Does Trait Mindfulness Buffer the Effect of Technology Induced Work Interruptions on

Attention Residue?

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Abstract

Technology induced work interruptions are a growing reason of dispersed attention in the working environment. Work interruptions associate positively with attention residue. Mindfulness is increasingly popular in the research field, which findings suggest that high levels of it associate negatively with attention residue. We predicted that high levels of mindfulness would buffer the association between technology induced work interruptions and attention residue. We conducted a daily diary study looking at the moderation effect of trait mindfulness buffering the relation of technology induced work interruptions and attention residue (N=109). Multiple linear regression analysis showed that technological interruptions increase attention residue. Furthermore, we found support for the negative relation of mindfulness on attention residue. However, no support was found for the interaction effect. The study enrichens the field by showing the importance of technology induced work interruptions lowering our cognitive abilities, in increasing the attention residue and highlighting that trait mindfulness lowers it.

Keywords: interruptions, work, technology, attention, mindfulness

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The Effect of Technology Induced Work Interruptions on Attention Residue Buffered by Trait Mindfulness

Today's working environment drastically differs to the one in the past, because different types of communication media are present in everyday work setting (Wajcman & Rose, 2011). Due to the increase in technology, interruptions caused by it are omnipresent in today's work setting (Wajcman & Rose, 2011). It has become almost inevitable to get interrupted either physically – coworkers' need to socialize – or virtually – texts, e-mails, phone calls – when working (Puranik et al., 2020). A definition of a work interruption suggested by Puranik et al. (2020) is any situation in which the primary task stops because the secondary task demands individual's attention. These interruptions do not only present a problem for the knowledge workers, but also cause billions of dollars of costs annually for the U.S. economy (Puranik et al., 2009).

Because interruptions in today's working environment are only increasing, disrupted attention is consequently now more present than ever (Leroy, 2009). In this article the focus is on the cognitive perspective, highlighting the relationship between work interruptions caused by technology and attentional residue. The higher the attention residue, the lower the task performance, which can as a chain reaction further lower our job satisfaction and well-being (Leroy, 2009).

Since interruptions are more present each day, we need to look for solutions to overcome them or at least lessen their effect. That is why a lot of research is now focused on how to reduce the strains of work stressors and bringing the attention more to the present moment where it should be (Sonnentag & Frese, 2012). One of the techniques introduced in their article are meditation techniques, especially those of mindfulness's approach. With mindfulness meditation you enter a state of being more mindful. This means you are more

aware of the present moment with your bodily sensations, which could bring more attention to the task you are working at and help reduce attention residue.

With this study I will first look at the relationship between technology induced work interruptions and attention residue. Secondly, I will investigate how trait mindfulness relates to attention residue. And lastly, I will investigate whether trait mindfulness moderates the relationship between technology induced work interruptions and attention residue. A lot of studies show that work interruptions influence our attention (Puranik et al., 2020). Only a few focus on technology induced interruptions, that is why this study will introduce a novelty looking into the relationship of a work interruption induced by a technology and how it impacts our attention. Recent studies suggest that mindfulness could be a successful approach in organizational settings that could reduce work-related stress. Despite these findings, to our knowledge there is no study that focuses specifically on the effect of trait mindfulness to the relationship of technology induced work interruptions – which are scattering around the workplace each month more – and attention residue. Hence, this study will try to further explore if mindfulness can moderate the relationship between technology induced work interruptions and attention residue, such that high levels of mindfulness lower attention residue.

Work Interruptions Negatively Relate to Attention Residue

As mentioned above, an interruption can either be physical, but it can also be virtual. Technological innovations have notably shaped means by which we interact with the world in the 21st century (Wilmer et al., 2017). Technology in our rapidly moving modern world is therefore a double-edged sword. On one hand it makes our lives easier on many different aspects, however, on the other hand technology can in many situation's present distractions rather than extenuating circumstances (Wilmer et al., 2017). There are two types of external

work interruptions, physical or non-technology induced and virtual or technology-induced (Puranik et al., 2020). External events rooted in information technology that occupy one's cognitive attention and disrupt one's flow on the task at hand are examples of technology-induced work interruptions (Addas & Pinsonneault, 2015). For example: text notifications, phone calls, e-mails, instant messages, software update notifications or news notifications(Addas & Pinsonneault, 2015; Puranik et al., 2020; Wajcman & Rose, 2011). To summarize, as one is interrupted, one's attention is redirected from the task at hand to a new one (Keller et al., 2020).

