Focused, Aroused, but so Distractible: A Temporal Perspective on Multitasking and Communications

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ABSTRACT
A common assumption in studies of interruptions is that one is focused in an activity and then distracted by other stimuli. We take the reverse perspective and examine whether one might first be in an attentional state that makes one *susceptible* to communications typically associated with distraction. We explore the confluence of multitasking and workplace communications from three temporal perspectives – prior to an interaction, when tasks and communications are interleaved, and at the end of the day. Using logging techniques and experience sampling, we observed 32 employees *in situ* for five days. We found that certain attentional states lead people to be more susceptible to particular types of interaction. Rote work is followed by more Facebook or face-to-face interaction. Focused and aroused states are followed by more email. The more time in email and face-fo-face interaction, and the more total screen switches, the less productive people feel at the day's end. We present the notion of emotional homeostasis along with new directions for multitasking research.

Author Keywords
Facebook; Email; Face-to-face interaction; multitasking; productivity; interruptions

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Human Factors

INTRODUCTION
While studies of multitasking and disruption have long been a focus of the CSCW and CHI communities, the emphasis has mostly been on understanding how disruption occurs from an engaged state, either due to external stimuli such as notifications or visits from colleagues, or self-interruptions. However, there has been little research investigating whether a person's particular mental state at the time could make one more susceptible to being distracted.

Prior work has shown how online interactions, in particular the use of social media and email, can be used to infer what type of attentional state a person is in, such as being focused or bored [22]. However, while such an association was established, the direction of causality was not clear: Does being in a particular attentional state make one more susceptible of switching from their current task to pursue certain online activities? Or rather does switching attention from an ongoing task to certain activities lead one to be in a particular attentional state?

In this paper, we explore the relationship of multitasking and communications in the workplace. As this relationship is a complex phenomenon, we choose to examine this relationship through three temporal perspectives, as multitasking occurs throughout the day: what happens prior to switching activities that may lead to workplace communications, how are communications manifest during task switching, and how do the cumulative effects of multitasking affect people's assessment of work productivity at the end of the day? Understanding the relationship of multitasking and communications is important, as workplace communications comprise a significant portion of the workday [10]. Further, communications such as informal face-to-face interactions or email are noted as a major source of workplace distraction [10, 20, 26]. This study builds on prior work [22], which examined how attentional states in the workplace vary over the day, with digital activities.

We conducted an *in situ* study in a large, U.S. global organization where we tracked online activities of users throughout the workday, and collected self-reports of their engagement and feeling of being challenged using the experience sampling method (ESM) [13]. Leveraging the framework derived in [22], we associated different attentional states with online activities. The results suggest that particular attentional frames of mind lead

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people to be susceptible to different types of task switches to varying degrees. We also found a relationship between the amount of task switching and workplace communications. We discuss the impacts of our findings on the current understanding of multitasking and attentional states, and introduce the notion of emotional homeostasis.

RELATED WORK

Multitasking and disruption

Existing work in the domain of multitasking and disruption has primarily focused on how multitasking impacts attention in the workplace, in particular, the effects of an ongoing task being interrupted by another activity. The underlying assumption is that external or internal stimuli cause people to change their focus from their current activity to another task. This may often be characterized as distraction or disruption to the interrupted task, even though the interruption may be beneficial [6, 16, 20]. For example, Czerwinski et al. [4] conducted a diary study to understand how interruptions cause information workers to switch activities in the workplace. Distractions as such can affect focus on ongoing tasks. Mark et al. [20] found that it takes people on average around 23 minutes to resume an interrupted task. Iqbal and Horvitz studied how external interruptions cause information workers to attempt to leave their ongoing task at a stable state and then enter into a 'chain of distraction', comprised of a series of activities including checking email, instant messaging and browsing [10]. O'Conaill and Frohlich [26] showed that 64% of workplace interruptions are beneficial, but the recipient also does not resume work after 40% of the interruptions. More recently, Mark et al. showed in a study of multitasking among Millennials that the amount of multitasking is positively associated with stress, but social media usage coincides with lower stress [24].

Other work has focused on internal interruptions, where a person may interrupt themselves during ongoing work without external stimuli [1, 7, 17]. Jin and Dabbish derived seven categories of self–interruption in the workplace – adjustment, break, routines, waits, inquiry, triggers and collection. However, research has suggested that the organizational environment and individual differences may determine how susceptible one may be to different types of self interruption [7].

