cumulative interruptions, with single effects influencing and amplifying each other. This leads us to formulate new propositions that allow to convert the effects of single interruptions (results of laboratory studies) to effects of long-term exposure to interruptions as they occur in the work setting (results of field studies).

Besides arguing for qualitative and quantitative shifts in effects when moving from the laboratory to the field, we suggest that the underlying cognitive mechanisms differ and that successful coping with multiple interruptions requires different strategies as compared to single, isolated interruptions. By doing this, we aim to advance interruption research and to enhance its ecological validity by examining interruptions in the contexts in which they appear in everyday work life.

## DEFINITION OF INTERRUPTION

An interruption is a temporary suspension of a person's goal-directed action (Brixey et al., 2007, p. E30). Being interrupted means that the person stops the execution of an action before a chosen goal or sub-goal (task goals are typically broken down into sub-goals that can be executed successively or at separate time intervals) is reached, with the intention of resuming the action at a later point in time (cf. Altmann & Trafton, 2002). Thus, the activity is postponed, but not ended. This implies that

there is no "closure" and that the mental resources required by the activity remain activated (cf. Altmann & Trafton, 2002; Zeigarnik, 1927). In this respect, interruptions are different from voluntary breaks, which occur after (sub)actions are closed and mental resources have been released (Jett & George, 2003).

Interruptions can be classified in many ways. For instance, Jett and George (2003) have suggested distinguishing between intrusions, distractions, and discrepancies, based on the meanings of the interruptive occurrences for the acting person. With regard to their origin, they can be loosely categorized as external or internal. External interruptions originate from *calls* by clients, colleagues, superiors, or others, whether orally, by telephone, email, or other means and changing conditions, such as the malfunction or status change of a machine, computer, or vehicle. These interruptions are usually unintended and uncontrollable. Many of these conditions force or affect a change of activity to perform another task and to give it priority over a current task. Internal interruptions, on the other hand, originate from a person's own thoughts (e.g., plans, inventions, worries), emotional states (e.g., happiness, anxiety), or physical needs (e.g., eating, drinking, urinating, changing clothes). Internal interruptions are diverse in that they occur intentionally or unintentionally and can be controllable or uncontrollable. This diversity, combined with the fact that interruptions with internal origins are not directly observable, makes them difficult to study. We therefore limit our study to interruptions with an external origin and concentrate on interruptions that imply *things to do* (labelled *interruptive tasks*), although we will also consider *forced breaks*.

Halting an ongoing action does not mean that no further activity occurs. On the contrary, by their very nature, interruptions free up resources for other activities related to the newly presented tasks. What makes the study of interruptions worthwhile is not only the suspension of the ongoing (primary) task but also the shift to the other (interruptive, secondary) task and the resumption of the primary task after the secondary task has been completed (or rejected). Researchers can study this, to some degree, by observing a person's activity. However, to describe and understand what happens when people are interrupted and how this affects their performance and well-being, a conceptual framework is required that covers the mental processes involved in producing and regulating task activities. Action regulation theory (ART) is an important contribution to such a framework (Frese & Zapf, 1994; Hacker, 2003; Hacker & Sachse, 2014). It provides a detailed description of how a person handles the interruption on a cognitive level, how a new action plan for the interruptive task is generated, how this plan is executed while the existing action plan is kept activated in memory, and how cognitive resources are released and activated as the person switches between tasks.

In the following section, we first describe the cognitive processes involved in single interruptions. Then we

develop ideas about what happens when interruptions accumulate and how we define such accumulation.

## ANATOMY OF SINGLE INTERRUPTIONS

What happens when people are interrupted can be described at two levels—a *surface* level of observable activities and a *deep* level of underlying cognitive, emotional, and energetic processes. We describe both levels and discuss the links between them, which leads to an integrated and new representation of the interruption process.

### Surface level

Interruption researchers have typically taken an observer's perspective and tried to understand interruptions from observed changes in activities at the surface level (Brixey et al., 2007; Traflet, Altmann, Brock, & Mintz, 2003). This has led them to divide the time interval around interruptions into different phases and to make inferences about underlying processes from the measured duration of these phases. A common distinction in this approach is between the pre-interruption phase during which a person carries out a primary task, the interruption phase during which the person perceives and responds to the interruption, and the post-interruption phase during which the person resumes and concludes the primary task. The interruption phase has further subdivisions. For instance, Zijlstra et al. (1999) have distinguished between episodes related to interruption reception and execution, interruption completion, changeover from the interruptive task to the main task, and resumption of the main task. More recently, Brixey et al. (2007) referred to an interruption lag (a period from the perception of the interruption to the acceptance of the interruptive task), acceptance of the interruption, interruption handling (following one of several strategies), and resumption lag. These distinctions referred to here are somewhat arbitrary and unsatisfactory because one cannot map the deep-level processes into observable activities in a one-to-one manner. We therefore first analyse interruptions from the perspective of the mental processes involved in goal-directed action and then propose a more fine-grained distinction of processes that may be useful in observational research.

### Deep level

ART is a psychological theory that explains how people carry out goal-directed action, which has been developed and extensively tested in Europe (Frese & Zapf, 1994; Hacker & Sachse, 2014). The theory posits that mental representations of goals and action plans drive goal-directed actions and that, to carry out an action, the person must set an appropriate goal (subjective task), develop or recall an action plan, and execute the plan

while monitoring progress and outcomes. An important tenet of this self-regulation theory is that increasing familiarity with the task changes mental representations and the way these translate into actions (routinization, automation). Researchers of self-regulation theory have distinguished three modes of execution, called *regulation levels*, which involve different types of mental representations and which differ in cognitive demands (cf. Rasmussen, 1983): automatic or skill-based (stereotyped and unconscious actions, e.g., typing an "A"); associational or rule-based (actions are already organized in schemas; they just have to be adjusted to the situation, e.g., writing an acceptance letter); and intellectual or knowledge-based (a complex action that requires an analysis of the situation, e.g., writing a review). The theory sheds light on performance effectiveness as well as consequences for the person performing the tasks. It explains how *regulation hindrances* (among them, work interruptions) act as stressors (e.g., Greiner, Ragland, Krause, Syme, & Fisher, 1997) and how control over work maintains a balance between performance and well-being. It also emphasizes the importance of *action efficiency*, the ratio of achievement to required mental resources (Zijlstra, Cavalini, Wiethoff, & Meijman, 1990). A final concept in ART is that of *action strategy*, which refers to a deliberately chosen variant of an action plan by which the person seeks an optimal balance between the demands and the constraints of the task setting on the one hand and personal resources and psycho-physiological state on the other hand (Hockey, 1997; Meijman & Mulder, 1998). Strategies point to the phenomenon of human agency. People are not a passive playing field for variables; they are aware of what happens in their work and act when too many interruptions occur, using specific strategies that allow them to achieve the best possible results under varying conditions.

