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Interruptions to workflow: Their relationship with irritation and satisfaction with performance, and the mediating roles of time pressure and mental demands

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Understanding the mechanisms of workflow interruptions is crucial for reducing employee strain and maintaining performance. This study investigates how interruptions affect perceptions of performance and irritation by employing a within-person approach. Such interruptions refer to intruding secondary tasks, such as requests for assistance, which occur within the primary task. Based on empirical evidence and action theory, it is proposed that the occurrence of interruptions is negatively related to satisfaction with one's own performance and positively related to forgetting of intentions and the experience of irritation. Mental demands and time pressure are proposed as mediators. Data were gathered from 133 nurses in German hospitals by means of a five-day diary study (four measurements taken daily; three during a morning work shift and one after work, in the evening). Multilevel analyses showed that workflow interruptions had detrimental effects on satisfaction with one's own performance, the forgetting of intentions, and irritation. The mediation effects of mental demands and time pressure were supported for irritation and (partially) supported for satisfaction with performance. They were not supported for the forgetting of intentions. These findings demonstrate the importance of reducing the time and mental demands associated with interruptions.

Keywords: workflow interruptions; diary study; time pressure; mental demands; performance; irritation; work stress; nurses

Introduction

Workflow interruptions are part of the everyday experience in many occupations. The third European Survey on Living and Working Conditions, conducted across 15 European countries, showed that almost one third (28%) of employees indicated that they are interrupted several times a day "in order to take on an unforeseen task" (Boisard, Cartron, Gollac, Valeyre, & Besançon, 2003, p. 3). Workflow interruptions can be defined as temporary suspensions of goal-directed action (Brixey et al., 2007, p. E30). We focus on interruptions that are externally initiated and caused by intrusions of secondary, unplanned tasks within the accomplishment of another

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(a primary) task. For example, a nurse who is washing a patient (primary task) is interrupted by a student nurse (externally initiated interruption) asking for help because an elderly patient has slipped. The nurse will stop her/his action to join the student nurse in helping up the patient (accomplishment of the second task). Such interruptions break the continuity of task performance (Brixey et al., 2007, E32). A plethora of experimental, as well as cross-sectional field studies, has shown that interruptions can be classified as severe stressors. Interruptions at work have been shown to be negatively related to job satisfaction (Kirkcaldy & Martin, 2000) and positively related to irritation and psychosomatic complaints (Grebner et al., 2003), as well as depressive moods (Rout, Cooper, & Rout, 1996). Furthermore, there is evidence that workflow interruptions not only decrease performance (Bailey & Konstan, 2006) but also increase the risk of medication errors in hospitals (Balas, Scott, & Rogers, 2004; Carlton & Blegen, 2006).

Despite this research, to date, the underlying mechanisms linking interruptions with negative outcomes in real work settings are underexplored. In this study two potential mediators of the relationship between workflow interruptions and strain and performance are proposed and empirically tested, namely mental demands and time pressure. So far, in field studies, interruptions have only been examined in cross-sectional or purely descriptive observation studies. This study, to the best of our knowledge, is the first to apply a daily diary method, collecting data over five consecutive working days both during a work shift and before going to bed. Since interruptions are highly prevalent in the health care sector (Boisard et al., 2003), we chose to carry out this research among nurses. As the prevalence of workflow interruptions is likely to vary from day to day, the diary method provides a methodologically sound opportunity to test for within-person effects, instead of between-person effects. Furthermore, the (partial) separation of measures of the independent (workflow interruptions during the work shift), mediator (mental demands and time pressure during the work shift and in the evening) and dependent (performance and irritation in the evening) variables reduces the bias of common-method variance. We first review theoretical and empirical evidence of the relationship between interruptions and performance and irritation before presenting arguments for proposing mental demands and time pressure as mediators.

Workflow interruptions: Relationships with performance and irritation

According to action regulation theory (Hacker, 1973, 2005), work (flow) interruptions are classified as stressors – so-called regulation obstacles. Regulation obstacles thwart the achievement of action goals, with the result that additional effort or risky behaviour is needed to achieve these goals (Hacker, 1973, 2005; see also Frese & Zapf, 1994). Work (flow) interruptions can cause decreased performance (Bailey & Konstan, 2006). The accomplishment of the interruption task, the demands of task switching and the resumption of the actual task all cost additional effort and time (Brixey et al., 2007). This additional effort is likely to be the cause of the decreased performance. The results of laboratory studies have shown that interruptions prolong the processing time of both the interrupted and the interrupting task and lead to more errors in both tasks (Bailey & Konstan, 2006; Eyrolle & Cellier, 2000; Trafton, Altmann, Brock, & Mintz, 2003). In observation studies, workflow interruptions were found to be a risk factor for medication errors and for errors in air traffic

control (e.g. Balas et al., 2004; Carlton & Blegen, 2006; Ho, Nikolic, Walters, & Sarter, 2004). The interruption, and consequential delay to the actual task, forces a person to defer their intended actions, which requires the use of prospective memory (McDaniel & Einstein, 2000). The person must "remember to self-initiate performance of the uncompleted intention[s]" (Einstein, McDaniel, Williford, Pagan, & Dismukes, 2003, p. 148), which requires a high level of activation of the intentions in the working memory. If this activation level cannot be maintained because of a complex interruption task, *forgetting of intentions* is the consequence (Einstein et al., 2003; cf. goal-activation theory: Altmann & Trafton, 2002). The interrupted person forgets the task which she/he was originally engaged in and/or any tasks she/he wanted to do afterwards (which were already in the prospective memory). In three laboratory experiments, under several conditions, Einstein et al. (2003) showed that interruptions cause forgetting of intentions.

