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ORIGINAL ARTICLE

Effects of task interruptions caused by notifications from communication applications on strain and performance

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Abstract

Objectives: To examine the effect of automatic communication notifications on performance and strain. Because of the benefits of communication, we expected this effect to be moderated by fear of missing out (FoMO) and social norms of responsiveness, expressed in the experience of telepressure.

Methods: A field experiment ($N = 247$) was conducted in which participants in the experimental group disabled their notification during 1 day ($N = 124$).

Results: The findings revealed that a reduction of notification-caused interruptions is beneficial for performance and reducing strain. The moderating of FoMO and telepressure was significant for performance.

Conclusions: Based on these findings, reducing the number of notifications is recommended, especially for employee's low in FoMO and medium to high telepressure. Future work needs to analyze the role of anxiety impeding cognitive performance when notifications are disabled.

KEYWORDS

FoMO, interruption, notification, performance, social norms, telepressure

1 | INTRODUCTION

"Do you expect to read this [Article] without interruptions [caused by your smartphone or notebook]?"[1(p. 308)]

Probably not. As indicated by this introductory quote, task interruptions are ubiquitous today, as information and communications devices provide always-on connectivity.[2] With about 65.3 notifications per day, these visual-, auditory-, and haptic signals of new incoming information on ICT devices have become a prominent source for interruptions.[3] In this way, they support collaborative practices, instant communication and the feeling to be connected to others.[4,5] However, these benefits need to be considered alongside the negative effects through high frequency of notification[6] and their interrupting character.[2] In addition to these overall negative effects, more recent research has started to explore potential positive effects of interruptions. Together, these findings suggest that interruptions, despite their cognitive costs, might also have positive effects, and these positive effects depend on individuals' goals and needs.

Recent studies on the effects of deactivating notifications (or e-mails) for a certain amount of time[4,7–10] indicate that turning off notifications can have positive effects on performance and reduced strain due to less interruptions.[7] However, findings indicate high variability in effects[8]: Whereas some individuals reported higher productivity and lower stress levels, others do not, which can

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be explained by an increase of self-interruptions to check messages as well as more anxiety about missing messages.[4,7–10] These results suggest that boundary conditions need to be considered to better understand the effects of interruptions by notifications on performance and well-being. A possible boundary condition refers to individual differences in the level of fear of missing out (FoMO), which is the desire to be constantly connected with others.[11,12] FoMO is based on a fundamental human need for relatedness.[12] Notifications, as they help to connect people, contribute to the satisfaction of the need for relatedness through technology-based communication.[13] In this study, we refer to FoMO to explain why turning off notifications will result in worse outcomes in some individuals. We will argue below that individuals high on FoMO are motivated to self-interrupt which will in part explain why they do not benefit from turning off notifications and reducing interruptions.

Availability expectations as social norms to be available[3] arise partly due to the wide spread of mobile devices,[14] and differ between social settings[15] such as different work organizations. We will argue below that because humans try to adapt their behavior to these social norms,[16] they will try to cope with the situation in which automatic notifications are switched off by enhancing their self-checking behavior and internal interruptions.

The overall aim of this study was to analyze the effects of notification on strain and performance, and to provide an explanation for why turning off notifications differentially affect individuals. By examining the impact of task interruptions caused by notification of communication applications on well-being and performance, and by examining differential effects, this study contributes to knowledge on how to manage interruptions. The research model of this study is depicted in Figure 1. A quantitative field experiment with the treatment of notification presence (normal setting vs. disabled notifications) in a between subject design was conducted to answer the research question.

1.1 | Theoretical background

According to the action regulation theory (ART),[17] all human action is directed towards goals defined as "a mental representation of an intention to accomplish a task, achieve some specific state of the world, or take some mental or physical action"[18(p. 39)] and consists of sub goals on different levels of mental processing with different cognitive demands.[1] In terms of interruptions, this means that action plans have to be adjusted to the interrupting task[19] which requires additional mental effort by attentional shifts and the set of new goals and inhibition of the old ones. The interruption process begins with the attentional focus on a primary task, known as the pre-interruption phase, in which only "relevant" information for the current attentional focus or the execution of the primary task are selected to process them and other information in the sensory register are filtered out (inhibit).[20] The beginning of the second phase, the "interruption phase" starts at the moment an interrupting stimulus is perceived (not filtered out in the early stage) and forces attentional focus.[2]

After becoming aware of the "interrupting" stimulus and before the acceptance/handling of the interrupting task, an interruption lag emerges.[21] If the stimulus is accepted as a task (not inhibited), this can lead to

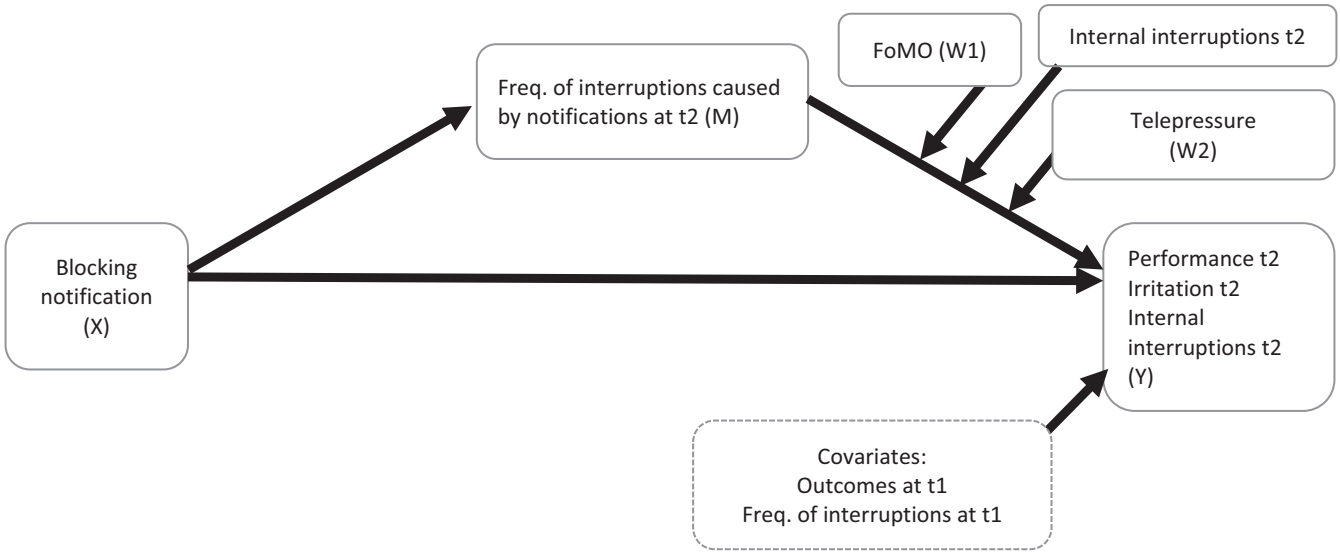

FIGURE 1 Theoretical model. *Note*: X, Y, M, W1, and W2 refer to notifications in Hayes process macro. t1, t2 refer to the first and second survey.