From the perspective of ART, there is no essential difference between the primary and the interruptive tasks. Both require redefining an objective task into a subjective task, orienting to the task situation, preparing or selecting an action plan, and executing the plan at an appropriate regulation level while monitoring its progress and results. The only difference is that the execution of the primary task is already occurring when the interruptive task presents itself. Thus, the person must attend to the interruptive event, recognize the objective task inherent in it, define a subjective task, prioritize and schedule the old and the new task, switch over from the old to the new task at some point, prepare for, and finally execute it. After this, the individual must switch back to the old task, prepare for its resumption, and continue executing it from an appropriate point in time, as well as find the suitable regulation level. Researchers have speculated that effects of an interruption are contingent upon the phase within the sequential actions of the primary task where the interruptions occur. The items

kept in memory to resume the task later on are important in that respect. This again depends on the general complexity of the primary task. Thus, albeit the timing of the interruptions likely matters, it is hard to make a clear prediction.

There are also emotional and motivational dimensions to this. The interruption of the ongoing action poses a hindrance that is likely to create irritation or anger; motivationally, the person must stay committed to the first task while becoming motivated to carry out the second task.

### An integrative framework of the interruption process

In the following, we elaborate on the consequences of this pattern of mental activities. In doing so, we extend the surface-level phases distinguished in observational research (cf. Brixey et al., 2007) with deep-level phases, which helps to gain a deeper understanding of how interruptions unfold.

Figure 1 shows that the processes involved in handling interruptions, even if it is a single, isolated interruption, are rather complex. There are two parts that are assumed to fulfil a key role in this process: the interruption lag and the resumption lag (Altmann & Trafton, 2002). The proposed model shows that the interruption lag comprises perceiving and interpreting the interruptive event, defining the interruptive task, prioritizing and scheduling, task-switching, and preparing for the execution of the interruptive task. After this, the interruptive task is executed and completed. What follows is a resumption lag, which includes task-switching (back to the primary task) and preparing for the execution of the primary task. Researchers have described the resumption of the primary task as one of the main costs of

interruptions (Altmann & Trafton, 2007; Bailey & Konstan, 2006; Cades, Werner, Trafton, Boehm-Davis, & Monk, 2008) because it calls for additional effort and time. The degree to which this is the case depends on the amount of information that must be retrieved and the (memory) effort that is needed to do that; both factors depend on the way in which the person makes use of the interruption lag (cf. goal-activation theory, Altmann & Trafton, 2002).

The amount of information to be retrieved is determined by the complexity of the primary task. If something or someone interrupts a person while writing an article, it will take that person longer to resume writing than it would take if instead the interruption occurred while the person was sorting papers. Speier, Valacich, and Vessey (1999) found that interruptions of complex decision tasks (in which several calculations have to be made and a vast amount of information is kept in mind) led to worse decisions than interruptions of simple tasks (short and routine additions or subtractions), which can be explained with the help of ART. Complex tasks have a higher level of regulation (in the aforementioned examples, intellectual level versus associational level), which imply a greater use of resources—that is, they pose a greater demand on the working memory. There are more regulations to be carried out, and the action plans are more complex. If tasks with more extensive action plans have to be resumed, more effort and time are needed.

The memory-related effort needed to retrieve information about the primary task depends on the degree of distraction, which we define with reference to the time lag of the interruption and the working memory demand of the interruption. According to goal activation theory (Altmann & Trafton, 2002), a long time lag encourages memory decay. Although a person can prevent this by rehearsal, that person will still need further resources.

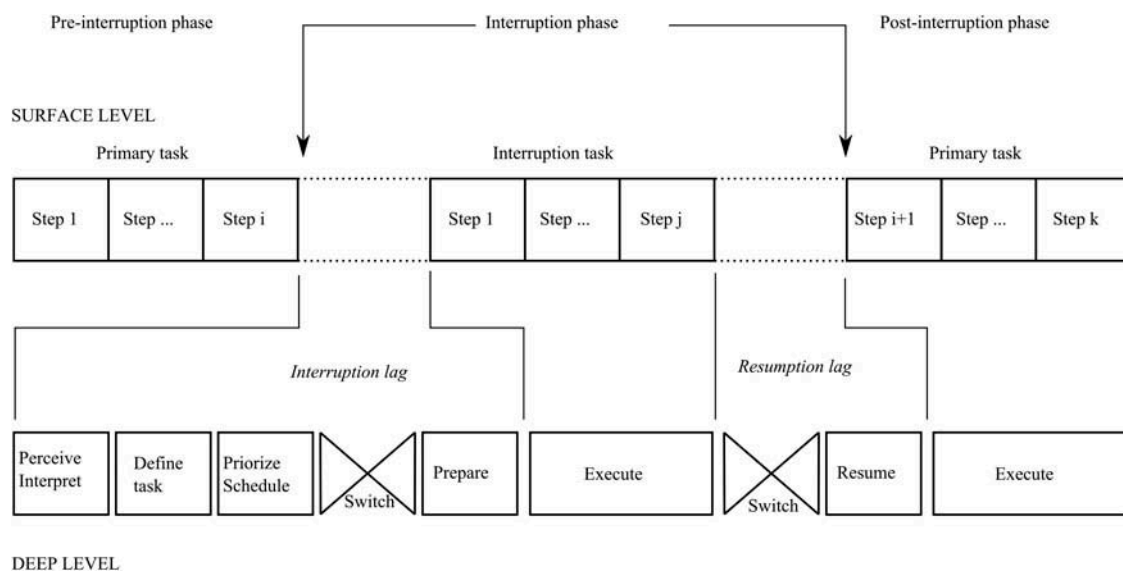


Figure 1. The phases of interruptions.

Monk, Boehm-Davis, and Trafton (2004) determined that interruptions by tasks led to longer resumption lags than interruptions by forced breaks. This is because people can use breaks to think about the primary task—to keep it in mind. Cades et al. (2008) suggested that the activation of primary tasks could also take place during simple non-demanding interruption tasks. They showed that less complex interruption tasks (choice of the higher of two 2-digit numbers) led to shorter resumption lags than more complex interruption tasks (aforementioned complex-decision tasks plus further calculations and decisions).

Thus, the complexity of the primary and the interruption tasks determines the effort required for the resumption of the primary task. This can be kept low by a strategic use of the interruption lag (Altmann & Trafton, 2002). One possible strategy is to “strengthen ... memory for the resumption point” (Boehm-Davis & Remington, 2009, p. 1125) by making notes about the steps to be taken when resuming the primary task. Alternatively, the interruption may be ignored, or the interruptive task may be delegated (i.e., transferred to another person). This will keep the time lag of the interruption short. Another option is to reduce the amount of knowledge a person needs to recall to reactivate the primary task (Boehm-Davis & Remington, 2009). One can achieve this by using the interruption lag to finish a subtask of the primary task. However, a person must decide all this in the prioritization phase.