Research has also found positive effects of interruptions; interruptions of monotonous tasks may lead to a faster accomplishment of the interrupted tasks (Mark, Gudith, & Klocke, 2008; Speier, Valacich, & Vessey, 1999; Zijlstra, Roe, Leonora, & Krediet, 1999) because interruptions increase complexity and full attention is therefore paid to task fulfilment. However, these conditions do not apply to the work of nurses. Hence, we do not expect positive consequences of workflow interruptions on the performance of nurses in this study.

Not only do interruptions mean that workflow is disturbed (and the task is delayed), but they can also lead to additional tasks having to be accomplished, i.e. the number of tasks which have to be accomplished during the working day increases. One possible consequence is that the person does not manage to complete all tasks (both the actual and the interruption tasks) and must leave some unfinished. This equals a reduction in the quantity of tasks accomplished. However, in many occupations there are tasks which cannot be left unfinished. Nurses, for example, must give every patient their medication, wash them all and serve each of them their meals every day. Regardless of compensation effects related to greater efforts, workflow interruptions are likely to decrease performance quality (Hockey, 1997) and in turn, the satisfaction of an individual with their own performance.

In an interview study, 16 nurses reported that stressful working days with a lot of workflow interruptions caused them to spend less time on activities such as talking and listening to patients. On such hectic days, they were dissatisfied with the quality of the work accomplished (Baethge & Rigotti, 2010a). Similarly, Kirmeyer (1988) observed 72 police radio dispatchers and found that interruptions decreased the quality of their performance. They "spent less time than usual handling each request or complaint from the public" or "provided [. . .] less individualized attention than usual to police officers who radioed in with requests for information" (Kirmeyer, 1988, p. 623). This leads to the following hypotheses:

> *Hypothesis 1*: a) A high frequency of workflow interruptions is positively related to forgetting of intentions, b) a high frequency of workflow interruptions is negatively related to the satisfaction of an employee with his/her performance.

Interruptions are demanding; additional effort is needed to cope with the situation created by interruptions (Hacker, 1973, 2005), task switching requires cognitive resources and the number of tasks increase. Frequent interruptions utilize a lot of

mental resources and can be overtaxing. In addition, the greater workload caused by the higher number of tasks reduces opportunities to recover (Baethge & Rigotti, 2010b), which likely leads to higher strain. Cross-sectional studies have found relationships between interruptions at work and health-related factors like depression (Rout et al., 1996), psychosomatic complaints (Grebner et al., 2003) and emotional exhaustion (Wülser, 2006). Action regulation theorists and researchers in cognitive sciences consider the deferral of goals to be a problem and stress factor caused by interruptions (Altmann & Trafton, 2002; Frese & Zapf, 1994). "Stress has to do with the thwarting of goals" (Semmer, 1996, p. 85). What does this mean though? Not only can workflow interruptions delay the achievement of single goals by the intrusion of a new task, but the accumulation of workflow interruptions may even jeopardize the achievement of the targets of the day. This happens because of the increasing number of tasks created as a result of interruptions. Consequently, the work sequence may need to be reorganized and some tasks may need to be skipped. This is likely to cause strain. Possible consequences include rumination by interrupted individuals on their unfinished tasks or the low quality of their performance (Zeigarnik, 1927). Furthermore, feelings of frustration and a loss of control can result (Mark et al., 2008).

Irritation is a concept that involves both emotional and cognitive strain. Irritation describes a state of mental impairment caused by goal discrepancies and includes both cognitive (rumination) and emotional dimensions (e.g. reacting grumpily; Mohr, Müller, Rigotti, Aycan, & Tschan, 2006). Cross-sectional studies provide preliminary indications that interruptions are associated with a higher level of irritation. In a sample of 339 call centre employees (Grebner et al., 2003), interruptions were significantly and positively correlated with irritation. Likewise, Konradt, Hertel, and Schmook (2003) reported a positive relationship between work (flow) interruptions and irritation in a sample of 72 employees (data processing, telecommunication, financial services). Furthermore, irritation has been shown to be a mediator of the relationship between stressors at work and the deterioration of well-being, including depression and psychosomatic complaints, in both cross-sectional (Höge, 2009; Jacobshagen, Rigotti, Semmer, & Mohr, 2009) and longitudinal studies (Dormann & Zapf, 2002). This leads to the following hypothesis:

> *Hypothesis 2:* A high frequency of workflow interruptions during the working day is positively related to irritation in the evening.

Potential mediators

As outlined above, workflow interruptions are assumed to relate to lowered performance and the experience of greater strain. We have considered several approaches in trying to explain these relationships, which can be clustered into two main types that seem to mediate the relationship between workflow interruptions and its outcomes: these types are mental demands and time pressure.

Mental demands. Workflow interruptions cause high mental effort. We have already mentioned the additional effort that interruptions entail. Interruptions disturb the intended sequential process of action (Hacker, 1973, 2005). The interrupted person

must become involved in a new task and then resume the former task later (Brixey et al., 2007), i.e. task switching is needed. This "mental 'gear changing'" (Monsell, 2003, p.135) requires considerable mental regulation. Attention must be shifted, goal states and action rules must be retrieved (Monsell, 2003) and when the primary (interrupted) task is resumed (Trafton et al., 2003), all these steps must be repeated. The delay of the actual task obliges the person to defer intended action. This deferral of the action goal involves the danger of forgetting intentions. To avoid forgetting (of the primary task), sometimes rehearsal is carried out during the accomplishment of the interruption (Einstein et al., 2003; Monk, Boehm-Davis, & Trafton, 2004). All this puts demands on attentional processes and working memory (prospective memory, McDaniel & Einstein, 2000; Monsell, 2003). The interrupted person needs to be highly focused. Cross-sectional studies provide support for this. In a sample of 232 office workers (Zapf, 1993) and 339 call centre employees (Grebner et al., 2003), work interruptions correlated significantly with concentration demands and in an observational study of 34 eligible doctors, workflow interruptions were significantly related to subjective workload (Weigl, Müller, Vincent, Angerer, & Sevdalis, 2012). This leads to our first set of mediation hypotheses:

> *Hypothesis 3*: Mental demands mediate the relationship between workflow interruptions and a) forgetting of intentions, b) satisfaction of the employee with his/her performance, and c) irritation.