dual-tasking, or an interruption that is processed immediately, negotiated, mediated, or scheduled. Assuming an immediate interruption, attentional and cognitive resources are immediately shifted and redistributed to the accomplishment of the interrupting task.[2,22] This also includes the adjustment of goals.

The last stage of the interruption phase constitute the "resumption lag".[21] This lag includes the period of time starting after completion of the interrupting task and including the time needed to retrieve information to the short-term memory to return to the primary task on pre-interruption level.[23] Even interruptions which were only perceived and not actively handled lead to a resumption lag. The interruption process provides several indications for the predominantly negative effects due to task switching demands, interferences between activated goals, and the interruption/resumption lag resulting in additional effort and time.[19,21]

1.2 | Effects of interruptions

Because dealing with interruptions requires effort, task interruptions are in general detrimental for performance and increase strain,[13] particularly in the case of external unanticipated interruptions.[1] Interruptions were found to cause more annoyance and anxiety, increase stress and frustration, and lead to errors in the primary task, less task accuracy and to longer task competition times or to the use of suboptimal strategies as well as to forgetting about the primary task.[1]

Three different pathways for these negative effects have been discussed: cognitive-, self-regulatory-, and affective pathway.[13] In the cognitive pathway, mental workload increases due to the demands of task switching and maintenance of primary task components while executing the interrupting task[1,12] which is cognitively demanding and time consuming and reduces productivity.[19,24] The self-regulation pathway describes the processes of goal adjustment triggered by interruptions, such as suppressing primary task goals and forcing interrupting task goals. Because interruptions hinder the achievement of the primary task goals and slow down the goal progress, they do also have motivational and affective implications such as frustration,[13] as frustrations occurs when the primary task goals and desired states are deferred.

Although positive effects of interruptions on outcomes are possible, the overwhelming evidence suggests negative effects. The amount of interruptions experienced at work today, are mainly evoked through ICT,[25] for example by voice calls, email, instant and text messages, or by pop ups of social media notifications.[13,26] Due to their high frequency, notifications remain the main source of interruptions in the field of ICT[4,7,10] although not every notifications is attended to.

We therefore expect that turning off automatic notifications is overall beneficial for individuals' performance, which is supported by empirical evidence that most external interruptions harm performance.[13] Reducing notification-caused interruptions through batching notifications to three times a day, improved productivity at the end of the day with a moderate effect size.[8] In the study of,[7] participants also reported higher productivity in the condition with notifications disabled and fewer interruptions caused by notifications. More interruptions increase time loss due to the requirements of task switching (more mental effort) and more (cumulative) resumption lags[27,28] which is detrimental to reaching (daily) performance goals.[27] Using a compensating strategies, such as working faster, results in a decrease in quality of performance (i.e., less accuracy and more errors).[20,29] Thus, on basis of the available evidence we expect:

> ***H1.*** Fewer interruptions caused by notifications lead to a higher performance at the end of the day.

Following the ART, interruptions are considered as stressors, because interruptions impede or hinder the employee from achieving a set goal[28,30,31] on primary tasks. The accumulation of interruptions over the day could also threaten the accomplishment of the daily goal[19] which is detrimental for well-being. The additional time required due to interruptions creates distress because individuals need to work faster to get work done.[24,32] Working faster on the interrupting task in order to quickly return to the primary task as a compensating strategy comes at the expense of well-being.

In this study we focus on irritation, defined as "a state of psychological impairment [as a result of experiencing stress at work] caused by perceived goal discrepancy"[19(p. 50)] which includes both a cognitive (e.g., rumination on problems at work) and an emotional dimension (e.g., reacting grumpily).[33] Irritation is a reaction on acute stress felt during the workday[33] and related to variation in daily interruptions. Based on the available evidence on interruptions and strain, we hypothesize.

> ***H2.*** Fewer interruptions caused by notifications lead to a lower irritation at the end of the day.

Although notifications are disrupting, there are also benefits such as real time information delivery or enhancing the feeling of relatedness,[4] which is in line with the recently demonstrated positive effects

of interruptions.[34] We suggest that individuals' goals and needs differ, and thus, the positive effects might prevail for individuals who like to be connected and available to others, that is individuals high on FoMO. FoMO is defined "as a pervasive apprehension that others might be having rewarding experiences from which one is absent,"[12(p. 1841)] what leads to the desire to constantly be connected with others,[11,12] and maps onto the basic human needs of relatedness. According to self-determination theory, when basic human needs are fulfilled, intrinsic motivation, performance and well-being arise. The need for relatedness is a powerful motivational drive to connect with others.[11] The use of ICT with applications such as instant messengers or social media platforms have significantly facilitated the opportunities to always connect with others, sharing content or have rewarding experiences with one's network[35] giving the user the opportunity to always be connect to others. When notifications are blocked, fewer interruptions from notifications might lead to lower feeling of relatedness and feeling socially separated.[4]

For this reason, we expect individuals with fewer automatic notifications to interrupt themselves more often to check for missed notifications and to satisfy the need for relatedness.[8] This connection between fewer notifications and higher rates of checking behavior have been demonstrated in several notification disabling studies.[4,7,8] We expect individuals high on FoMO to interrupt themselves more often to check for missed notifications because they will be anxious to miss something when notifications are disabled. Taken together, because of the lower feeling of relatedness, higher anxiety to miss important information, and because of the expected increase in internal interruptions, a reduction in notification-caused interruptions will have a smaller impact on strain and performance for individuals high in FoMO than for individuals low in FoMO. We thus expect.

