Interruptions at work as risk for high work intensity and their relation to negative short-term consequences of strain – A diary study among tram drivers[1]

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ABSTRACT
The aim of this study was to investigate whether specific indicators of interruptions at work are related to negative short-term consequences of strain throughout a workday under conditions of high time constraints and low control. To do this, 40 tram drivers were accompanied for one workday. The additional temporal effort due to interruptions as well as the proportion of work breaks with delays was recorded via observations. Negative short-term consequences of strain were measured every two hours via a questionnaire. Multilevel modelling indicated that the additional temporal effort due to interruptions was a significant predictor of an immediate fatigue reaction, whereas there was a delayed fatigue und stress reaction to shortened breaks due to interruptions. The results are interpreted in terms of the compensatory effort the drivers use to compensate for shortened breaks and extra time due to interruptions. Furthermore, implications for the measurement of interruptions as well as for the occupation of tram drivers are discussed.

Keywords
Interruptions – work intensity – short-term consequences of strain – stress – fatigue – tram drivers

1 Introduction

The present study aims to gain insight into the relationships between interruptions at work and negative short-term consequences of strain if a job is characterized by high time constraints and low control. Following Baethge, Rigotti, and Roe (2015) in relation to Brixey et al. (2007), interruptions can be defined as temporary externally caused incidents at work that force a person to stop a goal-directed action. They usually come along with unpredictable extra tasks that must be accomplished before continuing the primary task and thus additional temporal effort must be made (Baethge et al., 2015; Rigotti, 2016). Furthermore, interruptions have an unpredictable nature and are not usually part of the regular schedule (Claessens, van Eerde, Rutte & Roe, 2010). Interruptions that come with extra temporal effort should have a more negative impact when there is very little time and few opportunities to control the work process (Baethge et al., 2015; Li, Magrabi & Coiera, 2011).

Taken together, interruptions at work have been the subject of numerous studies in the past. Two German Reviews (Baethge & Rigotti, 2010; Rigotti, 2016) point to the negative impact of interruptions on health and well-being (e.g., irritation: Baethge & Rigotti, 2013; physical complaints: Lin, Kain & Fritz, 2013; depression: Rout, Cooper & Rout, 1996; burnout: Holden et al., 2011) and especially on performance (Bailey & Konstan, 2006; Eyrolle & Cellier, 2000; Li et al., 2011). However, most of these cross-sectional studies were carried out in the health sector and mainly

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scrutinized the frequency of interruptions. Fewer studies take other characteristics of interruptions (e.g., their duration) into consideration (Rigotti, 2016). Although interruptions are mostly short-term incidents at work, there is no study which investigates the short-term effects of interruptions on strain.

1.1 Interruptions as regulation obstacles

In terms of action regulation theory, interruptions can be seen as regulation obstacles (Hacker, 2003; Hacker & Sachse, 2014; Frese & Zapf, 1994). This theory posits that the work process consists of several goal-oriented actions. Demands at work have their origin in the task or the work environment and have regulation requirements to reach a specific goal. The demands may also include regulation problems (which are more related to the work environment) as well as resources for regulation (which are more related to the task). Incidents that disturb the regulation of action towards the goal (either during preparation or execution of the task) are called regulation problems, and are divided into regulation obstacles, regulation uncertainty (e.g., qualitative overload), and overtaxing regulations (e.g., time pressure: Frese & Zapf, 1994). Regulation obstacles themselves are divided into interruptions and regulation difficulties. According to Leitner, Volpert, Greiner, Weber, and Hennes (1987), those regulation obstacles are directly related to the task and therefore directly impede the work process. Oesterreich, Leitner, and Resch (2000) added that those obstacles are not necessary for the work or product itself. Moreover, the work could be better accomplished if these incidents were not present. Regulation difficulties are caused either by missing information or poorly designed work spaces that hinder necessary work movements. However, interruptions can be caused by people (colleagues, supervisors), disruptions of functions (technical problems), or blockades (Frese & Zapf, 1994). This means that interruptions either come with extra tasks (e.g., a colleague asks for help) and therefore increase the quantity of work, or they postpone or block the work (e.g., supply shortages force assembly-line workers to stop work until enough material is back in stock) and shorten the remaining time for carrying out the task while the amount of work remains the same (Rigotti, 2016).

Rau and Göllner (2018) recently formulated a model with work demands that are related to the level of quantitative work intensity. As proposed by Roe and Zijlstra (2000), in this model work demands represent the objective requirements posed by the tasks to be performed and the working conditions. These demands are the same for each job incumbent. Rau and Göllner's (2018) model understood work intensity as a function of the ratio of work quantity to the available time in regard to the level of cognitive regulation required for carrying out the task. The level of cognitive regulation can be characterized by automated to controlled (knowledge-based) processes or even intellectually controlled processes (Hacker, 2003). The quantity of work is determined by the number of personnel. The available time for the task is specified by time constraints, regulation obstacles (e.g., parallel task handling, work interruptions, workload peak / lack of personnel, lack of time to expand the knowledge needed for new job requirements) and the objectively given possibilities for coping. „Objectively given" means that these coping possibilities are predefined in the work task and therefore are legitimately usable for the employees and are not linked to sanctions. High work intensity is caused by contradictions between these conditions. For example, the existence of high time constraints and the occurrence of disturbances during work, or a mismatch between high time constraints and complexity, which is determined by the cognitive regulation level and the given time, or a mismatch between time constraints and requirement for knowledge acquisition in case of new job tasks (knowledge acquisition needs time).