We can best study interruptions and their potential impact by simultaneously looking at surface-level and deep-level events. This is particularly true when the work setting provides many different interruptions. In the following section, we develop propositions regarding the consequences of the accumulation of interruptions.

## THE ACCUMULATION OF INTERRUPTIONS AND THEIR EFFECTS

Although studies have offered useful analyses of isolated interruptions, we believe that they do not sufficiently offer an understanding of the cumulative interruptions that are typical in real-work settings. During a workday, multiple qualitatively different interruptions may occur, producing different outcomes. Furthermore, we believe that the process of dealing with interruptions becomes much more complex and cognitively demanding as more interruptions happen. Thus, the effects of isolated interruptions observed in laboratory research do not easily generalize to effects that occur during the workday.

At the surface level, the accumulation of interruptions is visible as a complex pattern of sequential episodes in which steps of primary tasks and interruptive tasks alternate. At the deep level, this implies elevated demands on memory, attention, and action regulation, compared with situations with few or no interruptions. For instance, if just one single interruption happens, the scheduling task

is limited to the decision of whether to perform the interruptive task now or later. If several interruptions happen during a day in which a person is working on several tasks, the scheduling task will be more demanding and involve a higher cognitive load. The sequence of cognitive processes involved in shifting from one task to another will also be more complex. In the same way, the interruption process changes when interruptions accumulate, and their effects are likely to change as well. To gain a better understanding of this, we should consider a longer period than has typically been used in past research and look at cumulative interruptions during the time frame of an entire workday or even several workdays.

Cumulative interruptions include the growing number of sequential interruptions that occur during a certain time interval (e.g., one working day). To assess their effect, we need to consider the number of interruptions during that interval and the magnitude of the interruptions in terms of their time and cognitive demands. We define the time demand by the frequency and length of the interruptions and equate it to the amount of time lost by interruptions. This is the quantitative aspect of cumulative interruptions, whereas we regard the cognitive demand to be the qualitative aspect. The cognitive demand depends on the complexity (cf. working memory demand) of the interruptive and the primary task (see Figure 1, deep level). The complexity of the primary task determines the amount of information a person should retrieve after the interruption is finished and thus the duration of the resumption (Altmann & Trafton, 2002; Monk et al., 2004). The complexity of the interruptive task determines the level of distraction of attention away from the primary task (Speier et al., 1999) and the magnitude of the additional demand (e.g., additional tasks that increase workload) needed. Therefore, we conceive of the effect of cumulative interruptions as the interaction of time (frequency and length) and cognitive demand (complexity of the primary and interruption task) of interruptions, with the highest expected effect when both factors are high.

We should make clear that we do not conceive of *cumulative interruptions* as a variable; that is, ranging from few to many interruptions one after another. Because the number and type of interruptions to which people are exposed to varies with occupation and work setting (consider, e.g., dispatchers, sales people, nurses, train drivers), we instead think of *interruption profiles* that contain several serial and nested occurrences of interruptions. We use accumulation as a generic term referring more loosely to the prolonged exposure to profiles with multiple interruptions over time, where the profiles can differ.

The profile of interruptions emerges from observed effects of cumulative interruptions across occupations and settings. For example, in work settings such as hospital nursing, dozens of interruptions occur every

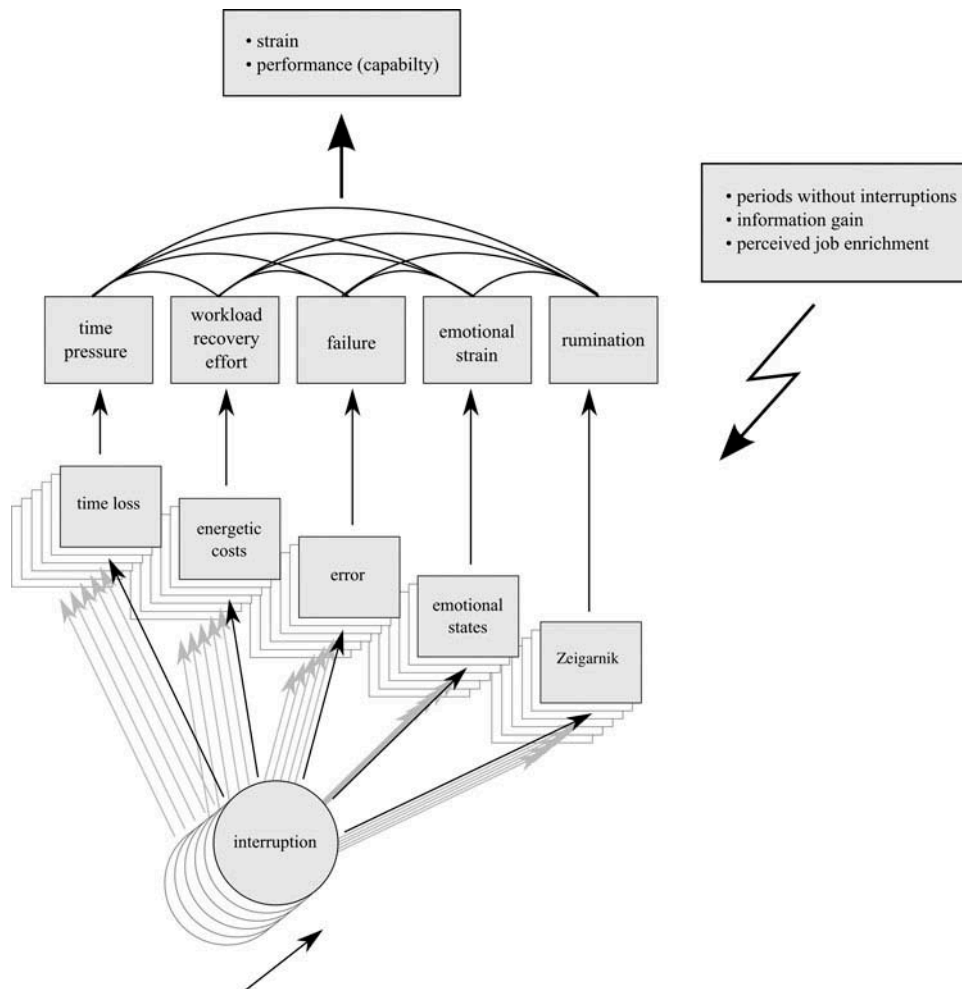


Figure 2. Cumulative interruptions.

day, yet the level of complexity of the interruptive tasks varies. Meanwhile, in settings such as factory work, interruptive tasks are of a similar complexity, but the numbers vary per day. In this article and at the actual stage of research, we cannot go into detail on such workplace-specific differences, nor can we refer to every possible pattern of interruption. This forces us to start discussing cumulative interruptions in a generic way, assuming that there are several dissimilar interruptions in a day over a series of multiple workdays. We will discuss a prototypical cumulative process of interruptions, consider different impacts of interruptions, and develop propositions as to what to expect when interruptions accumulate. Starting from the effects that have been described in laboratory and simulation studies, we will discuss the qualitative shift one can expect when interruptions accumulate over time and when their effects unfold. As depicted in Figure 2, we will present a set of propositions that includes an expected shift from time loss to time pressure, from energetic costs to workload and need for recovery, from errors to failure, from emotional states to emotional strain, and from Zeigarnik effects to rumination.