Time pressure. Another factor which may mediate the effect of workflow interruptions on performance and strain is time pressure. Interruptions are not only disturbing because of the mental regulations they require, but also because of the time they take (Eyrolle & Cellier, 2000). On the one hand, time is lost by additional regulations that are caused by interruptions (e.g. resuming the primary task). Laboratory studies have shown that interruptions lead to an increased amount of time taken in the accomplishment of the interrupting and the interrupted tasks (Bailey & Konstan, 2006; Eyrolle & Cellier, 2000). On the other hand, the "interruption task" itself needs time to be accomplished. Workflow interruptions usually involve additional tasks that were not part of the planned schedule of the day. The consequence is that more tasks have to be done in the same amount of time. The more workflow interruptions that occur, the more time that is lost (by the accomplishment of these additional tasks) and the *accumulating* time loss likely leads to time pressure. Mark et al. (2008) found a significant positive relationship between interruptions and perceived time pressure in a simulation study in which 48 study participants had to solve mail editing tasks. If time pressure goes beyond a certain level, it has negative effects on performance and increases irritation (Durham, Locke, Poon, & McLeod, 2000; Höge, 2009). In laboratory studies it was found that severe time pressure leads to worse performance in complex decision-making tasks (Durham et al., 2000) and to increased relapse errors (Betsch, Haberstroh, Molter, & Glöckner, 2004). A significant relationship between time pressure and irritation was found in a cross-sectional study of 576 nurses (Höge, 2009) – an occupation with a high occurrence of interruptions (Baethge & Rigotti, 2010a). Grebner et al. (2003) found significant correlations in a cross-sectional study of 339 call centre employees between both interruptions and time pressure and between time pressure and

irritation. Based on the above theoretical analysis and empirical evidence, we formulated the following hypotheses:

> *Hypothesis 4*: Time pressure mediates the relationship between workflow interruptions and a) forgetting of intentions, b) satisfaction of an employee with his/her performance, and c) irritation.

Figure 1 graphically presents the research design and all hypotheses of this study.

Method

Procedure and sample

The nursing directors of 56 hospitals were contacted, 10 of whom agreed to take part in the study. Once the timescale for fieldwork was agreed the respective nursing directors sought volunteers who had (or could arrange to have) five consecutive morning shifts during that period of time. Before the diary study started, the participants completed a paper-and-pencil questionnaire that collected demographic data, and they were introduced to using the handheld computers for the study (E-TEN glofiish X610/50; software: IzyBuilder Research). During the five days of the diary study all participants were working morning shifts. Each day they were expected to report any stressors and demands at three points during their work shift. A signal, at pseudo-randomized intervals (randomized within three different intervals – at the start, middle and end of the work shift, with the constraint that there had to be an hour between two signals), prompted them to fill in the work shift questionnaires. In addition, they were required to complete an evening questionnaire before they went to bed regarding their well-being and performance. The data collection for all participants took place between June and December 2010.

The sample consisted of 133 nurses (8.3% males) from 10 German hospitals. We chose this occupation to test our hypotheses because of the frequency of workflow interruptions in this setting (on average 62 times during the morning shift, Baethge & Rigotti, 2010a; see also Gadbois, Bourgeois, Goeh-Akue-Gad, Guillaume, & Urbain, 1992). The age of participants ranged from 21 to 61 years with an average age of 41 years ($SD = 11.5$). Participants worked in wards for internal medicine (24.8%), surgery (17.3%), neurology (14.3%), paediatrics (7.5%), intensive care (6.0%), gynaecology (5.3%), ENT (4.5%), geropsychiatry (3.0%), dermatology

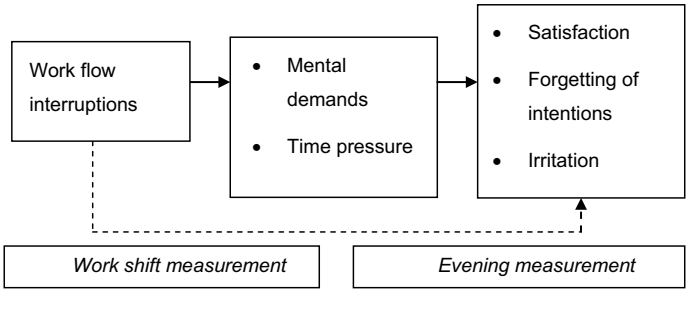

Figure 1. Model of the relationships investigated in the study.

(1.5%), urology (0.8%), emergency ward (0.8%) and others (8.3%). Organizational tenure ranged from 0 to 43 years; average tenure was 18.3 years ($SD = 12.4$). Most of the participants (80.5%) were employed full-time and on a permanent contract (82.0%).

Measures

It is recommended that daily measurements are kept as short as possible in order to avoid decreasing participation and to minimize intrusive effects (Reis & Gable, 2000). To this end, we used short scales for both the work shift questionnaire and the evening questionnaire.