Interruptions are related to an increase in work intensity because they create an imbalance between the available time and amount of work that needs to be done. This is because they either postpone the actual task or force the worker to carry out extra tasks by handling the interruptions (this includes coordination effort). Rau and Göllner's (2018) model of work intensity further implies that this becomes more severe if the work requires a high level of mental regulation. Thus, the occurrence of interruptions is linked to fluctuations of work intensity during a workday.

1.2 Interruptions and work intensity of tram drivers

The occupation of transit operators can be understood as a typical *high strain job* – characterized by high quantitative demands and low control (Hedberg, Jacobsson, Janlert & Langendoen, 1993; Kompier & di Martino, 1995; Meijman & Kompier, 1998). This involves different specific occupations like bus, underground/subway, train, truck, and tram drivers. Although driving is the main characteristic of each occupation, there are some major differences regarding the rail mount, local versus long-distance transport, the amount of contact with other traffic, and operating in urban versus rural areas. In the past, a major research interest was the health-threatening character of the occupation of bus driving (Tse, Flin & Mearns, 2006). Less concern was given to tram drivers, which might be owed to the fact that this is probably the smallest driver group. Most studies do not even differentiate between specific groups of drivers and instead summarize them under the term *transit operators* (e.g., Greiner & Krause, 2006). Similar to train drivers, one could assume that tram drivers experience an even greater loss of control as the rail mount precludes swerving in case of a hindrance. To date, only a few studies that scrutinized the work and occupational health of tram drivers specifically could be found (Meifort, Reiners & Schuh, 1983; Naznin, Currie & Logan, 2017; van Dierendonck & Mevissen, 2002).

In general, examining tram drivers has a high potential for clarifying the characteristics and consequences of work, because the conditions for carrying out the work are very similar across different drivers. This is mainly because of the small amount of control regarding the work procedure. Additionally, tram drivers usually have very high time constraints due to the driving schedule. The scientific advantages are approximately laboratory-like conditions where certain work demands (like interruptions) can be analyzed while other characteristics are held somewhat constant (Evans & Johansson, 1998; Spector, 1992).

The work intensity of tram drivers can be analyzed using Rau and Göllner's (2018) work intensity model. The level of cognitive regulation for tram driving can be described as a processing of information that is mainly based on *if, then* rules that are supplied by traffic signs, lights, and local circumstances. The knowledge for these rules is delivered via driving school and recurring service briefings throughout the year.

The task of tram drivers is not very complex. Therefore, the amount of work and the available time can be precisely determined. A single unit of action is one stop on their route. This includes initiating the brakes, stopping the vehicle, opening the doors, watching the passengers enter / exit, closing the doors, driving to the next stop, and attending to traffic regulations like traffic lights or signs. Usually there is a specific amount of time (generally a few minutes) available for this action. Generally, this is precisely assigned to different stops and routes, respectively, which is documented in the driving schedule. Therefore, drivers in local transport mostly work under maximum time constraints. Interruptions are not scheduled, which is understandable regarding the unpredictable nature of them. The occurrence of an interruption that demands extra time together with maximum time constraints should result in a quantitative overload for the drivers. Options for coping are nearly nonexistent due to limited control. Driving faster or speeding up the change of passengers typically violates traffic and organizational regulations and are not objectively given and legitimately usable possibilities for coping with interruptions. In most cases, the extra time that is needed to deal with interruptions comes at the expense of the break at the terminus.

Greiner, Krause, Ragland, and Fisher (1998) observed work barriers as extra time for 27 routes of transit operators in relation to absenteeism rates in the preceding year, finding a relationship between work barriers and absenteeism. Short-term consequences for psychological health and well-being of these demands were not considered, but the results point to the potential long-term effects of work barriers, which can be understood as interruptions, on health.

Interruptions for tram drivers can be classified depending on requirement for responding. We are only interested in events that cause a brief interruption of work and therefore require short additional time for reaction. These are events that are referred to as daily hassles. Examples are impediments to driving, like wrongly parked vehicles, vehicle errors or errors at traffic lights as well as near accidents or negative behaviors of passengers or pedestrians. All these events usually come with additional tasks, for example to get off the tram, check the track switch, and if necessary contact the control center for further instructions. Besides those daily hassles there are other events that interrupt work, like accidents and strong verbal or physical assaults by passengers or route deviations. Accidents and assaults by passengers display outstanding incidents and are significant exceptions from the work routine. These cannot be seen as simple interruptions in the work process as they might cause emotional reactions and could be traumatic. Route deviations can also not be categorized as daily hassle since the make the original quantity per time relation obsolete. Therefore we are not interested in those events.

1.3 Additional effort due to interruptions and strain

Oesterreich et al. (2000) described different possibilities for coping with regulation obstacles if there is no need for a specific reaction. These possibilities are organizational resources and can be legitimately used to cope with obstacles like interruptions. They include returning the actual task to a supervisor or colleague in case of an interruption. Another one is to lower the quality or slow down the tempo of work. If these resources are not available, interruptions can only be handled through additional effort, which usually means working faster. Baethge and colleagues (2015) postulated that cumulative interruptions under conditions of elevated work load and time pressure restrict opportunities for breaks and therefore lead to an insufficient recovery.