The unpredictability of receiving e-mails, phone calls or instant text messages can become overwhelming (Puranik et al. 2020). These media can therefore constantly force a person to shift their attention from what they were focusing on to what caught their attention through a device (Puranik et al., 2020). When we move to another task, a leftover of our cognition's focus on the first task is still present and we take it with us when trying to resolve the second task. This is a so-called attention residue, which implies that the cognitive resources needed for the first task consequently interfere with our cognitive capacity needed for the interrupted task (Leroy, 2009).

An interruption is considered to result in two forms. Firstly, the behavioural performance of the current task is adjourned. Secondly, the attentional focus from the task at hand is disrupted (Puranik et al., 2020). Interrupting stimuli distract attentional system which consequently cannot dedicate its full focus to the primary task and therefore prevents the task to be fully finished (Leroy, 2009). In sum, attention residue simply means that thoughts about a previous task are still present even after you stopped working on it and they use important cognitive power that cannot be invested in another task (Leroy et al., 2009).

Theory of attention residue explains that when people get interrupted, they tend to cognitively stick on the task that had been interrupted (Puranik et al., 2020). When interrupted, some cognitive resources still persist focused on the primary task, which leads to less resources available to execute the new task. This is called attention residue (Leroy et al., 2009). There is a possible effect of smartphone-related technologies on divided attention or multitasking and focused attention (Wilmer et al., 2017). Focused attention is the ability to only direct attention to one stimuli, while ignoring other sources of information (Wilmer et al., 2017). One of the biggest problems of engaging in smartphone activity is that people are more likely to get consumed by all types of non-work-related notifications, therefore increasing the duration of the interruption (Wilmer et al., 2017). In addition, simply hearing the notification sound or recognizing the vibration of a device, alerts the worker enough to get distracted by it and he or she is less capable of focusing attention on the task at hand (Wilmer et al., 2017).

In summary, external work interruptions either by non-technology induced or technology induced cues distract us from the ongoing task, while trying to focus on the second task, which results in attention residue on the primary task that consequently lowers the performance on the interrupting task. We will take a deeper look into whether when one is interrupted by a technology induced cue – text, phone call etc. – hers or his attention residue increases, which means there is less cognitive capacity to work on the interrupting task because some of one's attention is still dedicated to the interrupted task even if one is no longer working on it.

The first hypothesis we will test in this study is:

Hypothesis 1. Technology induced work interruptions positively relate to attention residue.

Mindfulness Positively Relates to Attention Residue

Humans have an innate tendency to not pay attention or to operate on autopilot, also called mindlessness (Mesmer-Magnus et al., 2017). If mindlessness is applied to work, it can in some cases be dangerous, for example, doctors prescribing a drug, firefighters, and police officers. Mesmer-Magmus et al (2018) implied that being interrupted and fail to focus can at the end lead to higher work stress and in some cases even burnout. On the other hand, the awareness of constantly ongoing new stimuli – either internal or external – and the processing of that stimuli without reacting to them is what mindfulness stands for (Mesmer-Magnus et al., 2018). Mindfulness indirectly impacts different important areas of workplace, such as performance, well-being, and relationships (Good et al., 2016). A growing body of evidence is now showing that mindfulness supports people with all kinds of workplace stressors (Sonnentag & Frese, 2012).

Mindfulness does not only influence attention, but also cognition, emotion, physiology, and behaviour (Good et al., 2016). When one is mindful, one is able to maintain a moment-by-moment awareness of one's thoughts, feelings, bodily sensations, and surrounding environment, through a gentle, nurturing lens (Ellis, 2006). This could help with redirecting more attention to the interrupting task rather than having a part of one's mental workload stuck on the primary task. When mindful, an individual focuses on the here and now without judgement (Hülsheger & Alberts, 2021).