Work shift measures

Workflow interruptions. The participants were required to estimate the number of interruptions occurring from six different sources (doctors, nurses, patients, assistants, technical problems, telephone) during the previous half hour at three times during the work shift. The sum of each of the six sources was calculated. An example item is: "How often have you been interrupted by a nurse during the last half hour?"

Mental demands. For the work shift assessment we used an item from the Task Load Index (TLX, Hart & Staveland, 1988): "How high were the mental demands during the last half hour?" Answers were given on a 20-point scale ranging from 1 (*very low*) to 20 (*very high*) using a scroll bar.

Time pressure. We used one item from the TLX scale (Hart & Staveland, 1988): "How fast was the pace at which you had to accomplish your tasks during the last half hour?" Answers were given on a 20-point scroll bar ranging from 1 (*very low*) to 20 (*very high*).

Evening measures

Mental demands. We used an adapted version of the ISTA Scale "concentration demands", which examines mental demands like attention and memory demands (Semmer, Zapf, & Dunckel, 1999). The scale consists of three items. An example item is: "There were situations at work which demanded the highest level of concentration for short intervals". Answers were given on a five-point Likert scale ranging from 1 *strongly disagree* to 5 *strongly agree.* The α reliability ranged from .78 to .85 during the five days.

Time pressure. We used an adapted version (cf., Binnewies, Sonnentag, & Mojza, 2009) of the ISTA Scale "time pressure" (Semmer et al., 1999). It consists of three items. An example item is: "Today, I was pressed for time." Answers were given on a five-point Likert scale ranging from 1 *strongly disagree* to 5 *strongly agree.* The α reliability ranged from .91 to .94 during the five days.

We conducted confirmatory factor analyses to test whether the two mediators, time pressure and mental demands (evening measures), represent distinct constructs.

Analyses revealed a significantly better fit for the two-factor model ($\chi^2 = 117.40$, $df = 8$, $p < .001$, RMSEA = .086, CFI = .984, NFI = .983), with all items loading on their corresponding factors, than for a one-factor model ($\Delta\chi^2 = 641.658$, $\Delta df = 1$, $p < .001$).

Forgetting of intentions. We measured the forgetting of intentions during the evening assessment with one item: "Today, did you forget to complete a task you had started or planned to do?" Answers were 0 *no* and 1 *yes.*

Satisfaction of the employee with his/her performance. Satisfaction was assessed using one item (on the basis of Abramis, 1994): "Today, I satisfied the personal expectations I have of my work." Respondents had to indicate the extent to which they agreed with the statement using a five-point Likert scale ranging from 1 *strongly disagree* to 5 *strongly agree.*

Irritation. Irritation is defined as a state of psychological impairment caused by perceived goal discrepancy, and includes rumination on problems at work (cognitive irritation) and irritability (emotional irritation; see Mohr et al., 2006; Mohr, Müller, & Rigotti, 2005). We used an adapted version of the scale which measured irritation in the evening but referred to the extent of irritation felt during the day. Example items are: "If other people talked to me, I reacted grumpily" for emotional irritation; and "Even at home I thought of my problems at work" for cognitive irritation. Answers were given on a seven-point Likert scale ranging from 1 *strongly disagree* to 7 *strongly agree.* The α reliability ranged from .84 to .88 during the five days.

Analyses

We conducted multilevel analyses because the daily assessments are not independent of each other (using hierarchical linear modelling [HLM] software; Raudenbush, Bryk, & Congdon, 2009). They are nested within persons (Ohly, Sonnentag, Niessen, & Zapf, 2010). Multilevel analysis accounts for dependencies among the levels of analysis due to repeated measures and therefore is more appropriate than other techniques that assume independent observations (Ohly et al., 2010). In the present study, predictor, mediator and outcome variables were at the day level and predictor and mediator variables were centred to the respective person mean to strictly reflect intra-individual processes. Centring day-level variables at the person mean allows the removal of between-person variance from these variables. This eliminates the role of stable differences in explaining participant's day levels of perceived stressors, performance and strain (see also Ohly et al., 2010). In accordance with Zhang, Zyphur and Preacher (2009), we used fixed effects to avoid increased rates of non-convergence.

To test whether our data needed the use of multilevel modelling, we calculated the intra-class correlations (ICC) on the basis of the intercept-only models. The ICC explains how much of the variance can be attributed to the different levels of analysis. The between-person variance was 24.1% for forgetting of intentions, 38.5% for satisfaction with one's own performance and 55.3% for irritation. The within person variance (variance from one day to another) was 75.9% for forgetting of intentions, 61.5% for satisfaction with one's own performance and 44.7% for irritation. These figures imply that there was enough variance attributable to both

between- and within-persons in day-level irritation and performance to support the use of multilevel modelling in our study.

To test for mediation effects we first examined the required conditions for mediation following Baron and Kenny (1986; cf. Zhang et al., 2009): (1) the predictor must be related to the dependent variable, (2) the predictor must be related to the mediator, and (3) the mediator must be related to the dependent variable. If these conditions are all in the predicted direction, the predictor–outcome relationship will become non-significant (full mediation), or significantly weaker (partial mediation) after the inclusion of the mediator. To examine the significance of the mediating effects we applied the Sobel *z*-test. If the outcome variable was dichotomous, we used logarithmic regression.

According to Baron and Kenny (1986) there are two sources of bias in the mediational chain: an overestimation of the effect of the independent variable on the dependent variable and the problem of feedback (that the mediator and dependent variables are interchangeable). We counteract the feedback problem by measuring the mediators during the work shift i.e. before the dependent variable. As a result, it can be assumed that the mediator measured during the work shift is not caused by the outcome variable measured in the evening. The overestimation problem occurs when the relationship between independent variable and dependent variable is overestimated and there is a danger of overlooking a potential mediator. It can be minimized by a reliable mediator. During the work shift, we were only able to use a one-item measure for the mediator variables in order not to prolong the interruption caused by our measurement. To address this weakness we also measured the mediator variables in the evening with longer scales which had good reliability. Consequently, we test the mediation effect *twice*: once with a more reliable mediator (measured at the same time point as the outcomes: in the evening) and once with a temporally spaced mediator (measured during the work shift, thus at a different time point from the outcomes).