Particularly interesting and potentially worrisome are certain effects on strain—and hence on performance—that emerge as the consequences of several interruptions interact over time (thick upward arrow, Figure 2). In the section “Joint effects”, we discuss how these effects may combine in a downward spiral and consider possible buffering mechanisms (downward arrow on the right side, Figure 2).

## CHANGE OF EFFECTS: FROM ISOLATED TO ACCUMULATED INTERRUPTIONS

### Loss of time: Time pressure

An obvious consequence of an interruption is that it takes more time to complete the primary work. Studies of isolated interruptions have shown that interruptions cause loss of time (Cellier & Eyrolle, 1992; Monk et al., 2004; Zijlstra et al., 1999) and lead to more use of time in the accomplishment of both the interruptive and the interrupted (primary) tasks (Bailey & Konstan, 2006; Cellier & Eyrolle, 1992), which can be attributed to additional prioritizing, scheduling, and task-switching

(Figure 1). The amount of time loss noted in laboratory research on single interruptions is small and does not allow us to make inferences about the time that is lost when interruptions happen repeatedly in everyday work.

When looking at the issue of time loss from a wider time frame (i.e., a workday, or even an entire workweek), it is important to note that considerable time may be involved in carrying out the interruptive tasks themselves. Such additional tasks are often not a part of the planned schedule of the day (Claessens, Van Eerde, Rutte, & Roe, 2010). As a consequence, a greater amount of work (more tasks) must be done. When more interruptions occur during a workday, time loss attributed both to additional tasks and to the interruption itself will likely increase. The magnitude of time loss will depend on the number of interruptions and their complexity as well as on the degree of nesting. When interruptions are nested, (i.e., an interruptive task interrupted by another task), the time loss will likely increase because of the additional cognitive (scheduling and memory) demands.

We can assume that as interruptions increase, time loss will increase as well, resulting in time pressure. In a simulation study, subjects reported more time pressure when they were interrupted approximately 10 times during mail editing tasks (25 min) than when they were not interrupted (Mark, Gudith, & Klocke, 2008). A diary study of 133 nurses showed that during days with more work interruptions than usual, the perceived time pressure was higher (Baethge & Rigotti, 2013). Time pressure is a state of elevated arousal and activation, associated with the perception that the time available is insufficient to complete one's tasks (cf. Zapf, 1993). It is an important effect of interruptions because continuing time pressure can result in stress and a decline of productivity over the workday or work week (Kühnel, Sonnentag, & Bledow, 2012). Our first proposition reads as follows:

*Proposition 1:* Cumulative interruptions lead to increasing time pressure.

### Energetic costs: Challenge versus hindrance stressor

Previous studies have found that interruptions cause higher workload (Mark et al., 2008; Weigl, Muller, Vincent, Angerer, & Sevdalis, 2012; Zohar, 1999). As explained earlier, we attribute this to task-switching, processing large amounts of information, increasing load on working memory (cf. deep level), or the larger amount of work to be done. Interruptions will generally force the regulation level upward (Hacker & Sachse, 2014) because a person who is interrupted during an automated routine needs to find a suitable point in the action plan at which the action could be resumed, in terms of either a well-known, if-then rule (rule-based) or a renewed plan (knowledge-based). That means that

the interrupted person needs to stop the automated action and either find a proper stopping point (and later a point to resume) or decide whether to delay or ignore the interruption. This implies a rise in cognitive demands. Apart from the situation in which the person was performing a simple and monotonous task, the elevated workload calls for the mobilization of additional (compensatory) effort, which facilitates accomplishing the (primary and interrupted) task in the same or *less* time (Hockey, 1997; Mark et al., 2008; Zijlstra et al., 1999). Interrupted persons may work faster (Mark et al., 2008; Zijlstra et al., 1999), which can make them report more mental workload, time pressure, frustration, and higher stress (Mark et al., 2008; Zohar, 1999). In this sense, interruptions may act as a challenge stressor (i.e., performance increases at the expense of effort and the experience of strain).

Mobilizing additional effort cannot continue indefinitely. According to the compensatory control model, performance can “be protected under stress by the recruitment of further resources, but only at the expense of ... behavioural and physiological costs” (Hockey, 1997, p. 73). Resources will ultimately be depleted, and the person will become exhausted and need recovery to restore his or her resources (Sonnentag & Zijlstra, 2006). If recovery is not possible, prolonged expenditure of effort will ultimately lead to overstrain, which means that the person will no longer be able to cope with the higher workload. This is important in situations in which interruptions keep accumulating—typically, situations characterized by multiple tasks and tight deadlines, which offer little opportunity for recovery.

Recovery naturally occurs in rest breaks when people are temporarily relieved from work demands and have time to replenish their resources (Sonnentag & Zijlstra, 2006). However, situations with cumulative interruptions, accompanied by elevated workload and time pressure, typically offer limited opportunity for such breaks. Because of prolonged demands and limited opportunity for recovery, they harbour the risk of causing chronic fatigue and stress and exacerbating over time. Thus, in contrast to occasional interruptions, cumulative interruptions may result in the depletion of resources and thus the reduced ability to cope with demands, meaning that interruptions become a hindrance stressor rather than a challenge stressor.

*Proposition 2:* Cumulative interruptions lead to (1) increasing workload, (2) a greater expenditure of effort, and (3) a greater need for recovery.

### Errors: Failure

Several observational and laboratory studies have revealed that interruptions are associated with an increased risk of errors in both the interruptive and the

primary tasks (e.g., Bailey & Konstan, 2006; Westbrook, Woods, Rob, Dunsmuir, & Day, 2010). We can explain this finding by the additional cognitive demands of interruptions (cf. Figure 1, deep level).

One would expect that the accumulation of interruptions would lead to greater number of, and more severe, errors because of the greater number of disruptive and distracting events, and to the abovementioned depletion of resources. Moreover, lack of resources and increasing stress produced by ongoing interruptions can lead to the use of risky strategies (Frese & Zapf, 1994), which, in turn, can increase the likelihood of further errors. Once errors occur, they require a response. For instance, particular actions may have to be repeated, or undesirable outcomes may have to be corrected. This not only produces further time loss (Brodbeck, Zapf, Prümper, & Frese, 1993) but can also evoke negative emotions (Rybowiak, Garst, Frese, & Batinic, 1999). Over the course of a day or longer, we assume these effects contribute to the subjective perception of personal failure.