H3. FOMO will moderate the relationship of interruptions and outcomes.

H3.1. For individuals high on FoMO, a reduction in interruptions caused by notifications will have a smaller effect on performance, compared with individuals low on FoMO.

H3.2. For individuals high on FoMO, a reduction in interruptions caused by notifications will have a smaller effect on irritation, compared to individuals low on FoMO.

H3.3. For individuals high in FoMO, a reduction in interruptions caused by notifications lead to more internal interruptions, compared to individuals low in FoMO.

1.3 | Social norms about responsiveness: telepressure

Differences in social norms can also explain heterogeneous study findings. The social norms about responsiveness, are expressed in the experience of telepressure, a maladaptive psychological state and desire to confirm to the responsiveness norms of others, for example, the work or study group.[14,16] In other words telepressure represents the internal pressure to stay connected due to the interpretation of social norms.[36] Due to the lack of an appropriate multi-item questionnaire on social norms about responsiveness[14] the construct telepressure is used as an indicator of a maladaptive response to high (or low) social norms about responsiveness.

The experience of telepressure could neutralize the advantages of asynchronous communication applications by using these applications similarly to synchronous forms, which typically require an immediate response due to high social norms regarding responsiveness.[16] Because notifications are an essential part to supporting immediacy and fast response times,[7] reducing or disabling notification could result in higher checking behavior of missed notifications, to avoid violating responsiveness expectations.[4,7,8] Consequently, telepressure, as an indicator of high social norms about responsiveness, could explain differences in checking behavior after disabling notifications and differences between individuals in the effects of interruptions by notifications on performance and strain.[7] Especially for individuals high in telepressure such reduction of notifications could lead to a high frequency of checking missed notifications also at inappropriate times, in order to not violate responsiveness expectations. Due to these increase in internal interruptions for individuals high in telepressure, lower increase in performance and well-being than individuals low in telepressure could result. Therefore, it is hypothesized:

H4. Telepressure will moderate the relationship between interruptions and outcomes:

H4.1. For individuals high in telepressure, a reduction in interruptions caused by notifications will have a smaller effect on performance compared to individuals low in telepressure.

H4.2. For individuals high in telepressure, a reduction in interruptions caused by notifications will have a smaller effect on

irritation, compared to individuals low in telepressure.

H4.3. For individuals high in telepressure, a reduction in interruptions caused by notifications lead to more internal interruptions than for participants low in telepressure.

2 | METHOD

2.1 | Procedure and manipulation

Participants were recruited using social networks and personal contacts. They received a chance of winning one out of four vouchers worth 10 Euros. In addition, they were instructed that 50 cents per participants would be given to welfare (which was realized after the experiment). To ensure a high number of participants, we included students in addition to working individuals, based on the rationale that they would need be able to concentrate on tasks related to their studies, and show similar behavior. Moreover, most students in Germany work part-time. After receiving information concerning data protection, giving informed consent, participants filled out a baseline questionnaire (t1) assessing their natural checking behavior, FoMO, telepressure, the baseline of our outcome measures (strain and performance), and demographic variables in the first questionnaire. To prevent dropout, the experiment was limited to one work day (similar to[7]). Participants were instructed to select a suitable day for this experimental part, and to set a daily performance target (e.g., completing a specific task).

Participants were randomly assigned to one of two experimental conditions 1 day before the preselected day. In the experimental condition participants were asked to disable notifications as far as possible across all ICT devices (notebook, mobile phone, and wearables) and applications (e-mail client, instant messages, and social media platforms) to reduce the frequency of notification-caused interruptions, similar to Pielot and Rello's notification disabling study. They received detailed instructions on how to disable the automatic communication notifications across their devices (mobile phones, notebooks, and wearables). Participants in the control condition used their baseline notification settings. On the day of the experiment, they were reminded to set a daily performance target. They filled out the second questionnaire at the end of the day (t2).

2.2 | Sample

A total of 288 individuals completed both questionnaires, equaling a completion rate of 84.21%. After data cleaning on the basis of incomplete data or duplicates (elimination of 6 cases) and response duration of an average of less than 5 s per item (elimination of 35 cases), 247 cases remain in the final sample. In the final sample, 162 (65.6%) were female and 110 (44.5%) were employees. The mean age was 28.15 years (SD = 7.38), ranging from 18 to 62 years, with 80.2% participants 30 years or younger. 71.5% indicated having a bachelor's degree or higher level of education. 73.3% of the participants work (mostly) from home office during the data collection, 18.2% live alone in a household, and on average, participants reported to have a collaborative job with a mean of 2.48 on the perceived task interdependence (see below).

2.3 | Measures

Each of the following questionnaires were adapted to be suitable for both employees and students and to notifications during one working day. Non-German items were translated into German using the tool "deepl.com" and manually corrected. All measures were collected via self-report.

Frequency of interruptions were assessed using a single item: "How often are you getting interrupted by notifications?" (1 = never to 5 = very often).*

Internal interruptions to check messages were assessed using the item: "How often do you interrupt yourself to check messages or missed notifications" (1 = never to 5 = very often).

Performance was assessed using the perceived productivity scale of[29] consisting of six items. All responses are measured on a 7-point Likert scale, ranging from 1 = not at all to 7 = extremely. To ensure participants had a performance goal in mind when rating their performance, they were asked to set a "day target" and to respond with this goal in mind. A sample item was "Compared to what you had planned, how much did you achieve?" Although students and employees might have different daily performance goals (e.g., finishing a term paper vs. completing a work task), their goal attainment might be equally affected by frequent interruptions. Cronbach's alpha was high at t1 (.907) and t2 (.932).

Irritation was assessed using the scale by[33] which consists of eight items targeting experienced imbalance between personal resources and everyday strain. A sample item is "I get irritated easily although I do not want this to happen." All responses were measured on a 7-point Likert scale, with 1 = not true at all to 7 = totally true. Cronbach's alpha was high at t1 (.872) and t2 (.881).