According to the effort-recovery model (Meijman & Mulder, 1998) and the compensatory control model

(Hockey, 1997), a person shows short-term reactions as adaptive responses to being confronted with load dependent on work demands and the individual work potential and procedure. Under regular conditions, a person recovers from these load reactions in subsequent breaks where the load is no longer present. The optimal level for performance is reconstituted. But if recovery is impeded, then a discrepancy between the actual and required state for carrying out the task develops. The person must make additional effort to meet the load, which is associated with behavioral and physiological costs (Hockey, 1997). If the confrontation with too high of a load continues and the possibilities for self-regulation are depleted, then the person will respond with a strain reaction. Finally, if recovery from load is not possible, then the short-term load reactions will accumulate to create negative effects on health and well-being. The impaired recovery itself influences the demand effects negatively, increases the shortcoming in recovery and results in a lasting overactivity of the affected physiological systems (*allostatic load*; McEwen, 1998).

According to the work intensity model by Rau and Göllner (2018), interruptions only intensify work if they have a direct influence on the available time. Therefore, not the occurrence of interruptions per se, but the extra temporal effort should be considered (Oesterreich et al., 2000). As outlined above, interruptions are a potential threat to well-being if they cause shortened breaks, because recovery from load is restricted (Baethge et al., 2015). Thus, the actual shortening of breaks should also be taken into account. In the context of the working conditions of tram drivers, this seems even more important because there might be an accumulation of smaller interruptions from one terminus to the next. So, at the end of one route there might be a delay even though there was not a specific interruption, which the driver has to compensate for by using break time. This is due to the high time constraints based on the driving schedule that do not allow extending the break. Those little interruptions might be hard to capture. Therefore, we used multiple measures to capture interruptions, which included measures for additional temporal effort and delays in breaks.

Strain, an immediate reaction to task requirements, is a source for short-term or acute consequences. Depending on the individual conditions of the worker, these reactions can be positive and stimulating (e.g., engagement: Xanthopoulou, Bakker, Demerouti & Schaufeli, 2009) or negative and impairing (e.g., fatigue, stress, or monotony: ISO, 2017; Demerouti et al., 2002; Richter & Hacker, 2012). These are linked to long-term consequences of strain like burnout (Demerouti et al., 2002) or impaired sleep quality (Pereira, Meier & Elfering, 2013). This study only examines fatigue, stress, and monotony as negative short-term consequences of strain.

As described above, under conditions of high time constraints with little control, interruptions that come with extra temporal effort should increase work intensity and therefore force a driver to make additional effort (e.g., speeding up to remain on time) to meet demands. Consequences of this additional effort might be an immediate fatigue or a stress reaction (Meijman & Mulder, 1998). Fatigue refers to a temporary impairment of mental and physical efficiency that depends on the foregoing intensity, duration, and progress of mental strain, whereas stress is described as a complex psycho-physiological reaction to conflicting and negatively evaluated demands as a result of strong over- or underload causing the frustration of personal goals, values and social roles (Demerouti et al. 2002; ISO, 2017; Richter & Hacker, 2012). We made the following hypotheses:

H1: Additional temporal effort due to interruptions and delays in breaks is related to an increase in the acute experience of stress.
H2: Additional temporal effort due to interruptions and delays in breaks is related to an increase in the acute experience of fatigue.

Interruptions may have different effects for monotony, which is a state of reduced activation with feelings of tiredness and reductions in responsiveness due to repetitive tasks (Demerouti et al., 2002; ISO, 2017). Baethge and colleagues (2015) stated, with respect to Hacker and Sachse (2014), that interruptions cause a rise in cognitive demands. This can be explained by the act of interruption itself. When carrying out an automated routine and being interrupted, one must make either a rule-based decision or create a new knowledge-based plan about when and how to resume the interrupted task. Moreover, the task that is associated with the interruption might be a diversion from the normal working routine. Additionally, monotony can be diminished due to interruptions as well as task changes (ISO, 2017). We hypothesize that:

H3: Additional temporal effort due to interruptions and delays in breaks are related to a decrease in the acute experience of monotony.

There are several hints that professional experience might play a role in the successful handling of interruptions and, therefore, performance (Burger et al., 2010; Zijlstra, Roe, Leonora & Krediet, 1999). Successfully handling interruptions requires that a person immediately knows how to react to the interruption in that way can eliminate it quickly or has enough time to familiarize with the new situation

(Rau & Göllner, 2018). Having more work experience means that certain interruptions have likely already been experienced. Therefore, future occurrences of the same or a similar interruption might be less disruptive, as they can be eliminated faster (Trafton & Monk, 2007). For drivers, this might also be the case for interruptions through functional shortcomings. But the additional temporal effort cannot always be influenced by the driver (e.g., when a car driver returns to their wrongly parked car) or not every situation can be trained beforehand. Since we are only interested in events that are referred to as daily hassles (brief interruption of work; short additional time required for the reaction) professional experience should only be important at the beginning of the tram driver's job.