*Proposition 3:* Cumulative interruptions increase the probability of error and subsequent failure.

### Emotional states: Emotional strain

Interruptions typically evoke emotional responses, because of both the semantic content of the interruptive events (e.g., good or bad news, illegitimate additional task) and the frustration caused by disruption of the ongoing action. Research has suggested that negative responses are common, as they relate to performance problems, high work pressure, and hindrances to a smooth workflow. According to (laboratory) studies of isolated interruptions, typical emotional responses include anger, anxiety, and frustration (Bailey & Konstan, 2006; Krediet, 1999; Mark et al., 2008; Zijlstra et al., 1999).

Cumulative interruptions are likely to produce more severe and longer-lasting emotional reactions, which may become detached from the interruptive events; that is, people may not be angry because of one specific interruption, but because they remain emotionally aroused. Repeated interruptions may, in other words, trigger an emotion episode (Frijda, 1993; Weiss & Cropanzano, 1996), which is a state of continuous emotional engagement with a heightened level of arousal and attention. During emotion episodes, even small events “take on increased ... emotional significance” and may make the person overreact (Weiss & Cropanzano, 1996, p. 41). Beyond this, concerns about one’s performance and its effect on others, and about the impact on one’s self-image, may cause additional anxiety. Hence, we propose that cumulative interruptions can bring a person to a state in which every additional stressor (large or small, interruptive or otherwise) is experienced as a

burden and contributes to the emergence of emotional strain.

Klinger (1975) offered another theoretical angle with the *incentive–disengagement cycle*. According to this theory, emotional strain is a state of losing the incentive to achieve a certain goal (Mohr, Müller, Rigotti, Aycan, & Tschan, 2006). People become strained by not being able to achieve anticipated goals. Several sources provide empirical evidence for such effects. Cross-sectional studies have shown a positive relationship between work interruptions and both emotional exhaustion and (emotional) irritation (Grebner et al., 2003; Wülser, 2006). In a within-subject design, Baethge and Rigotti (2013) reported a positive relationship between the amount of interruptions during a morning shift and irritation in the evening in a sample of nurses.

It is not only the accumulation of negative feelings that may lead to emotional strain—and to emotional exhaustion in the long run—but also the higher workload caused by the accumulation of interruptions. Meta-analytic results support a positive relationship between workload and emotional exhaustion (Lee & Ashforth, 1996). Hence, we postulate that the accumulation of interruptions can cause emotional strain via recurrence of negative emotions and increased workload.

*Proposition 4:* Cumulative interruptions lead to emotional strain. This effect is mediated by (1) negative emotional states and (2) increased workload.

### The Zeigarnik effect: Rumination

Zeigarnik (1927) found that people remembered interrupted and unfinished tasks better than they did finished tasks. This also applies to tasks that people have accomplished at a lower level of quality than aimed for. The assumed reason for these effects was that the intention (or need) to finish the task could not be met (Zeigarnik, 1927). The interruption is unwelcome and causes negative emotions and the experience of stress (Bailey & Konstan, 2006; Mark et al., 2008; Zeigarnik, 1927). The closer one gets to the target, the stronger the intent to finish the task (Conlon & Garland, 1993; Lewin, 1935; Zeigarnik, 1927), and the more disturbing an interruption.

Single interruptions, as studied in the laboratory, will probably not cause appreciable negative effects because the accomplishment of the task is delayed only by a few minutes at most. However, real-life interruptions will cause longer delays and have the potential to jeopardize the aimed-for task accomplishment, particularly as they accumulate. A possible consequence is rumination about tasks that one cannot finish. Rumination is “a class of conscious thoughts that revolve around a common instrumental theme and that recur in the absence of



immediate environmental demands requiring the thoughts” (Martin & Tesser, 1996, p. 7). Rumination can amplify negative emotions (Lyubomirsky & Nolen-Hoeksema, 1993) and can lead to cognitive interference (Dobson, 2000). It diverts attention from the actual task and increases the likelihood of distraction (Eysenck & Eysenck, 1985). It also consumes cognitive resources that a person needs to solve tasks, and it reduces performance (Bruch, Kaflowitz, & Kuethe, 1986; Glass et al., 1995), which, in turn, can lead a person to ruminate still further. Thus, we propose that cumulative interruptions not only cause instantaneous memory effects but also can lead to rumination and associated negative (emotional and cognitive) effects.

*Proposition 5:* Cumulative interruptions lead to an increase in rumination.

## JOINT EFFECTS

We have addressed effects known to be associated with isolated interruptions and have discussed how they might develop as interruptions accumulate. In this section, we describe what may happen when these effects interact.

### Risk of a downward spiral: Strain

Although research has examined the effects of interruptions mostly in isolation, we must consider the possibility that they interact and amplify each other. For instance, errors and failures call for corrective action, which poses an additional workload and takes additional time (Brodbeck et al., 1993). Growing workload and increasing time pressure raise the probability of error and failure (Elfering, Semmer, & Grebner, 2006) and can produce negative emotions or emotional exhaustion (Barling & Macintyre, 1993). Such effects can enhance rumination, which distracts attention from the work, and so on. Given such interactions, we do not expect a linear increase in the effects. In the following, we focus on two outcomes of work, (i.e., strain and performance), which seem to be influenced differentially by chains of effects such as those just mentioned.

Previous studies of interruptions suggest that strain and task performance, although related, develop differently over time. Zijlstra et al. (1999), in a study with experienced secretaries working in a simulated office, showed that the time spent on the primary task (and the interruptive task) decreased in the course of three interruptions—with a steeper decrease in the beginning and a weaker decrease in the end. At the same time, subjective effort increased, whereas mood and well-being decreased (Zijlstra et al., 1999). Mark et al. (2008) replicated these findings. These results are in line with the compensatory control model of Hockey (1997), which posits that when confronted with rising