Fear of missing out was assessed using a scale[12] consisting of 10 items, which targets the general FoMO rewarding experiences, using a German translation by Ref. [37].

A sample item is "I fear others have more rewarding experiences than me." The response options of the statements ranged on a 5-point Likert scale, from 1 = "does not apply at all" to 5 = "does apply completely to me." Cronbach's alpha was .775 in the current study.

Telepressure was assessed using a scale[16] consisting of six items assessing participants' experience of pressure to immediately respond to messages. The response options of the statements ranged from 1 = "do not agree to 7 = "strongly agree". Cronbach's alpha was .884.

Because individuals might feel worse and perform worse when they miss important message from collaborators especially when working in highly interdependent contexts, we assessed task interdependence as a control variable. A sample item is "I need information and advice from my colleagues to perform my job well." using[38] on a 5-point scale, ranging from 1 = "completely agree" to 5 = "completely disagree." Cronbach's alpha was .839.

As an additional check if our manipulation was successful, we assessed self-checking behavior ("I check emails, instant messages and social media news...") ranging from 1 = "always through external notifications" to 5 = "always initiated by myself and never through external notifications." Whereas internal interruptions to check messages can be regarded as a maladaptive response to blocked notifications, self-checking might be regarded as adaptive behavior to receive messages at appropriate times (e.g., after finishing a task). Demographic variables such as age and gender, working from home were measured respectively in single items.

Analyses. The statistical analysis was conducted using the software SPSS and Hayes PROCESS macro[39] using model 4 (mediation model) and model 14 (moderated mediation). Specifically, model 4 tests the indirect effect of the intervention X on the outcomes Y (performance or irritations) through the mediator M (frequency of interruptions). Model 14 tests whether the effect of the mediator on the outcomes (performance, irritation, and internal interruptions) is moderated by FoMO or telepressure (see Figure 1). In the analyses we controlled for the respective outcome (i.e., performance or strain) and, in Model 4, for the mediator frequency of interruptions at t1. Task interdependence was unrelated to most study variables (Table 1), but correlated to performance. We thus included task interdependence as a covariate in a robustness check. Because the sample included both students and employees, we checked for differences between the two groups using t-tests. Students reported higher FoMO, lower performance at t1 and t2, and lower task interdependence. We thus controlled for student status in an additional robustness check.

To check if participants followed instructions and changed their behavior, a repeated measures ANOVA was conducted to test for significant differences between the two groups for the frequency of interruptions, internal interruptions (as maladaptive response to blocked notifications) as well self-checking (as an adaptive response to blocked notifications) using t2 data, and controlling for the respective outcome assessed at t1.

3 | RESULTS

Descriptive statistics and intercorrelations for all variables of t1 and t2 are presented in Table 1. Of note, irritations exhibited a high stability ($r = .75$, $P < .01$). Consistent with our differentiation of adaptive and maladaptive responses to blocked notifications, internal interruptions were related to lower performance and higher irritations, while self-checking was unrelated to both outcomes.

The ANOVA results are shown in Table 2. For frequency of interruptions, results revealed a significant group × time interactions. Analyses of simple main effects indicate that the frequency of interruptions at t2 was lower in the experimental group than in the control group ($F = 37.92$, $P < .001$) whereas the groups did not differ at t1 ($P = .55$). These results indicate that our manipulation was successful. For self-checking, results show a significant group × time interaction. Analyses of the simple main effects indicate that at t1, the control group showed higher self-checking than the experimental group ($F = 4.98$, $P < .05$) whereas at t2, the experimental group showed higher self-checking than the control group ($F = 24.59$, $P < .001$). The simple effect of time was significant in the experimental group ($P < .001$), but not in the control group ($P = .152$). For internal interruptions, the group × time interaction was not significant, indicates that blocking automatic notifications in the experimental group did not increase internal interruptions to check for messages.

3.1 | Hypothesis testing

Hypothesis 1 stipulates an indirect effect of the intervention on performance via reduced interruptions. Results can be seen in Table 2 (left part). The intervention reduced the frequency of interruptions t2, and interruptions t2 was negatively related to changes in performance. Moreover, the indirect effect via this mediator to was significant, as indicated by the bootstrapped confidence interval excluding zero. Thus hypothesis 1, fewer interruptions caused by notifications lead to a higher performance was confirmed.

Hypothesis 2 stipulates that the intervention is effective in reducing strain via reducing interruptions. Results can be seen in Table 3 (right part). The intervention

TABLE 1 Intercorrelations of all study variables.

		M	SD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	Age	28.15	7.38																	
2	Gender	1.66	0.48	−.09																
3	Intervention	1.50	0.50	−.03	.15															
4	Status	1.56	0.52	−.44	.23	.02														
5	Home office	1.27	0.44	.23	−.08	.03	−.39													
6	Task interdepend.	2.48	0.89	−.12	.06	.07	.25	−.21												
7	FoMO	2.39	0.62	−.21	.04	.02	.17	−.12	−.01											
8	Telepressure	3.43	1.18	.09	−.10	−.16	−.10	.03	.17	−.28										
9	t1 Internal interruption	3.61	0.77	−.13	.19	−.07	.14	−.10	−.11	.16	−.38									
10	t2 Internal interruptions t2	2.94	0.86	.02	.14	.01	.07	−.09	.02	.13	−.18	.25								
11	t1 Self-checking	3.05	0.98	.16	.03	−.14	.10	.09	−.03	.06	−.08	.01	−.01							
12	t2 Self-checking	3.37	1.10	.07	.08	.30	.08	.03	.08	.06	−.08	−.03	.13	.31						
13	t1 Interruptions	3.49	0.81	−.10	.07	.04	.09	−.14	−.16	.10	−.27	.50	.18	−.30	−.19					
14	t2 Interruptions	2.50	.89	.10	−.10	−.37	−.16	.02	−.09	.12	−.08	.04	.25	.01	−.40	.16				
15	t1 Irritations	3.49	1.24	−.02	.11	.07	.07	−.05	−.07	.38	−.27	.19	.19	.06	.07	.16	.09			
16	t2 Irritations	3.15	1.19	−.03	.09	.04	.11	−.02	−.02	.41	−.22	.18	.23	.09	.03	.14	.16	.75		
17	t1 Performance	4.63	1.07	.16	−.01	−.03	−.24	.19	−.19	−.24	.09	−.25	.00	−.07	.08	−.11	−.02	−.13	−.18	
18	t2 Performance	4.87	1.13	−.01	−.05	.00	−.12	.12	−.14	−.17	−.12	−.09	−.26	−.09	.01	−.13	−.18	−.14	−.23	.40

Note: $N = 247$. Intervention was coded as 1 = control group 2 = experimental group. Status was coded as 1 = employee 2 = student. Home office was coded as 1 = true 2 = false.
$|r| > .12$, $P < .05$; $|r| > .16$, $P < .01$; $|r| > .22$, $P < .001$.