Workplace communications such as informal face-to-face (**F2F**) encounters, as well as online interactions with email, comprise a significant chunk of the workday, and have been found to take up over a quarter of people's time in the workplace [10]. Correspondingly, these communications also comprise a significant amount of interruptions. Email and informal F2F interactions alone make up over 40% of interruptions [10]**.** Facebook (**FB**) users in the workplace on average spend almost nine minutes a day on FB. Typically this involves multiple visits, which also interrupts workflow [23].

While most studies have looked at distraction due to multitasking, no study to our knowledge has attempted to study the phenomenon from the reverse perspective – that people can be in particular frames of mind, or attentional states, that make them more susceptible to being distracted. Linking the attentional state to types of activities can provide a better understanding of the nature of distraction and the subsequent effects on productivity.

Attentional states in the workplace

Attentional states in the workplace are important to study as they appear to be related to mood and possibly job performance. Grandey et al. [11] found that positive affect was related to job satisfaction, whereas negative affect was related to negative emotional reaction, e.g., disappointment, depression and unhappiness. More recently, Mark et al. [23] found that face to face interactions at work were associated with positive mood at the time they occur, whereas more Facebook use was positively correlated with positive mood at the end of the workday. More relevant to our study is that mood has been shown to have an effect on distraction; e.g., Alder and Benbunan-Fich [1] showed that negative feelings trigger more self-interruptions than positive feelings.

We are interested in the relationship of attentional states and people's digital activity. To inform our study we draw from a long legacy of related concepts in psychology, which explain that people's actions are motivated by a desire to achieve a balanced emotional and psychological state. As far back as 460 BC, Hipprocrates proposed that health was related to a harmonious balance of elements in the body. In the early twentieth century, Gestalt theorists were interested in the idea of balance in terms of the perceptual field using the concept of *Pragnanz*: in other words, people try to reduce stress from the stimulus field so as to achieve an internal equilibrium [18]. About the same time, the physiologist Walter Cannon adopted the term homeostasis and expanded its reach to include emotional parameters as well as physical [5]. Kurt Lewin's *field theory* [19] built on the idea of balance and introduced the basic principle of tension reduction as it applies to internal states. According to Lewin, people experience tension when needs are not satisfied, and therefore they strive to attain these needs to reduce tension in order to experience a state of equilibrium. Lewin focuses on a person's momentary needs; any change of state is dependent on the situation and one's particular psychological state at the time. Other related theories that grew out of Lewin's field theory and that similarly discuss notions of achieving a balanced mental state include Heider's *balance theory* [12], which describes that people are motivated to maintain attitudes that are consistent towards other people and objects over time, so as to achieve a psychological balance. *Cognitive*

dissonance theory is also related, where discrepancies between attitudes and behaviors introduce dissonance [9]. If a discrepancy exists, a person will aim to reduce the dissonance.

More recently, internal balance, or homeostasis, has been approached in terms of physiological responses. As we are concerned with the reduction of tension, or stress, we are interested in how people maintain *emotional homeostasis* while multitasking. Emotion is typically defined as a mental state that arises spontaneously rather than through conscious effort and is often accompanied by physiological changes [25]. Homeostasis is defined as the ability or tendency of an organism or cell to maintain internal equilibrium by adjusting its physiological processes [25]. Responses to threats of homeostasis from stressors occur by facilitating neural pathways which mediate psychological functions such as arousal, cognition and attention [5]. Stress can thus create an imbalance and influence arousal and attentional state. People are constantly challenged by stressors in the environment and have developed adaptive responses in order to preserve homeostasis. Therefore, emotional homeostasis is a neural and physiological process that maintains the equilibrium of mental states that would enable a human to live and perform at normal levels [4]. It may be that, as workers get more stressed, bored or frustrated in the workplace, they seek out homeostasis by moving to another activity that brings them back to a balanced state.

Thus, these various theories share the basic commonality that people act in a way to seek out and experience a balanced internal state. In the broader context of multitasking in a digital environment, people may switch to activities that will lead them to experience more of a state of equilibrium if the current activity disrupts that balance. Following Lewin [19], Heider [12], and Festinger [9], people may choose actions that will lead them towards reducing inner tension [21]. This is a novel notion in the multitasking literature that we will explore in this work.