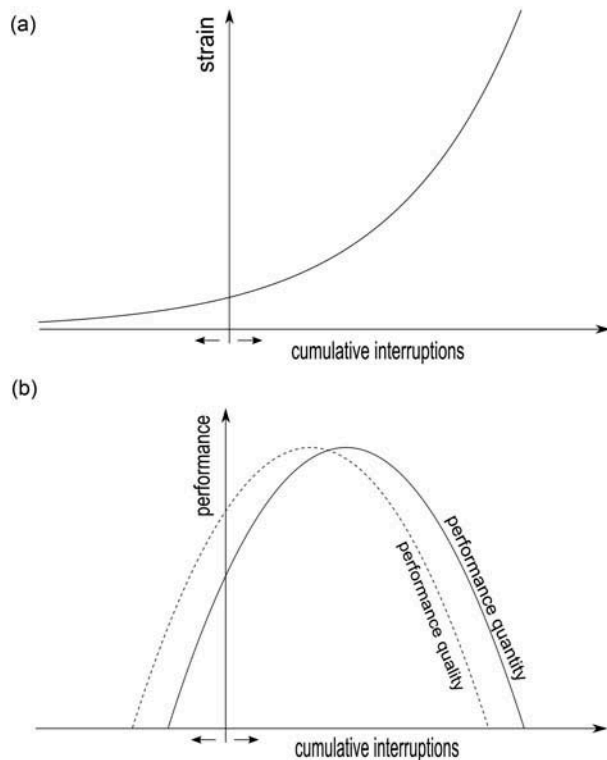
demands, people initially try to maintain their performance by investing more effort. Physiological activation (e.g., sympathetic and neuroendocrine responses) can even lead to short-term overcompensation and performance increase (Zijlstra et al., 1999). However, when confronted with a greater number of interruptions over a longer period (the study by Zijlstra et al., 1999 was limited to a maximum of three interruptions per hour within 2 half workdays over 2 weeks), further performance decline may be expected. This means that effort may continue to increase and resources may become depleted, triggering a need for recovery. Indirect evidence comes from the experiment by Altmann and Trafton (2007), who interrupted subjects up to 12 times in the middle of a complex computer game and observed a depletion effect between three 20-min blocks. In the last two blocks, participants needed more time to recover from interruptions than in the first one. Altogether, we expect that when people have to deal with a higher number of interruptions or prolonged exposure of interruptions, the previously described effects (i.e., time pressure, failure, high workload, need for recovery, emotional strain, rumination) will appear in combination and will likely amplify each other.

In this scenario, one would expect to see an accelerative increase of strain (e.g., following an exponential curve) because the cumulative interruptions will call for additional compensatory responses, resulting in greater resource depletion (Hockey, 1997). As predicted by the conservation of resources theory (Hobfoll, 1989), people may try to cope with these effects, for example, by asking colleagues for help or by using existing time buffers for recovery. However, restoring resources takes time (Sonnentag & Zijlstra, 2006), and if interruptions continue and opportunities for recovery are denied, subsequent demands will cause greater loss of resources (Hobfoll, 1989; Siltaloppi, Kinnunen, & Feldt, 2009). When resources become depleted, re-employing them will create even higher costs (Hobfoll, 1989). In addition, the abovementioned amplification of effects comes into play, and an upward trend of strain may result (see Figure 3(a)). Keeping in mind that the precise form of the development will depend on the interruption profile that is typical for a particular occupation and work setting, we come to the following proposition:

*Proposition 6:* Cumulative interruptions lead to an accelerative increase of strain.

### Performance

For performance, we would expect another trajectory over time. As said before, interruptions may first raise physiological activation, which allows for a faster accomplishment of the primary and the interruptive tasks (Mark et al., 2008; Zijlstra et al., 1999). Speier



**Figure 3.** The curve of (a) strain and (b) performance.

et al. (1999) found an increase of speed and accuracy in laboratory tasks, whereas in the experiment of Zijlstra et al. (1999), subjects carried out both tasks faster. The time they spent on each task even decreased, the more interruptions arose (zero, one, or three interruptions; Zijlstra et al., 1999). Nonetheless, the total time they needed to finish all their work increased.

If exposure to interruptions lasts longer, maintaining a high-level performance may become impossible. The accelerating increase in strain and the underlying loss of resources will likely affect the capacity to perform well. According to the compensatory control model, typical results of the abovementioned spiral are fatigue (subjective and physiological) and fatigue after-effects (Hockey, 1997) in the form of degraded performance (of interruptive and primary tasks) in this exhausted state.

Hockey (1997) and Hacker (2003) suggested that under such conditions, people may change their strategy and try to accomplish tasks with reduced effort, possibly resulting in risky behaviour or neglect of subsidiary actions. This does not need to be a conscious change; attentional narrowing (Hockey, 1997) or reduced memory capacity can cause people to neglect safety standards or skip subsidiary tasks even if they are not aware of it. Thus, they can still try to manage all tasks, but accomplish them at a lower level of accuracy and quality. Kirmeyer (1988), in an observation study of 72 police radio dispatchers, found a significant negative

relationship between performance quality (rated by the employees at the end of the day) and (the observed) workload caused by interruptions. The employees spent less time than usual on handling each request or complaint from the public and provided less individualized attention than usual to police officers who radioed in with requests for information or assistance. Strategies that neglect subsidiary tasks or reduce accuracy of quality raise the risk of errors (Frese & Zapf, 1994). As described earlier, handling of errors will consume further resources, augment the workload, and increase strain (Brodbeck et al., 1993; Hobfoll, 1989). As a result, their performance quantity may decrease, the interrupted employees cannot manage all tasks anymore, and instead of performing tasks faster, workers may become slower because they are exhausted. Adler and Benbunan-Fich (2012) revealed in their laboratory study of multitasking situations that performance quality decreased first, followed by a decline in performance quantity later on.

Thus, the cognitive and emotional overload caused by cumulative interruptions leads to a lower capacity to perform well and to lower quality and (later) quantity of performance. This can have a range of consequences in the long run, such as unmet client expectations (because of delays, inferior quality, errors), financial loss, and, at the personal level, guilt. A reduced sense of self-efficacy and/or a ruined reputation are also possible effects. It is conceivable that the negative effects of interruptions amplify each other, and the performance will degrade at an accelerated rate. Such performance degradation does not necessarily happen at the end of a long period: In a laboratory study, it was observed to occur over the course of about an hour (Altmann & Trafton, 2007).

Putting the foregoing together, we are inclined to expect that performance may develop according to an inverted U trajectory (see Figure 3(b)). The evidence for this pattern comes from the aforementioned studies that showed a relative increase in performance due to greater effort expenditure (Mark et al., 2008; Zijlstra et al., 1999). It is compatible with a study by Adler and Benbunan-Fich (2012) on self-initiated interruptions in a multitasking setting, which showed the lowest performance for those with the highest degree of multitasking, and the highest for those with a moderate degree of multitasking. The interruption–performance curve bears similarity to curves found for stress and performance (Muse, Harris, & Feild, 2003) and for arousal and performance (Yerkes & Dodson, 1908). Of course, the initial increase in performance is only possible if demands have not reached the maximum of people's capacity (Muse et al., 2003). If the work is already very demanding, interruptions might not lead to an initial improvement of the performance (cf., Speier, Vessey, & Valacich, 2003). This relationship is displayed in Figure 3. If the work is already very demanding, the  $y$ -axis shifts to the right so that the maximum of the inverted

U trajectory intersects the  $y$ -axis and only the falling part of the curve will be visible and measurable. Even in less demanding workplaces, one may not find an initial increase in the quality of performance. From the described study by Kirmeyer (1988), as well as further evidence from laboratory studies (e.g., Kapitsa & Blinnikova, 2003; Mark et al., 2008), we can conclude that performance quality likely drops before performance quantity, at least under the condition of complex tasks (see Figure 3(b)). As with strain, the precise curves will depend on the interruption profile and on the particular occupation and work setting.