TABLE 2 Means, standard deviations and results of the mixed ANOVA.

			t1		t2		Effect of time	Effect of group	Effect of time × Group
		N	*M*	SD	*M*	SD	$F(1, 245)$, partial η^2	$F(1, 245)$, partial η^2	$F(1, 245)$, partial η^2
Freq. interruptions	Experimental group	124	3.52	0.81	2.18	0.84	222.65*	13.50*	28.82*
	Control group	123	3.46	0.80	2.83	0.83	0.476	0.05	0.11
Self-checking	Experimental group	124	2.91	1.00	3.70	1.13	20.11*	3.27	42.55*
	Control group	123	3.19	0.94	3.04	0.95	0.08	0.01	0.15
Internal interruptions	Experimental group	124	3.56	0.82	2.94	0.83	111.38*	<1	<1
	Control group	123	3.67	0.71	2.93	0.89	0.313	0.00	0.00

Note: $N = 247$. Freq. Interruptions = frequency of interruptions through external notifications.

*$P < .001$.

significantly reduced interruptions, interruptions were related to changes in irritation. The indirect effect was significant, as evident by the bootstrapped confidence interval excluding zero. Thus, hypothesis 2 was supported.

Hypothesis 3 stipulates an interaction of FoMO and interruptions on (1) performance, (2) irritation, and (3) internal interruptions. Results for performance and irritation can be seen in Table 4, upper part. The interaction of frequency of interruptions and FoMO was significant in the case of performance, but not in the case of irritations. The conditional effects of interruptions at low ($M - 1$ SD), medium (M) and high ($M + 1$ SD) levels of FoMO are shown in Table 4, and are illustrated in Figure 2, panel 1. These findings suggest that for individuals with low and medium levels of FoMO, interruptions decrease performance, whereas for individuals high on FoMO, interruptions do not affect performance. This pattern is in line with H3.1. Thus H3.1, but not 3.2 is supported.

For internal interruptions as an outcome, the interaction of FoMO and frequency of interruptions was not significant (coeff. = −.03, SE = .08, $t = -.41$, $P = .68$). Thus, H3.3 was not supported.

Hypothesis 4 stipulates an interaction of telepressure and interruptions on (1) performance, (2) irritation, and (3) internal interruptions. Results for performance and irritation can be seen in Table 4. The interaction of interruptions and telepressure was significant in the case of performance, but not in the case of irritations. The conditional effects of interruptions at low (M – 1 SD), medium (M) and high ($M + 1$ SD) of telepressure are shown in Table 4, and are illustrated in Figure 2, panel 2. These findings suggest that for individuals with medium and high levels of telepressure, interruptions decrease performance, whereas for individuals low on telepressure, interruptions do not affect performance. This supports H4.1 about the differential effect of the intervention for different levels of telepressure, but not H4.2 concerning irritations.

As robustness check in two separate sets of analyses, including task interdependence or student status as additional covariate in the analyses did not change the results in a meaningful way, and task interdependence (student status) was not significantly related to frequency of interruptions or performance.

For internal interruptions as an outcome, the interaction of telepressure and frequency of interruptions was not significant (coeff. = .00, SE = .05, $t = -.07$, $P = .95$). Thus, H4.3 was not supported.

3.2 | Additional analyses

For individuals working in a strong collaborative context, high availability and response behavior is important to get work done, even though they are interrupted by notifications. We therefore tested whether task interdependence acts as a moderator in the relationship between reduced interruptions and performance or internal interruptions. The interactions did not reach significance (performance: coeff. = −.10, .08, $t = -1.27$, $P = .20$; internal interruptions: coeff. = .07, SE = .06, $t = 1.16$, $P = .24$), suggesting that reducing interruptions through notifications is effective, irrespective of task interdependence.

Because we argued that FoMO exerts its moderating effect partially through enhanced self-interruptions, we tested internal interruptions as an additional moderator, but the results revealed it is not (coeff. = .04, SE = .06, $t = .57$, $P = .57$ for strain; coeff. = .01, SE = .08, $t = .09$, $P = .93$ for performance). Together with the non-significant relationship of FoMO with internal interruptions, these findings suggest that FoMO does not exert its effect through enhanced internal interruptions.

TABLE 3 Direct and indirect effects of manipulation on outcomes performance and well-being.

	Performance						Irritation					
	Coeff	**SE**	***T***	***P***	***R***	***F***	**Coeff**	**SE**	***T***	***P***	***R***	***F***
Freq interruptions t2												
Constant	2.85	.38	7.58	.00			2.65	.29	9.05	.00		
Outcome at t1	−0.01	.05	<1	.88			0.07	.04	1.62	.11		
Frequency of interruptions t1	0.20	.07	2.98	.00			0.18	.07	2.74	.01		
Intervention	−0.66	.11	−6.36	.00	.41	16.04	−0.67	.10	−6.48	.00	.42	17.08
Outcome t2												
Constant	3.98	.52	7.58	.00			0.21	.33	0.65	.51		
Outcome at t1	0.41	.06	6.67	.00			0.71	.04	17.24	.00		
Frequency of interruptions t1	−0.08	.08	−0.97	.34			0.02	.06	0.23	.82		
Intervention	−0.12	.14	−0.81	.41			0.06	.11	0.55	.58		
Frequency of interruptions t2	−0.23	.08	−2.80	.01	.44	14.41	0.13	.06	2.04	.04	.76	81.17
	Coeff	**SE**	**LLCI**	**UCLI**			**Coeff**	**SE**	**LLCI**	**UCLI**		
Indirect effect	0.14	.06	0.04	0.27			−0.09	.05	−0.19	−0.002		

Note: $N = 247$. Intervention was coded as 1 = control group, 2 = experimental group.