Results

Table 1 presents the means, standard deviations and intercorrelations for all the variables included in the study.

Hypothesis 1 proposed a) a positive relationship between workflow interruptions and forgetting of intentions and b) a negative relationship between workflow interruptions and individuals' satisfaction with their performance. Hypothesis 2 proposed a positive relationship between workflow interruptions and irritation. Both hypotheses are the first prerequisite condition for Hypotheses 3 and 4 (Baron & Kenny, 1986). As shown in Table 2, results support interruptions having a significant positive relationship with forgetting of intentions (*odds-ratio* $=1.08$, $p<.01$), a negative relationship with satisfaction with one's own performance ($\beta=-.13$, $p<.05$) and a significant positive relationship with irritation ($\beta=.16$, $p<.01$). Thus, Hypotheses 1 and 2 were supported.

The results of the analyses to test for the second and third prerequisite conditions (Baron & Kenny, 1986) are presented in Tables 3 and 4. Hypothesis 3 proposed that the predicted direct relationships (Hypotheses 1 & 2) between workflow interruptions and performance (a, b) and irritation (c) were mediated by mental demands.

Table 1. Means, standard deviations and correlations among study variables ($N = 133$ employees, $n = 582–619$ occasions).

		M	*SD*	1	2	3	4	5	6	7	8
1	Workflow interruptions	3.92	6.73	-	.29**	.24**	.28**	.44***	.30***	−.19*	.12
2	Time pressure (work shift)	11.20	3.73	.33***	-	.83***	.57***	.56***	.27**	−.21*	.22*
3	Mental demands (work shift)	10.96	3.80	.27***	.75***	-	.43***	.53***	.22*	−.17*	.14
4	Time pressure (evening)	3.15	1.11	.30***	.51***	.38***	-	.67***	.37***	−.30**	.19*
5	Mental demands (evening)	3.60	.92	.40***	.49***	.46***	.66***	-	.30***	−.26**	.20*
6	Irritation	2.39	1.08	.23***	.26***	.24***	.38***	.28***	-	−.59***	.26**
7	Satisfaction with one's own performance	3.91	.88	−.17***	−.19***	−.16***	−.27***	−.22***	−.50***	-	−.37***
8	Forgetting of intentions	.13	.33	.14**	.18**	.13**	.11**	.12**	.20***	−.24***	-

Note: Correlations below the diagonal are day-level correlations, for which variables 1, 2 and 3 were averaged across the three work shifts. Correlations above the diagonal are person-level correlations.
* $p < .05$, ** $p < .01$, *** $p < .001$.

Hypothesis 4 proposed that the predicted direct relationships (Hypotheses 1 & 2) between workflow interruptions and performance (a, b) and irritation (c) are mediated by time pressure.

The results show that the second precondition of mediation was supported in all hypotheses. Work interruption had a significant effect on the mediators time pressure (both evening and work shift measurement) and mental demands (evening and work shift measurement). The third precondition was fully supported for Hypotheses 3b, 3c, 4b and 4c. The mediators time pressure (evening and work shift measurement) and mental demands (evening and work shift measurement) had a significant negative effect on satisfaction with one's own performance and a significant positive effect on irritation. The precondition for Hypotheses 3a and (partly) 4a is not supported. Time pressure evening (*odds ratio* = .13, $p = .444$) and mental demands (evening: *odds ratio* = 1.36, $p = .153$; work shift: *odds ratio* = 1.12, $p = .077$) did not have a significant effect on forgetting of intentions. The exception was time pressure work shift (*odds ratio* = .12, $p < .05$). Thus, Hypothesis 3a is rejected. The final mediation test of Hypotheses 3b, 3c, 4b and 4c is presented in Table 5.

Hypotheses 3c and 4c were supported by the results since the significant effect of work interruptions on irritation became non-significant after including the mediators time pressure (evening: $\beta = .02$, $p = .710$; work shift: $\beta = .06$, $p = .288$) and mental demands (evening: $\beta = .06$, $p = .258$; work shift: $\beta = .05$, $p = .425$) respectively. Hypotheses 3b and 4b were partially supported by the results since the significant effect of work interruption on satisfaction with one's own performance also became non-significant after including the mediators time pressure (evening: $\beta = -.08$, $p = .179$; work shift: $\beta = -.09$, $p = .165$) and mental demands (evening: $\beta = -.08$, $p = .165$; work shift: $\beta = -.09$, $p = .104$) respectively. However, the mediators time pressure (work shift: $\beta = -.08$, $p = .108$; *Sobel* $= -1.38$, $p = .169$) and mental demands (work shift: $\beta = -.09$, $p = .119$; *Sobel* $= -1.54$, $p = .123$) also became non-significant themselves. The results of the mediation test of Hypothesis 4a (work shift) mean that this hypothesis cannot be supported (time pressure: *odds ratio* = 1.07, $p = .363$; interruption: *odds ratio* = 1.07, $p < .05$; *Sobel* = .91, $p = .364$).

To further rule out common method bias, and underscore the direction of causality within our results, we tested – using multilevel analysis – whether our outcome variables measured in the evening (irritation, satisfaction, forgetting of intentions) had an effect on the number of interruptions reported the following day.