Mindfulness affects different aspects of human functioning: attention, cognition, emotion, behaviour, and physiology. Additionally, it has beneficial effects in the workplace, such as job performance, work engagement and authentic functioning (Kong & Jolly, 2019). According to Good et al. (2016) there is a direct relation between mindfulness and attention. This article highlights the importance of combining attention with awareness to derive to

mindful attention. Furthermore, attention tends to get prevailed by thoughts (Good et al., 2016). We are bombarded with stimuli each day and our thoughts have to assess these stimuli fast, put meaning to them and judge whether they are important or not. Metacognition happens when a thought is shifted inwards in order to only engage with itself (Good et al, 2016). Mindfulness is connected to attention registering the facts in internal or external stimulus without immediately putting meaning to them (Good et al., 2016). This means mindfulness could reduce attention residue, because mindful workers would observe the stimuli, but they would not evaluate it which would not distract them with their current task. Furthermore, the internal focus could be more on the thoughts they are currently having in their head, most likely helping them solve the task at hand. In sum, attention in the present can be fixed with the help of mindfulness, therefore mindful people observe rather than interpret stimuli in them and their environment (Good et al., 2016). Trait mindfulness reduces attention residue, which means people's attention is less easily divided between two tasks, but rather full focus goes to the task at hand. We will take a deeper look into whether when one is mindful by nature effects the ability to stay focused on one task rather than having scattered attention through more than one job at once.

The second hypothesis we will test in this study is:

Hypothesis 2. Trait mindfulness negatively relates to attention residue.

Technology induced work interruptions disrupt attentional focus on the task at hand. Consequently, leading to worse task performance and lower job satisfaction. It is hard to prevent interruptions, but it is easier to train yourself what to focus the limited attention to. Good et al. (2016) mention that attentional span is enlarged by mindfulness. This implies that more mindful people can still observe all the unimportant stimuli, but they do not attach meaning or focus to it, which makes them more productive with the task at hand.

With the current study I would like to look at whether how mindful someone is in general affects how they handle technology induced interruptions in terms of their focus division between the two tasks – interrupted and interrupting, precisely. If a person is mindful by nature, we assume that they can neglect any unimportant distractors from their external as well as internal environment. The end benefit of the negative moderation of mindfulness to the relationship of interruptions and attention residue is that people are able to perform better on their tasks. Experienced meditators mention that for them it is less effortful to devote to a certain task and they can do it faster than novice meditators. In line with aforedescribed paragraphs, the third hypothesis is:

Hypothesis 3. High levels of trait mindfulness buffer the relationship between technology induced work interruptions and attention residue.

Method

Participants

The participants were recruited through the social network of the researchers involved in this project. People were eligible to participate if they worked for a minimum of 20 hours per week. Interested participants received an email containing a link that led them to the baseline questionnaire. Additionally, posters equipped with a OR code linked to the study were hung around the city of Groningen. These participants were directly led to the study by scanning the QR code. After participants completed the baseline questionnaire, they were included in an email list and were sent the daily afternoon and evening questionnaires.

In total 91 individuals completed the baseline questionnaire and daily questionnaires. Of these, 64 (70.3%) identified as female and 27 (29.7%) as male. The age ranged from 20 to 60 years old ($M = 32.55$, $SD = 12.46$). Participants were from 11 different countries. Most participants were from The Netherlands (54.9%), followed by Romania (12.1%), Slovenia (11%), Ireland (6.6%) and Germany (5.5%). In regard to language skills, 15 (16.5%) people

indicated being native English speakers ($N = 91$). Of the participants that did not indicate being native English speakers, 34 (37.4%) indicated being fluent in English ($N = 76$). On average, participants worked 36.32 hours per week ($SD = 8.79$). The majority of the participants (28.6%) are working in the health and social welfare sector ($N = 91$).

Procedure

This longitudinal study consisted of two parts: a one-time baseline questionnaire and a series of short daily questionnaires. All the questionnaires were in English. The Ethical Committee of Psychology at the University of Groningen approved this research before conducting the study.

In order to motivate the participants to take part in the survey, we used two types of incentives. The first one was personalized feedback about their answers of the study. The second one was a monetary incentive, which chance of winning grew with individual's effort to participate in the study. The more daily questionnaires one answered the higher one's chance was to win €50.