4 | DISCUSSION

The goal of this study was to examine the role of FoMO and telepressure for performance and well-being when blocking notifications to reduce interruptions in a field experiment. In the experimental group, participants were asked to disable their notifications for one workday. The interruptions caused by notification were reduced more strongly in the experimental group, compared to the control group, and blocking notifications improved performance and reduced strain through reducing the frequency of notification-caused interruptions. Importantly, reducing interruptions is more effective (in terms of performance) when telepressure is medium or high (compared to when it is low), or FoMO is low to medium (compared to when it is high). We find no support for the assumed self-regulatory pathway: internal interruptions did not increase in individuals high on FoMO or telepressure as a result of the intervention. Moreover, internal interruptions did not moderate the effect of reduced notification-based interruptions on performance or strain. We will discuss these results and their implications in turn.

In line with other notification disabling studies[4,7,8] the intervention led to a significant reduction in the frequency of interruptions by notifications. The findings of a positive effect of the reduced frequency of interruptions on irritation and performance is in line with earlier studies,[4] and shows that individuals benefit in their strain levels and performance when the frequency of interruptions is reduced by turning off automatic notifications. This result supports the treatment of interruptions as a stressor according to ART[17] and is in line with most of the prior research on these kind of interruptions.[4,7,8,26] A reduced frequency of notification-caused interruptions leads to higher performance, consistent with previous research.[13] The higher performance results from reduced frequency of interruptions because the additional cognitive effort that comes with frequent task switching as well as the loss of time due to resumption lags are reduced,[20,27] and time and cognitive effort can be invested into the performance of the task. Of note, the frequency of interruptions was not only reduced in the experimental group, but also in the control group, indicating a demand effect. By taking part in the study that was announced as being about task interruptions, participants in the control group might have guessed the purpose of this study, and changed their behavior (or reporting of the behavior) accordingly. However, there is reason to believe that this demand effect does not invalidate our study findings. First, the decrease in frequency of interruptions was greater in the experimental group which was instructed to block notification, compared to the control group who did not receive this instruction. The

TABLE 4 Moderating effects of FoMO and workplace telepressure on the effect of frequency of interruptions on performance and irritations.

	Performance						Irritation					
Moderator FoMO	**Coeff**	**SE**	***T***	***P***	***R***	***F***	**Coeff**	**SE**	***T***	***P***	***R***	***F***
Constant	5.32	.86	6.21	.00			−0.04	.59	−0.07	.94		
Outcome at t1	0.40	.06	6.37	.00			0.66	.04	15.27	.00		
Intervention	−0.12	.14	−0.86	.39			0.05	.11	0.51	.61		
Frequency of interruptions t2	−0.74	.27	−2.77	.01			0.08	.20	0.37	.71		
FoMO	−0.65	.30	−2.19	.03			0.21	.22	0.96	.34		
Interaction	0.21	.11	1.99	.05	.45	12.43	0.02	.08	0.20	.84	.77	68.80
Conditional effect		**Effect**	**SE**	***T***	***P***							
Values of FoMO												
Low ($M = 1.77$)		−0.37	.10	−3.51	.00							
Medium ($M = 2.39$)		−0.23	.08	−2.95	.00							
High ($M = 3.02$)		−0.10	.10	−1.00	.32							
Moderator telepressure	**Coeff**	**SE**	***T***	***P***	***R***	***F***	**Coeff**	**SE**	***T***	***P***	***R***	***F***
Constant	3.20	.71	4.51	.00			0.41	.53	0.78	.44		
Outcome at t1	0.44	.06	7.32	.00			0.71	.04	16.69	.00		
Intervention	−0.25	.14	−1.78	.08			0.06	.11	0.53	.60		
Frequency of interruptions t2	0.29	.23	1.24	.22			0.08	.18	0.46	.65		
Telepressure	0.22	.16	1.32	.19			−0.04	.13	−0.33	.74		
Interaction	−0.17	.07	−2.60	.01	.50	0.25	0.01	.05	0.24	.81	.75	64.71
Conditional effects		**Effect**	**SE**	***T***	***P***							
Value of telepressure												
Low ($M = 2.26$)		−0.10	.11	−0.94	.35							
Medium ($M = 3.43$)		−0.30	.08	−3.83	.00							
High ($M = 4.61$)		−0.50	.12	−4.34	.00							

Note: N = 247. Intervention was coded as 1 = control group 2 = experimental group.

greater decrease indicates that our manipulation was successful despite the demand effect. Moreover, the reduced frequency of interruptions led to higher performance. The significant indirect effect indicates that the manipulation affected performance in the way we expected.

Again showing a demand effect, internal interruptions decreased in both groups that might be due to the way the study was announced, and participants responding accordingly. Consistent with this explanation, for self-checking, which does not refer to interruptions and therefore to the overall aim of the study, we do not find a demand effect, as only the experimental group shows the expected increase, but not the control group. In contrast to internal interruptions, self-checking for messages might be planned for specific times or occasions (e.g., before starting a new task), and are thus different from interruptions.