Table 2. Multilevel estimates of Hypotheses 1 and 2 and of the first prerequisite condition for mediation according to Baron and Kenny, 1986: independent variable → dependent variable ($N = 133$ employees, and $n = 624$ occasions).

	Forgetting of intentions		Satisfaction with one's own performance		Irritation	
	Odds ratio	CI	*B* (SE)	*β* (SE)	*B* (SE)	*β* (SE)
Intercept	0.12***	[0.09; 0.17]	3.89 (.06)***		2.40 (.08)***	
Interruption	1.08**	[1.02; 1.14]	−0.02 (.01)*	−0.13 (.05)*	0.02 (.01)**	0.16 (.06)**

Note: *B* = unstandardized coefficient; *β* = standardized coefficient; CI = 95% confidence interval.
* $p < .05$; ** $p < .01$; *** $p < .001$.

Table 3. Multilevel estimates of the second prerequisite condition for mediation according to Baron and Kenny (1986): independent variable → Mediator ($N = 133$ employees, and $n = 624$ occasions).

	Mental demands				Time pressure			
	Work shift		Evening		Work shift		Evening	
	B (SE)	β (SE)	*B* (SE)	β (SE)	*B* (SE)	β (SE)	*B* (SE)	β (SE)
Intercept	10.93 (.27)***		3.61 (.06)***		11.17 (.27)***		3.15 (.07)***	
Interruption	0.18 (.02)***	1.45 (.17)***	0.04 (.01)***	0.36(.05)***	0.20 (.02)***	1.60 (.16)***	0.06 (.01)***	0.45 (.06)***

Note: *B* unstandardized coefficient, β standardized coefficient.
*** $p < .001$.

Table 4. Multilevel estimates of the third prerequisite condition for mediation according to Baron and Kenny (1986): mediator → dependent variable ($N = 133$ employees, and $n = 624$ occasions).

		Forgetting of intentions		Satisfaction with one's own performance		Irritation	
		Odds ratio	95 % CI	*B* (SE)	β (SE)	*B* (SE)	β (SE)
Model 1	Intercept (Mental demands, work shift)	0.12 ***	[0.09; 0.17]	3.89 (.06)***			2.40 (.08)***
	Mental demands	1.12[t]	[0.99; 1.27]	−0.03 (.01)*	−0.12 (.05)*	0.08 (.01)***	0.31 (.05)***
Model 2	Intercept (Mental demands evening)	0.12***	[0.09; 0.17]	3.90 (.06)***		2.39 (.08)***	
	Mental demands	1.36	[0.89; 2.06]	−0.16 (.05)**	−0.15 (.04)**	0.28 (.05)***	0.26 (.04)***
Model 3	Intercept (Time pressure, work shift)	0.12***	[0.09; 0.17]	3.89 (.06)***		2.40 (.08)***	
	Time pressure	1.14*	[1.00; 1.29]	−0.03 (.01)*	−0.12 (.05)*	0.07 (.01)***	0.25 (.05)***
Model 4	Intercept (Time pressure, evening)	0.13***	[0.09; 0.17]	3.90 (.06)***		2.40 (.08)***	
	Time pressure	0.15	[0.81, 1.64]	−0.14 (.04)**	−0.15 (.04)**	0.32 (.04)***	0.35 (.04)***

Note: *B* = unstandardized coefficient; β = standardized coefficient; CI = 95% confidence interval.
[t] $p < .10$; * $p < .05$; ** $p < .01$; *** $p < .001$.

Table 5. Multilevel estimates of the mediation: independent variable + mediator → dependent variable ($N = 133$ employees, and $n = 624$ occasions).

		Satisfaction with one's own performance			Irritation		
		B (SE)	*β* (SE)	*Sobel*	*B* (SE)	*β (SE)*	*Sobel*
Model 1	Intercept (Mental demands, work shift)	3.89 (.06)***			2.40 (.08)***		
	Interruption	−0.01 (.01)	−0.09 (.06)		0.01 (.01)	0.05 (.06)	
	Mental demands	−0.02 (.01)	−0.09 (.06)	−1.54	0.08 (.01)***	0.29 (.06)***	4.41***
Model 2	Intercept (Mental demands, evening)	3.89 (.06)***			2.40 (.08)***		
	Interruption	−0.01 (.01)	−0.08 (.06)		0.01 (.01)	0.06 (.06)	
	Mental demands	−0.14 (.05)**	−0.13 (.04)**	−2.65**	0.26 (.05)***	0.24 (.04)***	4.22***
Model 3	Intercept (Time pressure, work shift)	3.89 (.06)***			2.40 (.08)***		
	Interruption	−0.01 (.01)	−0.09 (.06)		0.01 (.01)	0.06 (.01)	
	Time pressure	−0.02 (.02)	−0.08 (.06)	−1.38	0.06 (.02)***	0.23 (.06)***	3.59***
Model 4	Intercept (Time pressure evening)	3.89 (.06)***			2.40 (.08)***		
	Interruption	−0.01 (.01)	−0.08 (.06)		0.00 (.01)	0.02 (.06)	
	Time pressure	−0.12 (.04)**	−0.13 (.04)**	−2.66**	0.31 (.04)***	0.35 (.04)***	5.26***

Note: B = unstandardized coefficient; β = standardized coefficient.
* $p < .05$; ** $p < .01$; *** $p < .001$.

There were no significant effects (irritation: $\beta = .43$, $p = .148$; satisfaction with performance: $\beta = -.26$, $p = .443$; forgetting of intentions: $\beta = .06$, $p = .948$). This indicates that the number of reported interruptions on a given day is not influenced by the "state" of participants as a result of interruptions during the previous day.