INTERACTIONS AND MULTITASKING

As a starting point to examine more broadly how social interactions influence multitasking behavior in the workplace, we investigated the confluence of workplace communications and multitasking in terms of three temporal perspectives: prior to the interaction, throughout the day (how communication acts interleave with multitasking), and the cumulative effects at the end of the day (the effect on assessing productivity). As a first step we chose to focus on three prevalent types of communications that would cover online and offline interactions and work and social purposes. We therefore selected three types of communications common in the workplace: F2F, email, and FB. Our reasoning for selecting these three types of communications is as follows:

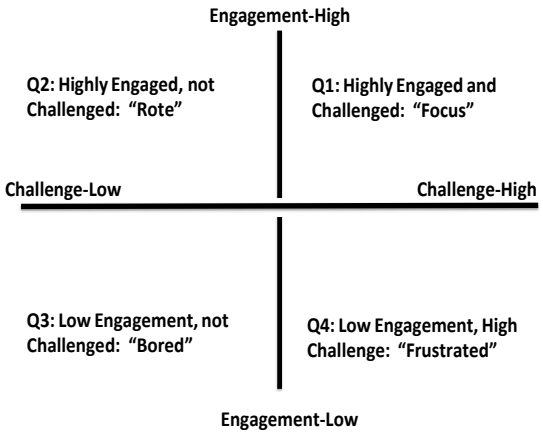

Figure 1. A theoretical framework of different attentional states [22]

F2F: informal F2F interaction is common in the workplace and is a significant source of distractions [8, 10]. F2F encounters are offline and are either work-related or social.

Email: online email communication is also a significant source of distractions, both due to self-interruption as well as external interruption, e.g., due to notifications [10, 16]. Email in the workplace is likely to be mostly work related, although obviously some personal email is also carried out.

FB: Facebook is also online communication and is likely a distraction mostly due to self-interruption. As [23] found, it can function as a quick break when people are engaged in work. FB in the workplace is generally social, though in rare cases it may be work-related.

Thus, we focus on contrasting workplace communications--differing in their online or offline nature and in being social or work-related, to understand the role they play in multitasking. While there are a number of other workplace interactions that also occur with other media (e.g., IM, LinkedIn, phone), as a starting point, we examine these three types (FB, F2F and email).

We emphasize that these types of communications could be work-related or social in nature, but our data does not allow us to make this differentiation. Our approach is to examine how engaging in these types of communications interrupts the *flow* of activity, regardless of whether they are social or work related. Similarly, when we consider a task that involves digital activity, such as Internet switching, we acknowledge that this may also be work-related or not. Our focus is on interruptions of the flow of activity irrespective of whether the communication type or target activity is work-related or not. We next describe

the three temporal perspectives that we focus on in our analysis.

Prior to the interaction: attentional states

Studies of multitasking and interruptions assume that people are highly engaged in their work and then the distraction pulls them away from their engagement. In this paper we take the opposite perspective: we examine whether people may first experience a particular attentional state that makes them *susceptible* to distractions such as checking FB, email, or chatting with a colleague. For example, a person may become bored in their current task, which makes them turn to FB as a break. Recent work suggests that FB can be beneficial as a quick break, leading to "grazing behavior", a low cost interaction from a cognitive resources perspective, potentially fun, and which enables the user to maintain some control over the duration of the interaction [23].

To examine this notion of attentional states, we draw on the theoretical framework used by [22], shown in Figure 1. This theoretical framework is based on considering attentional states in terms of two dimensions: engagement and challenge. *Engagement* is important to consider in the workplace as it is a mental state of absorption in an activity [28]. The second dimension that we consider is *challenge* in work. Challenge refers to the amount of mental effort that one exerts to perform a task and has been associated with motivation in work [14].

Figure 1 describes four attentional states, shown in each of the four quadrants. To be focused in work, engagement in an activity is not sufficient. A person can be engaged in an activity but it may not be challenging; a person can be involved in "mindless" activities such as filling out forms. Therefore, it is important to consider how challenging an activity is along with how engaged one is in the activity. Quadrant 1 indicates that when one is highly challenged and highly engaged then the attentional state can be characterized as 'Focus'. Quadrant 2 indicates that an attentional state where one is highly engaged but not challenged describes mechanical type of thinking. This is referred to as 'Rote' to indicate attentional states associated with rote type of work. Quadrant 3 shows that when one is not at all engaged and not challenged, then it indicates a state of being 'Bored'. Quadrant 4 indicates that when one is challenged but not engaged, then one is frustrated. An example of a frustrated attentional state could be when a software developer is working on solving a difficult bug in a program. We stress that these labels are merely referents; what is more important is to consider the underlying dimensions of being challenged and engaged.