2 Methods

2.1 Participants

The study was part of a project for analysis and designing working conditions in a German transport company with about 250 people employed in the tram service. The tram drivers were recruited via informational presentations in the regular service briefings. The study was separated in two parts. The first part was a survey part, which consisted of two appointments of each 1-2 hours. For participation the drivers had to come to the company before or after their working day or on their day off. From 86 drivers that initially were interested in participating in the study, only 66 (76.8 %) full-time drivers attended the first appointment (also 4 part time drivers participated in the first part, but where not analyzed, as driving was not their main profession), whereas five of those drivers didn´t attend the second appointment (*n* = 61, 70.9 %). The reasons for drop-out might be the high costs, because the survey part couldn´t be done during the actual working time. Part two of the study was a diary study, where the drivers were accompanied during a working shift for one day. All 61 drivers, who participated in both survey appointments, were approached to participate in the diary study. Mainly because of longer-term sickness absence and loss in interest in the study, eight drivers didn't participate in the diary study. For compensating the time spent participating in the study all participants received three hours on their working time account.

The remaining 53 drivers were accompanied during a working shift for one day by one observer. Data of 13 drivers (13 shifts) had to be excluded from further analysis because of incomplete assessment of strain (lack of measurement points; 5 shifts), missing data in the variable „additional time due to interruptions“ (1 shift), a split shift (drivers work about 4 hours, have a break for four hours and then complete the remaining four hours of their shift; 4 shifts) and special occurrences (i.e., vehicle damage, external accidents) that interfered strongly with the normal working routine (3 shifts). The remaining shifts (*n* = 40) featured comparable working conditions and were considered for analysis.

Eighty percent of the 40 drivers were male (*n* = 32) and 20 % of them were female (*n* = 8). The participants were on average 43.6 years old (*SD* = 9.5, range: 21 - 58) at the beginning of the study. Their professional experience ranged from 7 months to 40.8 years (*M* = 20.2 years, *SD* = 11.6) at the beginning of the diary study. The drivers in the final sample (*n* = 40) were not significantly different in gender, $\chi^2(1, n = 66) = 0.43$, $p = .51$, or age, $t(64) = 1.18$, $p = .24$, from the drivers who were excluded or decided against further participation in the study (*n* = 26).

2.2 Procedure and materials

Except for breaks, drivers could not turn away from their task. There was no time for additional tasks during driving. Drivers typically have only a few minutes for a break at the terminus, which is required to compensate for delays and for personal needs. Therefore, each of the 53 drivers was accompanied once for one whole workday by one observer. In total, 11 observers, who received observer training prior to the study, were involved.

At the beginning of each observation, the drivers received a short introduction and were informed about the procedure. They were handed a short questionnaire about different characteristics of their current shift. Then they received the ratings for measuring short-term consequences of strain at shift onset (see below for instruments of strain measurement). The same measurements of short-term consequences of strain were conducted approximately every two hours during the shift and after the shift.

The observer took a seat as close as possible to the driver´s cabin (but not in it). Measures of work activities and situations were recorded continuously throughout the time of observation in a minute-diary, so it was clearly documented what the driver had done at a certain point of time. Everything that occurred was classified using a predefined scheme. Categories for classification were: drive/stop, breaks, setting-up (e.g., preparation, control, or shutting down after pulling into the depot), communication, and miscellaneous. There was an extra sheet to record details every time there were breaks, interruptions, and communication.

Relevant to the present study was the record of breaks and interruptions. For breaks, the real length as well as the *delay* was measured. Breaks could either be turning times at the terminus, which mark the transition from one route the next one, or block breaks, where the driver leaves and changes the vehicle. Turning times appeared at every terminus but differed in length depending on whether the driver had an additional block break. Turning times were usually set between about 2 and 20 minutes, and block breaks between about 15 and 60 minutes.

Interruptions were recorded every time they appeared. They were classified into the initially described categories (vehicle damages or errors, errors at traffic lights or track switches, near accidents, negative behavior of passengers, route deviations, and impediments to driving). For every interruption, the time the driver needed to continue was measured in seconds (*additional time*). All measures were captured in writing.

It was ensured that the observations were spaced across week days (5 to 10 observations per weekday, but only 2 on Saturday) and shift positions (7 to 12 observations across early, intermediate, noon, and late shifts). Night shifts (which are only operated during weekends in the investigated transport company) were missed due to a lower traffic volume, which might violate the comparability to shifts from Monday to Saturday.

2.3 Measurements

Strain ratings. To assess the short-term consequences of mental strain, we used the unipolar rating scales of Richter, Debitz, and Schulze (2002). Currently this is the only available and reviewed instrument for the investigation of the cumulative consequences of strain. The rating scales consist of 12 adjectives that are rated regarding the question „Do you feel (adjective) at the moment?" on a 6-point ordinal Likert item [1 (*not at all*); 6 (*very*)]. The Likert items were summed up to the four Likert scales: engagement/positive temper (e.g., „Do you feel energetic at the moment?"), fatigue (e.g., „Do you feel exhausted at the moment?"), monotony (e.g., „Do you feel bored at the moment?") and stress (e.g., „Do you feel upset at the moment?"). For the present study, only the negative consequences of strain were relevant. The internal consistencies of the scales were on average acceptable to good (George & Mallery, 2003): stress $\alpha = .80$, fatigue $\alpha = .62$, and monotony $\alpha = .79$.

Because summing up the Likert items to Likert scales yields interval data (Carifio & Perla, 2008), and in order to use parametric tests, the Likert scales were analyzed metrically. Background is the review of Norman (2010) who analyzed real and simulated data showing that parametric tests can be used with data of Likert scales. Moreover he stated that parametric tests are generally more robust than nonparametric tests.