At the beginning of the baseline questionnaire participants were asked to give informed consent. In addition, participants received an information sheet, which informed them about their rights and risks. In the first week of our study, participants were asked to participate in the baseline questionnaire. The baseline questionnaire was designed to take around 15-20 minutes to complete. They had to provide us with their email addresses in order to send the daily questionnaires after. Starting in the second week of our study, the participants received short daily questionnaires for 10 workdays over a span of two weeks. The daily questionnaires entailed two short surveys, which took around 3-5 minutes to complete, per workday. These questionnaires were sent out during the participants' lunch break as well as after their work ended.

Measures

Technology Induced Work Interruptions

Technology induced work interruptions were measured in the daily afternoon questionnaire using the measure by ten Brummelhuis et al. (2012). To assess technology induced work interruptions participants were asked to answer questions concerning their work experiences. The scale consisted of 3 items, assessed on a five-point Likert scale with 1 = fully disagree to 5 = I fully agree. An example of an Item is: "Incoming emails and other online messages kept me from doing my job" (α = .915).

Attention residue

Attention residue was assessed in the afternoon survey based on nine items from the measure of 'off-task/on-task thoughts' developed by Leroy & Glomb (2018). The items were adapted to reflect participants' daily experiences. Participants had to estimate how often their attention was impaired by interrupting tasks during work. The scale ranged from 1 = never to 5 = always. A representative sample item is "I feel my attention was divided between the focal task and the interrupting task" (α =.711).

Trait mindfulness

Trait mindfulness was assessed in the baseline questionnaire using the M @ Work Scale by Hülsheger & Alberts (2021). Participants were asked to indicate to what extent statements about work experiences applied to them in the past few weeks. They estimated this on a five-point Likert scale ranging from 1 = strongly disagree and 5 = strongly agree. Example items are: 'During work, I find it easy to stay focused on the task at hand' and 'At work, I do jobs or tasks automatically without being aware of what I'm doing' (α =.827).

Analytical procedure

To test the hypotheses, we ran a multiple linear regression in SPSS with technology induced interruptions as independent variable, attention residue as the dependent variable and trait mindfulness as the moderator of their relationship. Before the regression analysis, we

centered the technology induced interruptions variable and the trait mindfulness variable. For the purpose of this study, multilevel analysis would be a better choice for analyzing the data, however this statistical technique is not part of the Psychology Bachelor curriculum. Aggregated data in a regression analysis was consequently used. Therefore, the results must be interpreted with caution and at the between-person level.

We checked the linearity assumption, homoscedasticity of residuals, independence of residuals and normality of residuals. The linearity and homoscedasticity of residuals assumptions were checked with a residual plot which had no pattern. The independence of residuals was done by correct sampling. The normality of residuals was checked with a QQ-plot, which did not have any great deviations. All the assumptions for multiple linear regression were met.

Results

Table 1

Descriptive statistics and Correlations for Study variables

Variable	n	M	SD	1	2	3
1 Attention residue	91	2.949	0.378	–		
2 Technology induced work interruptions	91	2.169	0.619	.311*	–	
3 Trait mindfulness	91	3.510	0.441	-.315*	-.081	–

*Correlation is significant at the at the 0.01 level (2-tailed).

The results show a significant relation between technology induced work interruptions and attention residue ($b = .158$, $SE = .060$, $p = .010$). The first hypothesis was therefore supported. The results also showed a significant relation between trait mindfulness and attention residue ($b = -.257$, $SE = .083$, $p = .003$). The second hypothesis was therefore

supported as well. There was however no significant interaction effect (b = -.189, SE = .142, p = .185). The third hypothesis was not supported. Overall, the model explained 19.74% of the variation of Attention Residue.

Table 2

Unstandardized Regression coefficients

	b	SE	p
Technology interruptions	.158	.060	.010
Trait mindfulness	-.257	.083	.003
Interruptions*mindfulness	-.189	.142	.185

Dependent variable: Attention Residue

Discussion

Technology is successfully and rapidly penetrating into today's workplace and more and more workers are becoming dependent on it. Nowadays, technology usage is a part of our daily lives because technological devices can primarily make things easier for us, however they can also amplify our cognition (Wilmer et al., 2017). Since technology has become very portable, we can take it and have it with us at all times. This offers a bigger opportunity to bombard us with more information per second and presents a harder job for the brain to rule out unimportant stimuli from the environment we are in (Christopher & Rosselli, 2021).