Therefore, we apply the framework in Figure 1 to examine a person's attentional state prior to an interaction. Our goal is to examine whether we can find relationships of particular prior attentional states with subsequent initiations of workplace communications. If so, this may suggest that a person may already be in a particular attentional state that makes them susceptible to certain types of interactions (or distractions).

During multitasking: how communications interleave with other activities

A second temporal perspective that we examine concerns how workplace communications interleave with other multitasking behavior. This analysis could shed light on the role workplace communications play in switching between different tasks. Certain communications could serve different functions in multitasking. They can be a break when a person is highly engaged in work, as [23] found with FB. They can also serve to provide information needed to perform tasks, such as when using email or F2F for task completion. They can also be habitual, as when one surfs the Internet, and then one becomes accustomed to also checking FB or email, starting off a chain of distraction [16].

The number of projects a person has can also affect how communications interleave with multitasking. We expect that the more projects one has, the more task switching occurs, which in turn could present more opportunities for initiating further communications. For example, if one switches projects, they may turn to email to retrieve newly pertinent information or they may seek a colleague to consult with for updates. We therefore look at task switches and project count in conjunction with our three main interaction types (FB, F2F and email).

Another common practice of activity switching could be due to switching websites on the Internet. When one switches between projects, email may play a more important role since it is generally work-related; one may need to use email to seek information for projects. On the other hand, when one uses the Internet – even if it is still related to the ongoing task- one may check FB, since it is a relatively low cost switch within the same application. However, if FB is a break from work as [23] suggests, then FB use might be prevalent while one is working and switching between projects. This relates to Lewin's idea of tension reduction. On the other hand, one might also choose to have F2F interaction while switching Internet sites if one is bored.

End of day: cumulative assessment of productivity

Our third temporal perspective focuses on how people feel at the end of the day. A longstanding question about multitasking is the effect that switching tasks has on productivity (cf [2]). It is unclear what effect the relationship of workplace communications and multitasking might have on productivity. We are particularly interested in the effects of FB, F2F and email interactions throughout the day on the cumulative assessment of productivity at the end of the day. The underlying reasoning behind this exploration is that these interactions could have both positive and negative effects on productivity. For example, while FB is generally

considered a distraction from ongoing activities, it could also serve as a break during a productive session, and therefore be considered with feeling engaged [23]. Likewise, F2F and email could be both work related and social.

Research foci

In sum, we study three types of workplace communications: FB, email, and F2F, from three different temporal perspectives:

- Attentional states prior to the communication
- Throughout the day: how communications interleave with multitasking
- End of the day: cumulative assessment on feelings of productivity

METHODOLOGY

We conducted an *in situ* study in the fall of 2012 at a large U.S. corporation. We used a mixed-methods approach where we logged people's digital activity along with using experience sampling (ESM). The logging allowed us to track a wide range of digital activities with detailed precision. As stated earlier, ESM was used to collect user perceptions of engagement and challenge, as well as other self-report measures at frequent intervals throughout the day. We also deployed surveys for other subjective and demographic measures. Further details of these, and other, measures not reported in this paper can be found in [23].

Participants were recruited through advertising, convenience sampling and other participants' recommendations. Thirty-two people (17 females, 15 males) participated. Participants included researchers, managers, administrators, an engineer, a department director, a designer, and a consultant.

Methodology. Each participant's digital activity was logged for a period of five work days, typically Monday through Friday. When participants traveled or missed a day, they made up the missed day the following week (in most cases). The computer logging software and ESM software were installed on participants' computers the Friday before the study began. Participants were assured of anonymity in their data and it was protected via encryption.