*Proposition 7:* Cumulative interruptions lead to an inverted U development of performance.

### POSITIVE ASPECTS OF INTERRUPTIONS AND BUFFERING CONDITIONS

We have discussed the detrimental effects of cumulative interruptions on strain and performance. It is important to note that under certain conditions, however, interruptions may also have positive effects. Furthermore, periods without interruptions may buffer the negative effects of cumulative interruptions.

#### Information gain and positive news

Besides the negative effects of interruptions, interruptions may also have positive effects, such as information gain. For example, a colleague can point out a mistake or facilitate work progress by giving useful suggestions. In this case, a person may be able to handle problems more effectively, and therefore performance may increase, even if the interruption has disturbed the workflow. Moreover, the information gain can be so large that it compensates for the negative effect on performance attributed to other interruptions. For example, information gain can lead one to save time, which will reduce time pressure and its associated negative effects on performance. Information gain could also reduce the error rate or increase performance quality. We assume that the occurrence of interruptions that cause an information gain can outweigh the negative effect of interruptions on performance by improving work progress.

In addition, interruptions may be associated with positive emotions, depending on the semantics of the interruptive event. Imagine a researcher interrupted by an email containing the acceptance of a paper in a peer-reviewed journal. Even though these kinds of interruptions arise as single events within the pattern of interruptions during a workday, they might entail the potential to buffer negative effects of cumulative interruptions.

*Proposition 8:* Information gain can reduce the negative effect of cumulative interruptions on performance.

#### Job enrichment

We interpret work interruptions as signs of work enrichment, in certain cases, because they tend to raise task parameters, such as skill variety, task identity, or task significance. For an employee performing monotonous tasks (e.g., in manufacturing), an interruption by a trainee asking for help, or a technical error, might have such effects. Instructing and monitoring the trainee is a more complete and meaningful task that requires additional skills. Something similar could happen if an employee has to diagnose a machine that is not working properly and is in need of repair. Especially in the last example, the employee will also receive very direct feedback about his or her performance. Hackman and Oldham (1976) postulated such task aspects to increase intrinsic motivation and job satisfaction within the Job Characteristics Model. This underlines the importance of the subjective redefinition of the task (Hacker & Sachse, 2014; Hackman, 1970). In agreement with the aforementioned assumptions, several laboratory studies have discovered an improvement in performance when a monotonous primary task is interrupted. Mark et al. (2008), for instance, gave students email editing tasks. The subjects worked faster and wrote shorter emails when interrupted. Speier et al. (1999) found that students completed their decision tasks faster and more accurately in the high-frequency interruption condition compared to the low one. Similarly, Zijlstra et al. (1999) observed that their subjects completed their text-editing tasks faster when interrupted compared to when they were not. Krediet (1999) established that interruptions could be associated with positive emotions due to having more variety at work, feeling useful, or gaining new perspectives on the task.

Under the special condition of monotonous work, interruptions have the potential to bring more variation, raise complexity, and even add to the completeness of the work, which should lead to a number of positive effects, such as increased performance and satisfaction. Correspondingly, Fisher (1998) found that interruptions reduce perceived boredom. Whereas interruptions often imply job enlargement, under certain conditions they can also lead to job enrichment. Besides, the work people do is not always of the same intensity, and interruptions can be welcomed in quiet episodes within an otherwise demanding job, as well.

*Proposition 9:* Performance decline due to interruptions is less when interruptions are perceived as job enrichment.

## Periods without interruptions

Periods without interruptions may prevent, stop, or at least buffer a downward spiral. As recovery occurs when stressors are absent (Demerouti, Bakker, Geurts, & Taris, 2009; Rook & Zijlstra, 2006), periods without interruptions may be used to recover from the typical demands caused by interruptions. During such intervals, the person can focus on one task, resulting in less information load and—if there are no other stressors—reduced concentration demands. With less effort to invest, the person can calm down and restore cognitive resources called upon earlier (e.g., time, vigour, ability to concentrate, positive mood; Hobfoll, 1989). In addition, a person can use the time to finish the current task without the disruptive effect of other tasks (and possibly less rumination about unfinished tasks). It may also be possible to regain some previously lost time and reduce time pressure. Finally, anger and frustration about previous interruptions may vanish and allow the person to concentrate fully on the next tasks.

In the case of highly interdependent tasks, within a team, Käser, Fischbacher, and König (2013) showed that quiet hours (i.e., periods without interruptions) were not related to performance gains. Hence, while effects on performance may be contingent upon the characteristics of tasks, we generally would assume a positive effect of interruption-free periods on the individual strain level.

*Proposition 10:* Periods without interruptions (duration and length) reduce the effects of cumulative interruptions on experienced time pressure, workload, failures, emotional strain, and rumination.

## Agency

We have described how interruptions and their effects can accumulate, and how a loss spiral could develop as well as be prevented. All the previous arguments describe how situational parameters affect the experience and behaviour of interrupted persons. As individuals are active agents who can shape their own situations, they may be able to influence the development of effects and stop a possible downward spiral themselves.

Laboratory researchers have described strategies to respond to single interruptions. They name delaying and ignoring interruptions, and delegation and making notes, to reduce the resumption lag (cf. Brixey et al., 2007). However, the time loss of a long resumption lag (as it may occur during a workday) may be negligible when compared to the time loss by the interruptive task. Accordingly, delaying the interruption to take notes will not cause an appreciable time gain. Moreover, ignoring an interruption is often not possible in real-work situations and may just increase the amount of interruptions because the ignored persons will likely call again until they are acknowledged. We can conclude that strategies

that are helpful in the case of single interruptions may not be sufficient in the case of cumulative interruptions. More research is needed in this matter.

When considering cumulative interruptions, other possible strategies may be considered. According to the compensatory control model, people first choose to expend more effort to manage all interruptions and primary tasks (Hockey, 1997). When this strategy fails, a reasonable strategy change would be to stop trying to complete all tasks and instead give priority to the main tasks (Hockey, 1997). They could actively redefine their work, including reorganizing their work schedules and skipping irrelevant or less relevant tasks. Another possibility is to ask colleagues for help or to delegate tasks to others. All these strategies still serve as responses to the situation. Another possibility would be to prevent, or at least schedule, incoming interruptions by actively generating interruption-free periods (e.g., closing and opening the door/mail program, switching the mobile phone off or on).

All these strategy examples are possibilities of how a person can influence the cumulative effects when a series of interruptions occurs. Thus, when examining effects of interruptions, it will be important to consider the strategies people use.