Additional time due to interruptions and proportion of breaks with delays. In order to allow the indicators for interruptions to be linked to the strain variables, the measurement points for strain were used to divide the shift into four segments: beginning to about two hours after start of work (referred to as 0-2h), about two to four hours (2-4h), about four to six hours (4-6h), and about six hours to the end of the shift (6-8h). It was only possible to measure strain approximately every two hours because this could only be done during steering-free times (turning times and block breaks). Therefore, the average segments are slightly different in length: M = 132.6 minutes (0-2h), M = 129.8 minutes (2-4h), M = 117.4 minutes (4-6h), and M = 124.1 minutes (6-8h), with a range from 60 minutes (4-6h) to 194 minutes (2-4h) for single segments. *Additional time due to interruptions* was calculated for each segment and in total by summing every length of additional time in seconds. *Proportion of breaks with delays* was calculated for each segment by first counting the total number of breaks (turning times and block breaks), and then only counting breaks with a delay. Out of these two numbers, a quotient was calculated to reflect the proportion of breaks with a delay. This was done because taking only the number of minutes of delay would be misleading as there are longer routes with fewer breaks and therefore less potential for delays. A quotient from 0 (no breaks with delays) to 1 (all breaks with delays) was calculated to be more comparable across different situations. Considering the individual segment and segment total variables, there were five variables representing each of the two independent variables (*additional time due to interruptions* and *proportion of breaks with delays*).

2.4 Data structure and statistical analysis

There are four repeated measures for interruptions, proportion of breaks with delays, and strain for every person (in total 160 observations for every dependent and independent variable across all analyzed drivers). These repeated measures can be seen as nested within the person. Therefore, the data structure is hierarchical with two levels. The data was analyzed in two ways: considering this hierarchical structure and not considering it. Hierarchical Linear Modeling was conducted using HLM software (sixth edition), which is available online (Raudenbush, Bryk & Congdon, 2004) and explained by Woltman, Feldstain, MacKay and Rocchi (2012).

3 Results

3.1 Interruptions and strain of tram drivers

On average, there was only a small amount of additional time due to interruptions (see Table 1) – in most cases just a few seconds with a maximum of about fifteen minutes in a single segment (6-8h). There were some workdays where there was no additional time due to interruptions at all. The range for the average amount of additional time was between 2 seconds (4-6h) and 35 seconds (6-8h). On average there were 75 seconds of additional time due to interruptions per day (SD = 182 seconds).

The most frequent (n = 42) and longest (M = 54 seconds) interruptions were impediments to driving. The second most frequent interruptions were (near) accidents (n = 23), but as predicted they led to only a small amount of additional time on average (M = 4 seconds). The second longest interruptions were vehicle damage or errors (n = 7, M = 27 seconds). The frequencies and lengths of the other interruption categories were: errors at traffic lights or track switches (n = 22, M = 19 seconds), negative behavior of passengers (n = 18, M = 1 second), and route deviations (n = 4, M = 3 seconds). In total n = 116 interruptions were recorded.

In every segment there were drivers who had a delay in every break or no break at all. Across all segments, no driver had a delay in every break (the highest measured quotient of delays was .9). On average, the quotient of delays (number of breaks in total divided by number of breaks with delays) ranged between .17 (4-6 h) and .36 (2-4 h). Across all segments, the drivers had a delay in 28% of all breaks (SD = 23%). Within the same measurement point of time the two indicators of interruptions were not significantly correlated, 0-2h: r = .19, p = .25; n = 39; 2-4h: r = .19, p = .25; 4-6h: r = .11, p = .51; 6-8h: r = .31, p = .05, but the total measures across all segments were significantly correlated, r = .43, p = .01.

Table 1 shows the descriptive data for the two indicators of interruptions across the different time points of measurement. Repeated measures Analyses of Variance (ANOVAs) with Greenhouse-Geisser adjustments for degrees of freedom revealed significant differences for the proportion of breaks with delays, $F(2.39, 93.15) = 3.38$, $p = .03$, $\eta_p = .08$, but not for additional temporal effort, $F(1.30, 49.47) = 1.14$, $p = .31$, $\eta_p^2 = .03$. Comparisons between points of measurement through Bonferroni-adjustment showed a significant difference between the proportions of breaks with delays between the segments 2-4h and 4-6h.

The means for the different short-term consequences of strain are presented in Table 1.

Repeated measures ANOVAs with Greenhouse-Geisser adjustments revealed a significant increase in fatigue over the shift, $F(2.55, 99.41) = 21.76$, $p = .00$, $\eta_p^2 = .36$. There were no significant changes over the

Tabelle 1: Descriptive statistics for indicators for interruptions and short-term consequences of strain.

Descriptive statistics		Measurement point			
		0-2h	2-4h	4-6h	6-8h
Indicators for interruptions					
Additional time	*M*	0:00:19	0:00:18	0:00:02	0:00:35
	SD	0:00:51	0:00:47	0:00:10	0:02:30
Quotient delay	*M*	.28	.36	.17	.28
	SD	.30	.38	.26	.36
Short-term consequences of strain					
Fatigue	*M*	1.84	1.97	2.23	2.79
	SD	.71	.83	.76	1.03
Stress	*M*	1.48	1.43	1.41	1.41
	SD	.79	.58	.63	.60
Monotony	*M*	2.17	2.05	2.13	1.92
	SD	1.08	1.13	1.19	.93

Notes: The quotient of delay is the total number of breaks divided by the number of breaks with delays. A quotient equal 0 means, that the driver was on time in every break and a quotient equal 1 means, that the driver had a delay in every break.