There is a body of literature looking at work interruptions and their effect on human attention (Leroy, 2009; Puranik et al., 2020). Yet, to our surprise, few research investigated how technology induced work interruptions relate to attention residue. Therefore, our aim was to look into the relations between technology induced work interruptions and attention residue. We were wondering whether technological interruptions increase attention residue. The findings of our study showed a significant result for that relation, supporting our first

hypothesis. In the past decade, a lot of focus has been on mindfulness and its effect on all types of work-related outcomes. There was already some existing literature focusing on mindfulness and its effect on human cognition (Good et al., 2016; Hülsheger & Alberts, 2021). However, to our knowledge, no research has focus on the relation of trait mindfulness on attention residue specifically. Therefore, our second hypothesis was that high levels of trait mindfulness would lower the attention residue. Our results showed another significant result and supported our second hypothesis. We also looked in the moderation effect of trait mindfulness on the relation between technology induced work interruptions and attention residue. We hypothesized that high levels of trait mindfulness would buffer their relation. This hypothesis was not supported.

Theoretical implications

The results of our study showed that technology induced work interruptions had an effect on attention residue. A great part of theories in organizational psychology argue that interruptions are preventing workers to deliver their best work (Leroy et al., 2020). Our findings suggest that not only non-technology induced work interruptions, but also technological interruptions lead to higher attention residue, which is in line with the overarching debate about technology taking over our lives in 21st century.

Another body of literature resulted in support for mindfulness as a solution for work-related outcomes caused by interruptions. Researchers before us were interested in how mindfulness influences other areas of human cognition, such as working memory, fluid intelligence, general mental ability, creativity, divergent and convergent thinking, and problem solving (Good et al., 2016). We wanted to expand this and look into what trait mindfulness does to attention residue. Our second hypothesis was supported, which suggests that trait mindfulness lowers attention residue. This is an important contribution to the

research field since it introduces another benefit of mindfulness in the workplace. If a worker is more mindful it can help the individual to only observe distracting stimuli and not immediately interpret it which helps to focus on the task at hand. Furthermore, when confronted with an interrupting task, the worker is more able to mentally let go of the task he or she was working on beforehand and better focus on the task he or she is confronted with in the present moment. To explain further, when mindful, the worker can control where the attention is focused to. The interruptions do not disappear, they are still there but no meaning is attached to them which helps with sustaining focus on the things that are important in that moment. Surprisingly, we found no significant result for the moderation effect of trait mindfulness on the relation of technology induced work interruptions on attention residue.

Practical Implications

Our study provided two significant supports for two different phenomena. This can be used in the organizational setting to help workers improve some of their constraints they are faced with. Firstly, this study showed that technology induced work interruptions lead to higher attention residue. Since attention residue is connected to productivity and performance, it is important to be aware that when interacting with technology, workers may possibly be less productive and need longer to finish tasks. Furthermore, high attention residue – which can be caused by technology – can lead to increase in errors and even higher chance of burnout. This finding could also encourage the workers to turn off the notifications for non-work-related stimuli, such as social media notifications. Furthermore, organizations and working facilities in which the use of technology is not part of the job, could implement a policy of a technology-free workspace. This could minimize the unimportant interruptions, which would help the workers to be more efficient not only timewise but also performance-wise. For the companies in which technology is crucial for the job itself, workshops on how to prioritize notifications could be held. For example, in the working time only work-related

notifications are on, and for the break all the others can be used. To add, app developers could focus on different settings which help prioritize and order notifications from most to least important. Another useful implication could be encouraging the employees to read a book in the break or talk to a co-worker, if possible, instead of scrolling on social media, playing videogames, or reading the news. Ultimately, technology is omnipresent, so it is unreasonable to expect from employees disconnect from it completely, therefore it is important to find a good balance between using it for benefit of the work itself and setting personal boundaries for the disadvantages that arise because of it.