## INVESTIGATING THE PROPOSITIONS

In developing our integrative framework, we have focused on a prototypical description of cumulative interruptions in the workplace and pondered the likely interaction between their effects. However, we have acknowledged that the number, duration, and complexity of interruptions and the way in which they intermingle with primary tasks vary across jobs and organizational settings. Gaining a better understanding of how interruptions affect workflow and experience, how people manage interruptions, and how their performance and well-being are ultimately affected will therefore profit from studies that distinguish between interruption profiles in different occupational groups and organizational settings. We would expect that nurses, pilots, dispatchers, and managers have different interruption profiles in terms of frequency, variability, duration, and complexity of interruptions. For instance, we may find that secretaries are exposed to more, and more varied, interruptions of comparable duration and complexity, whereas engineers experience more variance in complexity and duration, but have fewer and less varied (number of) interruptions. The outcomes of interruptions might reflect such differences. For example, in some occupations, errors might be more prevalent, but related to less severe consequences.

Our suggestion is that, to examine the propositions about the effects of cumulative interruptions, researchers should develop study designs that allow for investigating a few variables at the time. Following the distinction

between occupational groups, researchers could choose the variables under examination in a particular study according to the form of the interruption profile. As an example, it would be reasonable to examine the main effect on performance and strain of the number of interruptions in the case of secretaries, and the interaction effect of complexity and duration in the case of engineers.

In designing such research models, it would be helpful to distinguish between factors and processes that need to be studied temporally (within subjects) and differentially (between subjects). Considering the process character of our overall model, the ideal design for studying cumulative interruptions would be temporal; that is, processes should be identified and time series data collected to assess dynamic trajectories of surface- and deep-level indicators. Diary studies over several workdays offer a possibility to examine cumulative interruptions as they appear in the workplace (Baethge & Rigotti, 2013). Focusing on the occupation-specific characteristics of interruptions, researchers could count and specify the interruptions as they occur, which can then be related to performance and strain during the day. A long-term (as opposed to more differential) approach would be to relate different interruption profiles (over different occupations) to the long-term effects of performance and strain. Further differential analysis would be appropriate to study the moderating effects of workplace, task, and personal factors. In our opinion, these combinations of temporal and differential research (Roe, 2014) will be a recommendable way to examine the proposed effects.

As for the methods, it will be necessary for interruption studies to collect information at the surface and the deep levels simultaneously. This would be an argument in favour of work in simulated environments, as conducted by Zijlstra et al. (1999), because it allows for detailed measurements of cognitive and physiological processes and states. The availability of devices for real-time recording of work activity by video, sound, spatial movements, and computer interaction and of portable techniques for recording behaviour and underlying mental and bodily activity, will also allow field studies in certain real-life work settings (e.g., in hospitals, offices, control rooms). To cover the cumulative effects described in this article, one should adopt different lengths of time (Zaheer, Albert, & Zaheer, 1999), ranging from parts of a single workday to successive days or periods of half a year or longer.

We should emphasize that our model and the propositions are not exhaustive because there are various issues that would also deserve investigation in future research. One could argue that in today's work ecology, which requires many people to perform multiple tasks, it becomes less clear what the primary and secondary tasks are and "what interrupts what"—it may vary with the moment. In a multiple task perspective, where all

tasks are of equal importance, questions arise regarding the task characteristics (such as transparency, difficulty, predictability) and their compatibility in terms of required resources. A multitasking perspective also draws attention to the impact of the moment of switching between tasks, given the phases of action regulation for each task. One might theorize, for instance, that interruptions during the phase of developing an action plan will have greater impact than during the implementation of an action plan that has been firmly established. These and other issues have been addressed in recent research by Kirchberg (2014) and Kirchberg, Roe, and Van Eerde (2009).

## CONCLUSION

Previous research has mainly shown the effects of *isolated interruptions* in laboratory studies and the effect of a general work characteristic of *exposure to many interruptions*. Both research traditions seem to have existed independently of each other. This article discusses and integrates both research traditions.

We developed a theoretical framework that allows for the integration of extant knowledge on interruptions, the exploration of the implications of well-established theories, and the guidance of future research on interruptions in real-work settings, with a focus on the accumulation of interruptions over time. This framework is the basis for an integrative model and propositions about cumulative interruptions. This integrative model enables us to make predictions about the effect of cumulative interruptions, how people will respond to and handle interruptions in real-work settings and changes over time, and enables us to reveal implications for task performance, well-being, and agency. The theoretical framework and proposed model are complex, but we provide suggestions concerning how to set up studies to test the propositions.

Overall, 10 propositions have been formulated dealing with the underlying mechanisms of cumulative interruptions by mapping deep-level regulation onto the observable sequence of actions. Furthermore, we discussed mediating and moderating factors in the process of accumulating interruptions. In doing so, we disclosed the relationships between the effects of single interruptions found in laboratory studies and the health and performance outcomes reported in applied research. We explained how the accumulation of interruptions likely leads to a new quality of effects. Time loss becomes time pressure, errors become failures, emotional states may—along with a higher workload—culminate in emotional strain and raised effort, and a short-term increase of performance leads to overstrain and reduced performance quality (and ability) in the long run.

If all these effects act together in a downward spiral, and there is not enough opportunity for recovery, the mechanisms proposed may serve as an explanation for

the relationships between interruptions and health impairments reported in applied research (e.g., psychosomatic complaints, Grebner et al., 2003; emotional exhaustion, Wülser, 2006; depression, Rout et al., 1996). A major limitation of all these studies is their cross-sectional designs. There is clearly a need for longitudinal studies to shed light on causal effects of cumulative interruptions. Furthermore, the examination of interruptions in the state in which they appear at work (i.e., in accumulation) leads to newly proposed relationships. To achieve that aim, cumulative interruptions need to be quantified. Following the evidence and theoretical reasoning brought together in this article, we claim that it is not enough simply to count the number of interruptions. According to the proposed model, future research also will need to consider time and cognitive demand. So far, these aspects have been widely neglected in applied research.

Furthermore, in our propositions, we also addressed buffering mechanisms on the largely negative effects of cumulative interruptions. The most important factors are interruption-free periods (longer, more frequent) and strategy adjustment within a stressful day. These strategies differ from those laboratory researchers have suggested because the accumulation of interruptions during a workday (or longer period) leads to new qualities of effects. Restructuring of work sequences will likely reduce the incidence of evitable interruptions and help to cope with unpreventable interruptions. Contextual factors, such as participative decision-making, leadership styles, and provisions of job autonomy, might be interesting boundary conditions to consider in future research.

Because interruptions at work usually rank either second or first among the most important stressors at work (BAuA, 2013), we call for a more differentiated investigation of their antecedents, processes, and consequences in real-work settings. This will help to gain ecologically valid insights and to provide evidence-based guidelines for job design and training.

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Original manuscript received June 2013

Revised manuscript received February 2014

Revised manuscript accepted February 2014

First published online March 2014