Table 2: Correlations between indicators for interruptions, professional experience and short-term consequences of strain.

	Professional experience	Measurement point											
		0-2 hours			2-4 hours			4-6 hours			6-8 hours		
		Stress	Fatigue	Monotony	Stress	Fatigue	Monotony	Stress	Fatigue	Monotony	Stress	Fatigue	Monotony
Total													
Additional time	.13										-.03	.01	-.10
Quotient delay	-.09										.31*	.26	-.10
0-2 hours													
Additional time	-.06	.44**	.11	.15	.12	-.24	.21	.10	.01	.09	.06	.08	.15
Quotient delay	-.31	.12	-.10	-.11	.50**	-.18	.10	.26	.32*	-.07	.31	.29	.02
2-4 hours													
Additional time	.13				.51**	.01	.05	.44**	.02	.01	.19	.11	.01
Quotient delay	-.37*				.40*	-.15	-.02	.24	.20	-.02	.38*	.20	.09
4-6 hours													
Additional time	.04							-.13	-.28	-.11	-.19	-.24	-.12
Quotient delay	-.01							.08	-.15	-.24	-.09	-.05	-.26
6-8 hours													
Additional time	.14										-.11	-.04	-.17
Quotient delay	-.10										.24	.21	-.12

Notes: $^{*}p < .05$. $^{**}p < .01$.

course of a workday for stress, $F(2.30, 89.83) = .26$, $p = .80$, $\eta_p^2 = .01$, or monotony, $F(2.29, 89.14) = 1.49$, $p = .23$, $\eta_p^2 = .04$.

3.2 Relationships between interruptions and strain – between participants

Correlations between interruption variables and short-term consequences of strain were first analyzed between participants (see Table 2). There was no significant correlation between total additional time and strain measured after the workday. The total quotient of delay in breaks had a significant positive correlation with stress, but not with fatigue or monotony (6-8h). There were several significant effects for additional time and stress at different points of the workday. Sometimes an interruption indicator was not only related to the strain measure in the same segment but also in a later segment. For example, the additional time due to interruptions between the second and the fourth working hour (2-4h) was positively related to stress after four hours and after six hours. This was the same case for the delay quotient. The delay quotient for the segment 2-4h was correlated with stress after four and eight hours. The proportion of breaks with delays in the first two hours was correlated with stress after four hours and fatigue after six hours. There was no significant correlation with monotony. Table 2 also shows that professional experience is correlated with fewer breaks with delays between the second and fourth hour of the shift.

3.3 Relationships between interruptions and strain – Within participants

To investigate the overall effect of indicators for interruptions associated with high work intensity on short-term consequences of strain, we used multilevel modeling. First, we calculated the unconstrained null model to test whether there were differences in the outcome variables (strain) between participants on the group level (see Table 3). The equations for testing the null model were the following:

Level 1: $\textit{Strain measure} = \pi_0 + e$

Level 2: $\pi_0 = \beta_{00} + r_0$

The results of the chi-square test were statistically significant for all outcome variables, which justified conducting multilevel modeling. The intraclass correlations for each strain measure are also presented. They are calculated as a quotient from τ_{null} divided by the sum of τ_{null} and σ^2_{null}. It represents the portion of variance associated with the group level compared to level 1. Except for fatigue, all outcome variables showed a higher amount of variance on the group level (between participants). For fatigue, 60 % of the variance was attributed to the individual level – in this case between repeated measurements.

As a next step, the two predictors at level 1 – additional time though interruptions and the delay in breaks quotient – were added to the regression equation as group-centered variables:

Level 1: $\textit{Strain measure} = \pi_0 + \pi_1 \textit{(additional time)} + \pi_2 \text{(quotient delay)} + e$

Level 2: $\pi_0 = \beta_{00} + r_0$
$\pi_1 = \beta_{10} + r_1$
$\pi_2 = \beta_{20} + r_2$

The results for the random intercepts model are presented in Table 4. Only additional time was a significant predictor of fatigue. The quotient for delays in breaks was not a significant predictor for any outcome variable.

To measure the amount of variance explained by the level 1 predictor variables in the outcome variables as an effect size, we calculated the quotient from σ^2_{null} minus σ^2_{random} divided by σ^2_{null}. The two predictor variables explained only a small amount of variance in the strain measures, most for fatigue and least for monotony.

Table 3: Unconstrained null model (without predictors).

Dependent variables	Variance level 1 σ^2_{null}	Variance level 2 τ_{null}	*ICC*	*df*	*Chi²*	*p*
Stress	.19	.23	.55	39	240.36	.00
Fatigue	.49	.33	.40	39	146.41	.00
Monotony	.32	.84	.72	39	457.38	.00

Table 4: Random intercepts model.

Predictors level 1	Coefficient β_{stand}	p	Variance σ^2_{null}	Variance σ^2_{random}	Effect size r^2
Outcome – Stress					
Additional time	.002	.127	.186	.166	.110
Quotient delay	.109	.381			
Outcome – Fatigue					
Additional time	.001	.007	.492	.392	.204
Quotient delay	-.201	.498			
Outcome – Monotony					
Additional time	.0002	.436	.321	.304	.052
Quotient delay	-.165	.422			

Notes: Because very small effects are displayed here more decimals are presented for each number.