Secondly, this study showed that high levels of trait mindfulness led to lower attention residue. Mindfulness is an internal state of being completely present in the moment at hand. Since it is a trait, it can be strengthened through different practices, such as mindfulness meditation and yoga. When one is mindful, one is more aware of the bodily sensations and therefore more prone to experience their present moment fully. This is also reached through breathing exercises where the focus is on the breath which brings attention to the present because once one focuses on their breath, one is immediately more in touch with their body and the here and now experience. When a person meditates, their brain waves change from unstable to stable and coherent. Both brain lobes communicate more efficiently with each other, and the brain is able to find the right balance between hyperactivity and hypoactivity (Dispenza, 2014). In his book he also alludes that mindfulness meditation could directly affect people's brain in shifting from a chaos state to an organized, mindful state. One of the many aspects enhanced by mindfulness practice is attentional control, which is the degree to which one observes rather than immediately evaluates and interprets the stimuli one is presented with. This could help with maintaining focus on the task at hand and having control over when to interact with other stimuli. If what to focus attention to is chosen efficiently and consciously then it leaves more space in the cognitive capacity, which suggests that

mindfulness causes more controlled attention in settings where attention would otherwise be dispersed among many incoming stimuli (Good et al., 2016).

Therefore, companies could organize yoga workshops, meditation classes and maybe even hire a person to teach the employees the correct breathing techniques. This could be further implied in everyday life of the workers; they could use the breathing techniques when feeling disorganized or unable to focus. Instead of spending time on their phones they could stretch with yoga exercises or even meditate for a few minutes. To round up, individuals higher in trait mindfulness may be more productive and efficient, not only cognitive control but also decision making may improve and nevertheless increase in well-being.

Limitations and Future research

The goal of this study was to investigate whether mindfulness could buffer the relation of technology induced work interruptions on attention residue. Our results however indicated a positive relationship of technology induced work interruptions on attention residue and a negative relationship of trait mindfulness on attention residue. Interestingly, there was no significant result supporting the interaction effect of technology induced work interruptions and trait mindfulness on attention residue. One of the reasons why we derived at unsignificant result is the fact that we used regression analysis, even though for the purpose of this design a multilevel analysis would be more adequate. To justify as mentioned in the method section, multilevel analysis is not part of the curriculum, so the regression analysis was the best way to analyse our data. Finally, all of our participants' responses were subjective introspections, which could not be objectively observed and controlled for due to the nature of the study – self-reported survey instead of a controlled experiment.

Future research may therefore use a multilevel analysis and conduct face to face interviews instead of self-filling questionnaires with zero control. However, this may take

more time and cost more money. In order to prevent that, future research could organize a quick mandatory questionnaire for employees to answer on their lunch break. In addition, some of the participants also complained that the daily questionnaires were too long, which could demotivate them in answering truly in thoroughly.

Furthermore, future research could look at the difference in attention residue between jobs where technology use is crucial to do the required work and those that are independent from technology usage. To elaborate, different mindfulness mediation practices could be looked into and compared to the attention residue of those who need technology for their work to those who do not. Dispenza already proposed in 2014 that professional meditators' brains show more consistent activity patterns, which means that you can train yourself to pay more attention to the present moment and you have control over when you get interrupted. Therefore, long-term effects of mindfulness practice on attention residue could be inspected and compared to those of short-term.

Conclusion

Literature until now, except in the computer science area, mostly focuses on non-technology induced work interruptions. In this research, we primarily focused on technology induced work interruptions as they are a rising phenomenon in the work environment and are highly associated with job satisfaction, task performance, emotions, attitude, and well-being (Puranik et al., 2020). Our results enrichen the research field in such that technology induced work interruptions had a positive effect on attention residue. These outcomes support our first hypotheses and are in line with what other studies have found; Leroy (2009), Wajcman & Rose (2011), Wilmer et al. (2017). With this study we showed and supported that not only non-technology induced interruptions have an effect on attention residue, but also technology induced ones.

      Our study also showed that high levels of trait mindfulness decrease attention residue. Even though no significance was found for the third hypothesis, our study further contributed to showing what not to do in the future in regard to association between mindfulness and attention residue. It can be assumed that work interruptions induced by technological media are becoming increasingly worthy of considering as an indicator of changes in human attention. Nevertheless, high levels of mindfulness lower attention residue.

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