Our study reveals for whom blocking notifications is beneficial. Specifically, for individuals low or medium on FoMO, interruptions reduced performance, whereas it does not for individuals high on FoMO. Moreover, when telepressure is medium or high, interruptions reduce performance, but not when telepressure is low, suggesting that interruptions only interfere with performance when there is a strong social norm to respond to incoming messages. Individuals who perceive low social norms (low in telepressure in our study) thus benefit more from a reduction in interruptions caused by notifications. For individuals who perceive high social norms (high telepressure) blocking notifications would need to be complemented with interventions targeting social norms. Our findings underscore the importance of managing the expectations of the communication partners with

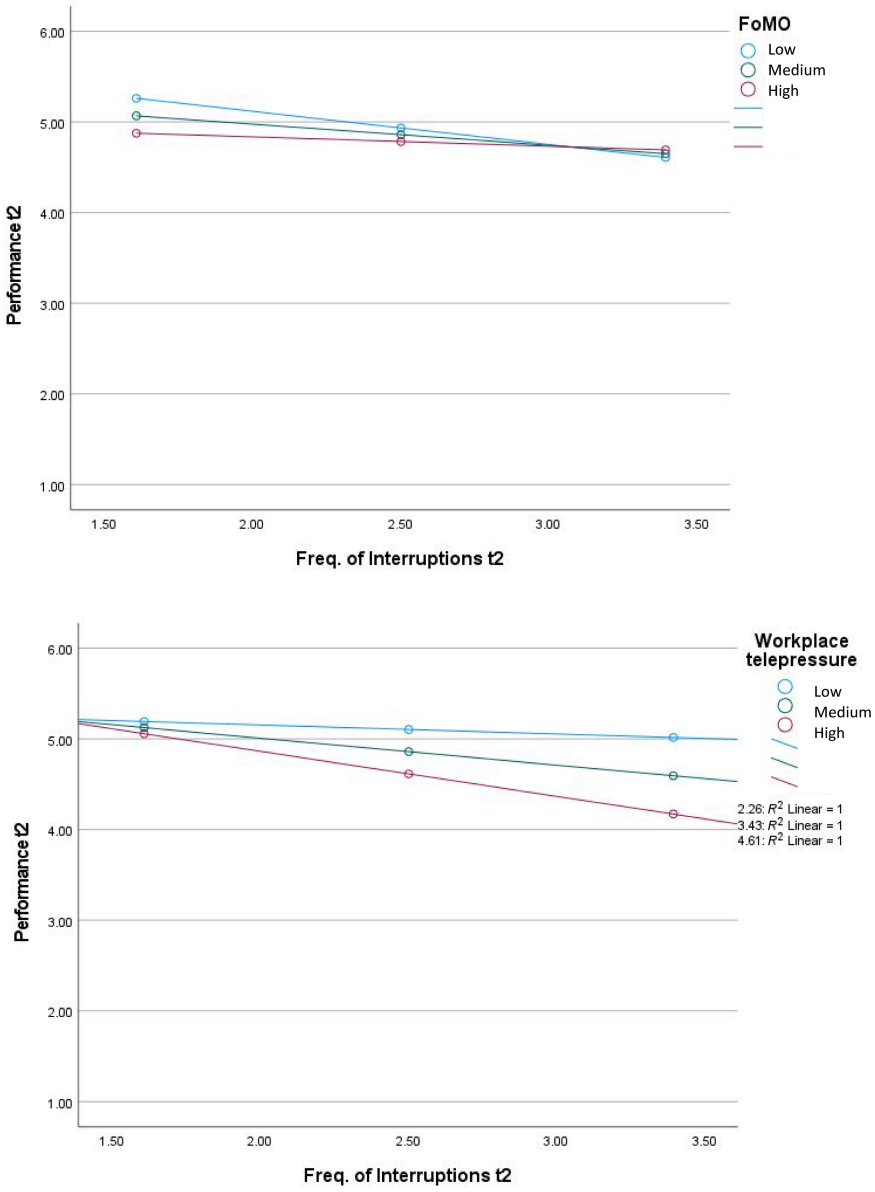

FIGURE 2 Moderating effect of FoMO and telepressure on performance. Panel 1: Moderating effect of FoMO. Panel 2: Moderating effect of workplace telepressure.

regards to response times as a key strategy for individuals high on telepressure.[7]

This finding is in line with the impact of FoMO in the social media research. Individuals high on FoMO seem to benefit less (in terms of their performance) from turning off automatic notifications. We did not find support for our assumption that this this effect would be driven by an increase of internal interruptions. The assumption was based on theorizing that individuals high on FoMO would attempt to satisfy their need for relatedness because they have a stronger desire to be always connected, compared to individuals low on FoMO. It might be that the short duration of 1 day might explain why we found no change in behavior.[8,40] Moreover, it might be that individuals left important notifications (e.g., from close friends or colleagues) running, which could have reduced the urge to self-check.[8] Future studies thus need to establish more experimental control and use longer time frames.

The lack of support for increased internal interruptions as a mechanism of the effect of FoMO raises the question why individuals high in FoMO showed lower performance compared to individuals low in FoMO in this study. In addition to the self-regulatory pathway (more internal interruptions due to less notifications), a cognitive-affective path has been suggested.[8] A reduction in notifications leading to fewer external interruptions, but the positive effects for performance can be nullified by the experience of anxiety when individual's FoMO is high. The experience of anxiety in turn leads to an increase in cognitive load and interferences while working on a task, thereby decreasing task performance.[8] This explanation is in line with research linking anxiety and impaired cognitive performance based on cognitive interference

theory performance and the attentional control theory. Individuals with high trait anxiety tend to have fewer resources available for control processes than individuals low in trait anxiety. Based on findings that state anxiety introduced task-irrelevant thoughts which interfere with task relevant thoughts and thereby reduce cognitive performance as well, future work needs to study this affective pathway by including a measure of state anxiety. Moreover, a stronger theoretical integration of (state) anxiety and (state) FoMO seems valuable. The affective, motivational and cognitive pathways could be tested simultaneously by including a measure of cognitive interferences as well.

Again, the short time frame of this study, might explain why there was no increase in irritation in individuals high on FoMO, as anxiety induced by the absence of notifications does not translate into a systematic increase in stress within 1 day.[7] Moreover, high stability of irritation (correlation of .73 between the two measurement points) makes it harder to find significant effects. Longer duration of the intervention as well as measurement of state anxiety (introduced by notification absence) that are more sensitive to anxiety could provide further insights into the mechanism. To fully capture well-being as a potential outcome, we recommend to assess positive and negative aspects. Finally, the findings for this moderation could be explained by the fact that not all notifications had to be turned off, and thus may have produced a much smaller effect than in a condition of complete notification ban.[8] In future research, participants should be instructed to disable all notifications to detect effects that occur, without connecting to others via notifications.