Discussion

In this study we examined workflow interruptions on the job as a daily stressor by applying a within-person approach. The number of workflow interruptions experienced during a working day was found to be related to an increase in the forgetting of intentions, a decrease in the satisfaction with one's own performance and heightened irritation in the evening. Furthermore, mental demands, as well as time pressure, were shown to act as mediators in the relationship between workflow interruptions and both satisfaction and irritation. They did not mediate the relationship between workflow interruptions and forgetting of intentions, however.

These results are in line with the assumptions of action theory (Hacker, 2005) and goal activation theory (Altmann & Trafton, 2002). Accordingly, interruptions can be classified as stressors, which are related to decreased performance and increased strain.

The impact of workflow interruptions on forgetting of intentions was not mediated by time pressure or by mental demands, although both emerged as related to workflow interruptions. The non-significant mediation, i.e. that time pressure and mental demands were not related to forgetting of intentions in our sample of nurses, is nonetheless interesting. Although Einstein et al. (2003) assumed that forgetting of intentions is caused by the demands put on the prospective memory and intended actions have to be delayed and kept in the memory due to the demands of a current task or situation, our non-significant findings suggest that other mechanisms may be at play. Given our results, further research may be needed to examine which attributes or consequences of interruptions do cause errors in prospective memory. The intensity of the distraction, for example, might be a relevant avenue of enquiry. What is more, mental demands may be too general a concept. Instead, the length of the delay (until the primary task can be resumed) or the complexity of the interruption task might be better predictors of the likelihood of forgetting of intentions. According to goal activation theory (Altman & Trafton, 2002), the length of the delay influences the activation of the action plan; long delays raise the risk of forgetting of intentions. A possible coping strategy is to keep the primary goal (as opposed to the intention to do the interrupted task) activated during the accomplishment of the interruption task (Monk et al., 2004). If the person already has further intentions in her/his prospective memory (tasks which she/he does not want to forget), the memory demands will be even higher and this is a typical strategy used by nurses to cope with high workload (Grundgeiger & Sanderson, 2009). Keeping the primary goal activated is only possible if the interruption task is not too complex (Monk et al., 2004). Based on this reasoning, the length of the delay and the complexity of the interruption are factors that seem likely to influence the memory demands triggered by interruptions. Hence, these qualitative features might explain the link between workflow interruptions and forgetting of intentions better than the number of workflow interruptions.

There were mixed results with respect to the mediation effects in the relationship between workflow interruptions and satisfaction with one's own performance. All conditions of the classic mediation model (Baron & Kenny, 1986) were met. That is, there was a significant negative relationship between workflow interruptions during the day and satisfaction with one's own performance in the evening. Furthermore, interruptions were positively related to the potential mediators mental demands and time pressure, whether they were assessed during the work shift or in the evening. However, the proposed mediation effect was only supported for mediators assessed in the evening. A possible explanation for these results may be found in the day-to-day routine of nurses. Workflow interruptions and the (work shift) mediators were measured three times a day. The last measurement was one to two hours before the end of the work shift. In these last hour(s) the workload tends to decrease. The patients often have an afternoon rest and the nurses and therapists complete their patient care documentation. During that time it is possible to accomplish any unfinished tasks, which may have an effect on the satisfaction a nurse feels with their own performance, which is rated in the evening. Accordingly, the probability of finding a mediation effect using the evening mediators, which are also retrospective, rather than taking the work shift mediators, which are measured during a comparatively high workload period (i.e. most parts of the day), may be higher.

It is possible that the effect of interruptions on performance in hospitals may be buffered by the workload level (interruptions, time pressure, mental demands) at the end of the work shift. Tables 3 and 5 show that work shift measures (of the mediators and the independent variable) are more weakly related to satisfaction with one's own performance than evening measures (of the mediators). This buffering effect seems not to apply to the outcome irritation. The impact of interruptions on irritation (i.e. rumination and emotional strain) was mediated by time pressure, as well as mental demands, regardless of whether they were assessed during the work shift or in the evening. Thus, future studies may usefully test the buffering effect of reduced workload at the end of the work shift.

In conclusion, we found that the daily number of workflow interruptions was related to two different factors related to performance: forgetting of intentions and satisfaction with one's own performance. This replicates findings of laboratory studies (Bailey & Konstan, 2006; Eyrolle & Cellier, 2000; Trafton et al., 2003) but has ecological validity. Further, we demonstrated that interruptions also have an impact on irritation on a continued daily basis, adding to prior results of cross-sectional studies (Grebner et al., 2003; Konradt et al., 2003). Our study provides the first evidence of the possible intervening processes explaining the effects of workflow interruptions. Interruptions lead to higher time pressure and higher mental demands, which can explain decreasing (satisfaction with) performance and increasing irritation. Our findings support the assumptions of action theory (Hacker, 2005) that interruptions are a stressor because of the additional effort, through the higher mental demands, that they require. The accumulating time loss leads to increased time pressure. These demands decrease the performance and increase the perception of irritation. The intervening processes linking workflow interruptions with forgetting of intentions require further examination through exploring alternative mechanisms such as those more related to memory. Thus, future research should address other explanatory mechanisms (third variables) of workflow interruptions.

Possible third variables to examine may include memory demands, task load or the need to multitask.

Limitations and suggestions for future research

The design of this study has a number of advantages over cross-sectional field studies dealing with correlates of workflow interruptions at work. However, a number of limitations of the research also need to be considered.