We logged online interactions with custom-built software that captured all activity in the Windows 7.0 Operating System. This included beginning and end times for the lifespan of every window, and the beginning and end times for each instance of every foreground window. Logging is done only when a window is moved to the foreground, i.e., if an email client is open, its use will not be logged unless it becomes active. Changing tabs in a browser was counted as separate switches. Mouse and keyboard activity were captured, as was computer sleep mode, so that we could ignore periods of time when a window was open but was not being used in the foreground. Capturing what email was being read or any other application interaction was not collected due to privacy and technical limitations. All participants used Outlook for email.

Email and FB interaction were measured through the logging program. F2F interaction was measured through the use of SenseCams [15], a lightweight wearable camera worn around the neck. The camera takes pictures approximately every 15 seconds. The images were then processed with face detection software, a publicly available application (http://research.microsoft.com/en-us/projects/facesdk/). The software does not recognize faces; it only provides information about whether a person was present or not in the photo. The counts in our F2F variable therefore do not measure *distinct* interactions, just the amount of interaction.

We used ESM, in the form of a small pop-up window that appeared on the computer screen to capture the participants' perspective *in situ*. Experience sampling has been shown to have both internal and external validity [13]. Experience sampling has been used extensively in studies to capture the experience of flow, an immersive state in an activity [13]. We used a hybrid interval-contingent and event-contingent sampling approach [13]. The sampling was done: 1) whenever a user left email after uninterrupted active use in that application for at least three consecutive minutes or when in Facebook after a full minute, and 2) whenever a user logged into Windows or unlocked the screen saver (event-contingent). If 15 minutes passed without a sampling, then a probe was triggered (interval-contingent).

Participants were instructed to go about their usual workday activities and were told to answer the ESM probes when the probe windows popped up on their computer screens. We emphasized that they should answer the probe questions as accurately as possible but they could cancel the probe window at any time. Subjects were given the following verbal and written instructions:

"Sometimes the rating scale will pop up and may annoy you, especially if you were in the middle of doing something. If you feel annoyed, do not rate your mood based on the annoyance of the pop-up window. Instead, rate your experience based on the task or interaction you were doing at the time of the pop-up window. If you feel that you cannot rate your mood fairly due to the annoyance of the pop-up window, then hit 'cancel' and the window will disappear."

We used rating scales used in other ESM approaches [21] to measure the following: for Engagement, participants were asked 'In the task/interaction you were just doing: How Engaged Were You?' using a 6-point Likert scale (0=Not at All; 5=Extremely). To measure Challenge, participants were asked the same question as above, but instead: "How Challenged Were You?' using the same Likert scale: (0=Not at All; 5=Extremely). We also measured Valence (positive and negative affect, not

Measure	Description
FB interaction	FB seconds 1, 5, 10 min. prior and after the probe FB counts of unique visits
Email interaction:	Email seconds 1, 5, 10 min. prior and after the probe Email counts of unique visits
F2F interaction:	SenseCam counts 1, 5, 10 min. prior and after the probe
Application Switching	Number of switches between applications (e.g. Word, Excel)
Internet switching	Number of switches on the Internet
Attentional states	Counts of ESM responses that fell into each of the quadrants: Focus, Rote, Bored, Frustrated states.
Arousal	low (-200) to high (+200)
Productivity self-report	daily end of day survey: 7-point Likert scale
Project count	general survey
Positive/negative mood	PANAS mood scale, from daily beginning and end of day survey) [29]

Table 1. Summary of measures used.

reported here) and Arousal, (on a vertical axis that crossed a horizontal Valence axis) using a range of -200 (low arousal) to +200 (high arousal), based on the Circumplex model for Valence/Arousal (for a review, including its validity, see [27]). Subjects were asked to click with their cursor on that point on the scale that best expressed their feeling "right now." The timestamp when participants submitted the probe was recorded. All data from ESM was normalized within participants.

Measures

Table 1 summarizes the measures from our collected data reported in this paper.

RESULTS

Our dataset consisted of 1,509 hours of participant observation (32 participants, five days each). Our experience sampling yielded 2,809 probes, averaging 87.8 responses per participant, and averaging 17.56 probe responses per person per day. Our SenseCam photo capture yielded 204,922 photos. The ESM results were normalized and we used the top and bottom third of responses for the engagement and challenge dimensions (i.e. eliminating the middle responses). Since only seven responses occurred in the 'Frustrated' category, we do not consider this category for the rest of the analysis. The responses fell in the quadrants shown in Fig. 1 as follows: Focused (45.4%), Rote (18.9%), Bored (35.6%).