With regard to telepressure, our assumption was only partially supported: Individuals low in telepressure benefited more from reduced notification-caused interruptions than individuals medium-high in telepressure, although the latter did not increase their checking behavior. The fact that individuals low in telepressure show higher performance irrespective of the level of interruptions is consistent with previous findings. Because the assumed self-regulatory pathway was not supported in our study, the question arises how the moderating effect of telepressure on the relationship of interruptions and performance can be explained. As discussed above, the anxiety which arises out of fear of violating social expectations can interfere with task performance (affective pathway). Moreover, individuals high on telepressure stay mentally occupied because of their constant alertness to the possibility of incoming messages (cognitive pathway) which interferes with task performance for individuals high in telepressure.

Telepressure did not moderate the effect of reduced frequency of notification-caused interruptions on irritation, which is inconsistent with the affective pathway discussed above. If individuals who are medium to high on telepressure were indeed anxious about violating social expectations, we would also expect to see an effect on irritations, which is similar to anxiety in that they are negative emotional states high on arousal. However, irritations exhibit some stability and thus cannot capture the short-term affective response we are proposing. As outlined previously, the lack of a moderating effect might be due to this stability and the short duration of the intervention (1 day). The negative effects of switching off notifications in a context with high social norms to respond quickly might be better captured using state affect ("How do you feel right now?"), and longer-term interventions are needed to reduce strain.

4.1 | Implications

Our study suggests that it is valuable to integrate social norms (and FoMO) into interruption research, as examining these boundary conditions might explain why individuals will continue to use automatic notifications, despite experiencing them as harmful and disruptive. For example, in one study 17 out of 18 individuals indicated that they would go back to automatic notifications, and reasons include "was behind responding" or "I like the ability … to monitor my inbox".[4] Although focus on the task at hand is increased for all users, some might suffer from blocked notifications because of their negative feelings, as described above. Consequently, reducing or blocking notifications works well for individuals low in FoMO. For individuals high in FoMO, this strategy for enhancing performance is not effective, and different measures would need to be taken. Given that FoMO seems to be higher in younger employees, an age-differentiated approach seems suitable.

As a practical implication, actively shaping prescriptive (e.g., via supervisors) social norms or implementing cross-organizational notification management systems[4] can contribute to reduce irritation and hence lead to higher well-being.[16] For example, guidelines on the organizational level regarding response times and communication with asynchronous communication applications could support the interpretation of prescriptive norms by descriptive norms about responsiveness.

4.2 | Limitations and future directions

Our field experimental design yields important benefits by studying the phenomenon in its context and including a control group, but at the same time pose a threat to internal validity. For example, participants in the experimental group were not exposed to a complete notification ban but

were left with the option to leave important notifications enabled to avoid selection bias caused by a high dropout of participants in the experiment.[10] This more lenient approach could be responsible for smaller effects, especially for the two moderators. As argued above, a complete notification ban might have created stronger urge to interrupt themselves among individuals high on FoMO or telepressure. Future work examining the moderation of FoMO and social norms should implement a complete notification ban.

In addition, all variables were measured via self-reports that could entail the risk of distortions. In particular, the frequency of interruptions measured using self-reports rather than objective behavioral data should be interpreted with cautions due to recall bias, and self-reports of performance might be inflated due to self-presentation concerns. Arguably, because these biases influence both pre- and posttest measures to the same degree, controlling for the t1 measures somewhat alleviates this concern. Still, using smartphone logs or specific apps to track notification-caused interruptions and use more objective measures of performance is needed to test the robustness of our findings. To obtain a more accurate measure of social norms, it would be valuable to assess a shared perception by multiple individuals rating the social norms in their work group, potentially using a more direct measure of social norms of responsiveness at work.[14,16]

Finally, for pragmatic reasons and to be able to collect a large sample, we included students in our study. The heterogeneous sample composition questions the generalizability of the results to older, less educated individuals. Moreover, the short treatment period of one working day also pose a threat to external validity, because participants may need time to adapt their behavior to this change, and some effects may take a longer time to emerge. Future works should address disabling notifications for more than 1 day in a more diverse sample. As the presumed mechanism (increased internal interruptions as a response to blocked notifications when FoMO or telepressure are high) was not confirmed, alternative explanations to the self-regulatory pathway such as the cognitive pathway or higher anxiety levels need to be tested in future work. Moreover, given that uninterrupted work gives more time on task, future research needs to disentangle the mechanisms leading to higher performance when work is interrupted less frequently.

Finally, we tested the moderating effects of FoMO and telepressure separately in order to avoid a Type II error (erroneously rejecting the hypotheses) because the power to detect interaction effects is generally low, and practical reasons prohibited the collection of an even larger sample. Testing the moderating effects separately seems reasonable because both moderators are only mildly correlated and theoretically distinct.

5 | CONCLUSION

In summary, this study contributes to a better understanding of the effects of interruptions by notifications on work-important outcomes under different conditions. The findings of the field experiment support previous research on the negative impact of notification-caused interruptions on strain and performance. Therefore, reducing the number of notifications has been shown to benefit knowledge and information workers. However, individual and contextual differences do also have an influence on the effects of notification-caused interruptions on perceived productivity, but not on irritation in this study. Individuals low in FoMO or low in telepressure benefit from a reduction of notifications by increased performance. These findings have implications on individual level such as more sophisticated notification settings to reduce interruptions especially specific groups, or at the organizational level for example the actively shaping of social norms about responsiveness to reduce the experience of telepressure.

AUTHOR CONTRIBUTIONS

L.B. conceived the ideas; L.B. collected the data; S.O. and L.B. analysed the data; and S.O. led the writing.

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CONFLICT OF INTEREST STATEMENT

The authors declare that they have no conflict of interest.

DATA AVAILABILITY STATEMENT

Research data are not shared.

INFORMED CONSENT

Informed consent was obtained through the website at the time the data was collected. Participants had the option of not responding to any part of the questionnaire at any time and discontinue the survey at any point.

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ENDNOTE

* We also assessed number of interruptions using the following "Please estimate the number of automatically generated notifications that interrupt you on a typical work or student day". Response ranged from 0 to 200 with a mean of 17.55 at t1 and

8.61 at t2. Frequency and number of interruptions were highly correlated ($r = .50$, $P < .01$ at t1; $r = .54$, $P < .01$ at t2), thus we only report the results concerning frequency of interruptions.

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