First, all measures were assessed using self-report data. This potentially entails the risk of self-serving bias and socially desirability in responses. However, since we were examining within-person effects in this study, and centred predictor variables around the respective person mean, the reported effects cannot be attributed to between-person differences. Future research should nonetheless try to replicate these findings by employing more objective measures. Interruptions could be observed by trained raters. Either during observations, but also in self-reported data, further features of workflow interruptions could be investigated. As we know from laboratory research, the timing of interruptions (Monk et al., 2004), the complexity and interference of tasks or the similarity of tasks (Gillie & Broadbent, 1989) can make a difference.

Also, performance indicators could be obtained from supervisors. Alternatively, objective indicators could be used, such as strain measured using physiological indicators. For any indicators used it is important that they are sensitive enough to reflect short-term fluctuations.

Second, the assessment of certain variables was carried out at the same time point (e.g. the independent variable and the proposed mediators, or the mediators and the dependent variables at three occasions during the work shift and in the evening). This may be the cause of common method variance (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003). However, data were gathered over the course of five days and the independent variable, the mediators and the dependent variables were at least partially separated in time. Further, as the last assessment during the work shift was circa one or two hours before the end of the work shift, it is possible that during the remaining time of the work shift our respondents had time to accomplish unfinished tasks. Time pressure and mental demands might be lower at the end of the work shift. Future research may also opt to assess job demands at the end of the working day, in order to avoid this problem.

Third, carrying out the assessment during an individual's work shift may be seen as intrusive since the reminder provided by the handheld device to key in responses is in itself an additional interruption (Ohly et al., 2010). However, in an observation study, an average of 62.8 interruptions per nurse ($SD = 36.7$, *range*: 13–149, Baetghe & Rigotti, 2010b) were recorded during a morning shift. Thus, three additional interruptions account for less than 5% of the average number of daily interruptions in this occupational group. Furthermore, the time needed to complete the daily survey was very short – on average 3 minutes. Therefore, it is unlikely that reported effects are caused by the extra efforts entailed in participating.

Fourth, within a sample of nurses interruptions are very frequent events. An interesting question might be whether these results can be replicated in other occupations with fewer interruptions. The majority of field research on interruptions has been conducted in hospitals (Rivera-Rodriguez & Karsh, 2010; Tucker & Spear,

2006). We speculate that in different occupations interruptions and the mediators may have different effects. There is evidence that interruptions and time pressure may also act as challenge factors (Mark et al., 2008; Widmer, Semmer, Kälin, Jacobshagen, & Meier, 2012). Mark et al. (2008), for example, found that interruptions (of simple and repetitive tasks, during a limited time frame) led to a faster accomplishment of tasks at the expense of increases in effort, time pressure, frustration and mental demands. Thus it can be assumed that in certain occupations conditions exist in which interruptions (and time pressure) act as challenge stressors. According to Hockey (1997), stressors can lead to increased performance at the expense of raised effort, but this cannot be sustained indefinitely. In the occupation of nursing, interruptions happen too frequently and time pressure is too prominent to act as a challenge stressor. To assess the generalizability of our findings it would be worthwhile studying other occupational fields. General job characteristics (assessed as between-person factors on level 2), such as average complexity, time pressure and decision latitude may act as cross-level moderators.

Finally, although predictors and criteria were assessed at different points in time, we cannot make causal inferences. Experimental designs would be necessary in order to definitively rule out reverse causations. The use of a cross-lagged panel design would permit the identification of such reverse effects. However, in our study we were able to prove that the evening measures of performance satisfaction, forgetting of intentions and irritation did not have a substantial relationship with workflow interruptions reported the next day. In addition to this, a longitudinal design with longer time lags would provide further insights into the process of interruptions and long-term effects.

Practical implications

The findings point to promising directions for interventions in the field of occupational health promotion. We found that workflow interruptions decrease performance and increase irritation (a mediator between stressors and severe health problems like depression and psychosomatic complaints, Dormann & Zapf, 2002; Höge, 2009). Therefore, employers and employees alike should be interested in reducing unnecessary interruptions and in furthering their knowledge of the potential coping strategies of interruption events. As workflow interruptions mainly occur as a social phenomenon they should also be dealt with at the team or even organizational level. A promising instrument in establishing comprehensive health promotion in the workplace is the participative approach of health circles. According to Aust and Ducki (2004), health circles can be described as "[. . .] discussion groups, formed at the workplace, to develop change options for the improvement of potentially harmful working conditions" (p. 259). Health circles allow employees – the experts in their jobs and of their working conditions – to find opportunities to reduce workflow interruptions. A group of 6–15 employees, each of them a possible interrupter her/himself, analyzes the occurrence of interruptions and discusses ideas for their reduction, during the course of between 6 and 10 meetings.

Having knowledge of mediating variables can also help to avoid the negative effects of workflow interruptions. Since workflow interruptions have a negative effect on irritation (and satisfaction with one's own performance) via high mental demands and time pressure, a possible intervention would be to keep interruptions short, i.e.

reducing time pressure. Further, strategies can be used to reduce mental demands after the occurrence of workflow interruptions. In experimental studies it was found that a delay in the accomplishment of interruptions leads to better performance (Ho et al., 2004). The time slot between the occurrence of an interruption (e.g. the sound of a telephone bell) and the accomplishment of the interruption (e.g. answering the telephone call) can be used to finish the interrupted task or at least to finish parts of the interrupted task. This will disburden the working memory and reduce the time taken to resume the task (Monk et al., 2004). An alternative is to make notes about the steps of the interrupted tasks, in order to take the load off the prospective memory and prevent the forgetting of intentions.

Conclusion

By moving from the laboratory to the field, and applying a within-person approach, this study provides original evidence that interruptions at work can be classified as daily stressors. Interruptions are likely to become one of the most frequent demands in modern working life. Learning about the mechanisms linking workflow interruptions to lowered performance and higher strain in ecological contexts is therefore a valuable research avenue to pursue.

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