	FB	Email	F2F
Number visits/day (counts)	20.98 (5.04)	74.05 (10.54)	--
Duration per day (sec.)	583.48 (206.75) (9 min. 43 sec.)	2071.16 (294.46) (34 min. 31 sec.)	86.88 (10.65)[1]
Duration per visit (sec)	17.75 (2.81)	32.06 (2.80)	N/A

Table 2. Average daily values of number of visits, duration, duration per visit, for FB, Email use. For F2F, only counts are available. Mean (SE).

We begin with an overview of our results. Table 2 shows the average daily duration, frequency, and duration per visit for Facebook, email, and F2F interactions. Because the SenseCam does not compute duration, we can only provide counts of faces detected in photos as a proxy for amount of F2F interaction. The average duration per visit for FB is about 18 seconds and for email is about 32 seconds. Participants averaged about 87 SenseCam counts per day (note that SenseCam counts are a proxy for amount of F2F interaction).

We discussed earlier that checking FB and Email might be a frequent and habitual behavior. We found that participants visited FB on average 21 times per day, with a maximum of 264 visits per day. If we examine only those days in our data where people visited FB at least once a day (i.e., of those who used FB on any day), the average visits per day climbs to 38 unique visits per day (SE=4.92). Participants visited email much more daily: averaging 74 times per day, with a maximum of checking 373 times per day.

Based on the work roles participants reported in a survey, work roles were coded into three categories: concerning Administration and technical support (5 people), Research (19 people), and Management (8 people). For Work Role, we found that for average daily duration of FB use, Researchers spend significantly less time on FB (M=309.59, SE=76.06) than Managers (M=952.15, SE=359.62) or Admins (M=669.15, SE=159.14): $F(2, 161)=3.53$, $p<.03$. There is no significant effect of Work Role on Email duration. With F2F, Admins average significantly more F2F time per day (M=101.58, SE=16.37), followed by Managers (M=98.46, SE=13.04), and then Researchers (M=60.47, SE=8.57), $F(2, 161)=4.34$, $p<.02$.

The average Project count per person is 6.7 (sd=3.7), with a range of 1-18. There is a significant difference of Project Count according to Work Role: $F(2,31)=3.68$, $p<.04$. Researchers (M=5.3, SE=.22) have fewer projects on average than Admins (M=8.7, SE=.93) or Managers (M=8.6, SE=.67). The average number of times that a

person switches applications daily is 566.0 (SE=41.89), ranging from 183 to 1035 times per day.

Overall, the usage data suggests that both FB and email usage are characterized by short bursts: checking many times per day with a short duration for each visit. Amount of F2F and FB interaction, as well as number of projects, differ by work role.

Attentional state: susceptibility to workplace communications

In our first research question, we are interested to see whether a person's current attentional state is associated with their subsequent workplace communications. Is it possible that a particular attentional state, such as feeling bored or feeling that work is rote, is a precursor to using FB, checking email or having a F2F interaction? Based on the ESM probe data, we can determine what type of attentional state the participant reported experiencing (using the framework in Fig. 1). Our probes asked people to rate how they felt "right now". Since we have timestamps of the logged computer data, we can therefore examine what activity people did *after* reporting their attentional state.

However, it is possible that if the person is already performing a certain workplace communication before the ESM probe, they could continue that communication after the probe. In that case it would be difficult to determine whether it was the attentional state that led to the communication or if it was the prior communication that was simply being continued. For example, if FB causes people to be bored, then a probe after FB use would show a bored state. If a person then subsequently continued FB use, we would not be able to determine if it was the bored state that led to FB use or if rather prior FB use continued after the probe. Therefore, we *controlled* for the same type of communication before the probe as the target communication we are investigating after the probe. By controlling for the same type of communication prior to the attentional state, we can control that this prior behavior is not influencing the analysis of the association of attentional state and behavior *after* the probe. It is important to keep in mind that there could be any number of activities that could influence a person's attentional state.

We used a GLM to examine attentional states prior to the three workplace communication types that we are investigating: FB use, email use, and F2F interaction, to see if there are significant patterns of prior attentional states. As we do not have any a priori knowledge of what window of time to test, we selected the timeframe of a 10-minute window of time prior to, and after, the probe. We also compared 5 and 1-minute windows, with similar results, but as the 10-minute window showed the strongest effects, we will report this analysis throughout the rest of the paper.