4 Discussion

4.1 Interruptions and acute stress and fatigue

It was hypothesized that both indicators for interruptions would be related to an increase in the experience of acute stress (Hypothesis 1) and fatigue (Hypothesis 2). Empirical support for both hypotheses is mixed. Taking the hierarchical structure of the data into account (at the within-participants level) additional temporal effort due to interruptions manifests itself immediately in the experience of fatigue. The coefficients may be quite small but can be used to make a statement about what happens. For example, if there are 10 minutes (600 seconds) of extra time due to interruptions, experiences of fatigue would increase by 0.6.

The underlying mechanisms might be related to increasing work intensity. The driver's schedule is technically manageable, but interruptions that come with extra tasks and time are not considered in that schedule. Due to the maximum time constraints of a tram driver's task, there are no possibilities for coping but speeding up, which violates organizational and traffic regulations. According Rau and Göllner's (2018) work intensity model, additional time due to interruptions creates an imbalance between the amount of work and the available time. The driver gets in a hurry and resources are depleted. Thus, it seems plausible that every interruption with additional temporal effort increases the fatigue level of the driver. Meijman and Mulder (1998) described this as „effortful coping", which is accompanied by elevated activity in the autonomous nervous system. If the demands exceed the possibilities for self-regulation and there are no other possibilities for adapting to this high load, then a fatigue reaction is the consequence.

For delays in breaks, another picture emerges. The reaction to shortened breaks manifests itself up to four hours later in consequences of strain. Therefore, there could be no relationship at the within-participants level for proportions of breaks with delays with any consequence of strain Drivers don't always react immediately with an adaption of stress or fatigue. The results point to a delayed fatigue reaction: the experience of fatigue after six working hours is related to the proportion of breaks with delays in the first two hours of the shift. There is also a delayed stress reaction: the experience of stress after the workday is associated with the proportion of breaks with delays between the second and fourth hour of the shift. Shortened breaks are always caused by smaller or larger interruptions during driving and apparently imply insufficient recovery for the drivers. According to the effort recovery model (Meijman & Mulder, 1998) and the compensatory control model (Hockey, 1997), this should lead to a suboptimal state to meet the demands and therefore an incomplete compensation of load reactions. Drivers must make additional compensatory effort to cope with the ongoing confrontation with load and a cumulative process starts, if there are no sufficient possibilities for recovery subsequently. This eventually leads to feelings of stress and fatigue and other impairments of health and well-being (Baethge et al., 2015; Meijman & Mulder, 1998; Sonnentag, 2003). A delayed fatigue reaction is also plausible for the relationship between additional temporal effort and fatigue, but the results only pointed to an immediate reaction at the within-participants-level. Additional temporal effort usually means that the driver has to speed up to be still in time. Apparently this causes an immediate feeling of fatigue, which is based on the results compensable during subsequent sufficient recovery time. Only if the break time is shortened and therefore more likely to cause an insufficient recovery, than the described cumulative process starts and leads to prolonged feelings of fatigue and stress throughout the work day.

Thus, there are no relationships between indicators for interruptions and consequences of strain in the second half of the shift. In the second half of the workday, coping with interruptions depends on a sufficient recovery in the first half. If drivers were able to fully recover in the first half of their shift, then they can cope with interruptions in the second half as well. These results are in line with results from Meijman and Kompier (1998), who accompanied 27 bus drivers for 2 work-days and examined objective workload indicators and subjective appraisals of the effort made to cope with time pressure, safety, and passengers using different physiological measures and feelings of activation versus deactivation. Objectively measured workload indicators and perceived effort are more strongly related in the second half of the bus drivers' shifts. Besides that, physiological activation during the second half was related to increased feelings of tension. In this regard, Meijman and Kompier (1998) stated that „physiological activation may be interpreted as a compensatory reaction in the effort to sustain work performance under conditions of increasing fatigue“ (p. 117). This also applies to the current results, which implicate thatthe tram drivers showed increased feelings of fatigue and stress in the second half of their shift due to shortened breaks and additional temporal effort due to interruptions in the first half.

4.2 Interruptions and acute monotony

It was hypothesized that additional temporal effort and delays in breaks would lead to a decrease in monotony. This was based on the assumption that interruptions usually mean changes in the task and thus increased requirements for cognitive regulation, which should, by definition, decrease monotony. This can neither be confirmed at the between-participants level nor the within-participants level. Therefore, Hypothesis 3 must be rejected.

The most frequent interruptions for tram drivers with the longest average additional temporal effort were impediments to driving. These incidents indeed interrupted the task, but hardly enhanced the level of cognitive regulation. This also applies to other interruptions for tram drivers, like near accidents. Baethge and colleagues (2015) stated that interruptions do not have a negative effect on performance if they are perceived as job enrichment. There is actually an improvement in performance if a monotonous task is interrupted (Mark, Gudith & Klocke, 2008; Speier, Valacich & Vessey, 1999; Zijlstra et al., 1999) and a decline in feelings of boredom (Fisher, 1998). The drivers only experienced rather small levels of monotony in the current study. Thus, there was not much potential for a decrease in monotony. Taken together, the interruptions for tram drivers cannot be seen as job enriching. Hence it seems reasonable that the indicators of interruptions were not associated with a decrease in monotony.

4.3 Limitations and strengths

In general, the analysis of one occupational group in one company for one day represents a limited sample in more than one way. The high comparability of demands across different drivers is an advantage for the analysis of a single characteristic of work, like interruptions (Spector, 1992), because effects on consequences of strain of other work demands are constant and do not contribute to the variance of strain under study. This was important for the study, because the effects of interruptions under conditions of high time constraints and low control should be scrutinized.

The independent variables might be more determined by the driver's person than previously thought. The driver has great influence on the length of additional temporal effort. For drivers, who just finished driving school, knowledge about handling interruptions is more salient. However, more experienced drivers might have more professional experience with possible interruptions and may be more capable of handling them (Burger et al., 2010; Trafton & Monk, 2007; Zijlstra et al., 1999). Due to this ambivalent role, it seems reasonable that there was no relationship between professional experience and additional temporal effort. There are similar concerns about the measure of delays in breaks. For the same reasons as mentioned above, the drivers differ in the additional effort they make to compensate for lost time caused by interruptions. There might be drivers that show more additional effort and therefore have fewer breaks with delays. Importantly, drivers that are more experienced have fewer breaks with delays between the second and fourth work hour. Taken together, there is probably more inter-individual variance for additional temporal effort and the proportion of breaks with delays due to interruptions that are not due to the interruption itself, than expected. The validity of the indicators for interruptions used in the present study might be a threat to the explanatory power of the results.

The calculation of relationships between observational and self-report data is also ambivalent. On the one hand, the relationships are not biased through the same source of variance and are therefore not overestimated (sources of variance are on the one hand the person, who provides the self-report measures and as in this case an observer, that provides observational data), but on the other hand it can also be underestimated, because self-reports of outcomes are influenced by various sources and environmental factors are only one of them (Frese & Zapf, 1988; Spector, 1992).

4.4 Future research

As this study looked at short-term consequences of interruptions and indicators of interruptions were measured prior to the outcome variables, the relationships can be interpreted causally. Future studies should also include longer time periods. One possibility would be a diary study over the course of a complete day, so that impairments for recovery after work in relation to interruptions could be analyzed.

Other considerations for future research are possible mediators and moderators for the relationships between interruptions and outcomes regarding health and well-being. The present study could not provide substantial evidence for the positive influence of professional experience on the handling of interruptions. There was only one significant negative correlation between professional experience and delays in breaks. Tram drivers might not be the perfect sample to use when examining this relationship. Directly after driving school there is probably a large increase in beneficial effects of professional experience, which remains relatively stable after a short time. The impact of professional experience for interruptions might be more relevant for more complex jobs.

Rigotti (2016) called for the examination of strategies for dealing with interruptions. In terms of this study, this applies to the additional effort that drivers make to handle interruptions. Like in the studies among bus drivers described by Meijman and Mulder (1998), the effort for coping with interruptions should be measured at several points in time. This might be an important mediating variable for the relationship between interruptions and outcomes regarding health and well-being.

4.5 Implications and conclusions

The present study showed that additional temporal effort is related to an immediate in-crease in the experience of fatigue, whereas delays in breaks due to interruptions in the first half of the shift cause a delayed stress and fatigue reaction in the second half. This is probably related to an increased and cumulated effort to deal with interruptions under conditions of high time constraint and low control (Hockey, 1997).

For the occupation of drivers in local public transport, the results reveal meaningful conclusions. Interruptions are not considered in schedules. They may be short-term incidents, but most modern schedules are planned to the minute. Companies adhere to applicable laws and regulations and the schedule is basically feasible. But it is not capable of dealing with interruptions, which increase work intensity and mostly result in shortened breaks due to a lack of coping alternatives (significant correlation between total additional time due to interruptions and proportion of breaks with delays). Based on the current results, one implication is that the current regulations for schedules are not in the interest of the driver´s health or guarantee sufficient recovery during work. Therefore, current schedule policies should be reworked to ensure health-promoting rather than health-threatening work conditions for the drivers. Transport companies should also find options to guarantee adequate breaks even in cases of delays for the drivers, especially in the first half of their shift. Based on the result that every additional temporal effort due to interruptions is linked to an increase in the experience of fatigue, schedules should not be too tight. Otherwise, the already poor health situation of drivers in public transport will become worse (Evans & Johansson, 1998; Greiner et al., 1998; Tse et al., 2006). An increasing experience of fatigue is also to be viewed critically with regard to an increasing risk of accidents. Mental fatigue is associated with a deficiency in functional efficiency due to losses of concentration and exhaustion (Demerouti et al., 2002). For drivers in local public transport there is a link between feelings of tiredness and accidents (Anund, Ihlstrom, Fors, Kecklund & Filtness, 2016).

Another more general implication is in regard to the digitization of work, which comes with extended availability and the presence of electronic communication devices in work contexts. Under these circumstances, interruptions at work probably will increase (Jett & George, 2003; Sonnentag, Reinecke, Mata & Vorderer, 2018). As the present study is the first to examine relationships between interruptions and short-term consequences of strain, there should be more studies that look at those short-term consequences, especially for „modern“ work places.

No digital progress should come at the expense of the health of employees, and the design of these modern workplaces should always seriously consider the possible threats to health, well-being, and performance due to increased interruptions.

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