Attn'l State	FB (sec.)	Email (sec.)	F2F (SenseCam counts)
Focus	13.26 (3.0)*	86.56 (5.6)*	1.32 (.18)*
Rote	28.62(4.6)*	68.03 (8.7)	1.84 (.28)*
Bored	18.95 (3.5)	64.77 (6.6)*	1.73 (.21)
	$F(2,1070)=3.92$, $p<.02$, $R^2=.13$	$F(2,1070)=3.64$, $p<.03$, $R^2=.20$.	$F(2,1070)=4.30$, $p<.02$, $R^2=.27$

Table 3. Mean (SE) of FB, Email, and F2F durations given each prior attentional state of Focus, Rote, Bored. *Indicates differences based on Bonferroni post hoc test, p<.05. Adjusted R^2 is reported.

Facebook

We found significant differences in FB use duration that followed the different attentional states (see Table 3). FB duration following a Rote state was longer than FB duration following a Bored state, followed by a Focused state; a Bonferroni post-hoc test showed a significant difference between Rote and Focused.

We next checked whether the same results also apply for the number of unique FB visits. In other words, is there a particular attentional state associated with FB checking behavior, as well as FB duration of use? A GLM using the number of FB visits in the next 10 minutes, controlling for FB visits in the prior 10 minutes, shows significant results consistent with the FB duration results in Table 3.

Email

We also found significant differences in email duration that followed the different attentional states (Table 3). Participants were more likely to use email longer after being in a Focused state, followed by a Rote state, followed by a Bored state; a Bonferroni post-hoc test showed a significant difference between Focused and Bored states. Participants are therefore more likely to spend more time in email when they are feeling focused, compared to when they are feeling bored, or doing rote work.

Checking the number of unique Email visits in the next 10 min. controlling for number of Email visits in the prior 10 min. shows no significant effect of Attentional state.

Face-to-face

For F2F, we used the SenseCam photo counts as a proxy for amount of F2F interaction. We used a log transform for F2F to improve normality. We found significant differences in F2F interaction counts following different attentional states (Table 3). Participants were more likely to have more F2F interactions after being in a Rote state, followed by a Bored state, followed by a Focused state. A Bonferroni post-hoc test showed a significant difference between Rote and Focused states. Thus, people are most likely to engage in more F2F interactions when feeling Rote (engaged but not challenged) in their current activity

and least when they feel focused (engaged and challenged).

Arousal and workplace communications

The result with email duration was contrary to that of FB and F2F interactions, with the pattern showing that one was first focused before doing email. We decided to explore this more closely. A focused state of attention involves the dimensions of high engagement and high challenge. An underlying mechanism that we expect would correlate with engagement and challenge is arousal. In the ESM probes, we had also asked people to rate their level of arousal. Indeed, we found that Arousal is highly correlated with the dimensions of feeling challenged (r=.42, p<.0001) and engaged (r=.57, p<.0001).

We next looked at whether one's level of arousal is associated with email use. A GLM analysis predicting Email duration in the next 10 minutes, with Arousal and Attentional state as independent variables, controlling for Email duration in the prior 10 minutes, showed a significant effect of Arousal: $F(1,1070)=5.30$, $p<.02$, $R^2=.20$. If Arousal is included in the model then there is a significant Arousal x Attentional State interaction: $F(1,1070)=2.92$, $p<.05$, and no main effect of Attentional State. The variance inflation factors (measuring multicollinearity) of Arousal and Attentional state were each 1.4, which is an acceptable level as it is below 5. Thus, Arousal is predictive of subsequent email use, and Arousal and Attentional state (i.e. Focus) interact to predict a higher level of email use.

Since FB and F2F were associated with following Rote work, we did not expect Arousal to be a significant predictor for these social communications (since Rote work should not involve high effort). Indeed, when Arousal was added to the GLM model previously mentioned, and with Attentional state predicting FB use in the next 10 minutes, controlling for FB use in the prior 10 minutes, it shows no significant effect of Arousal. Examining F2F amount in the next 10 minutes, a GLM also showed no significant effect of Arousal, controlling for F2F amount in the prior 10 minutes.

Thus, we had hypothesized that particular attentional states might be associated with particular communication forms that follow. Our results show that when people are in a rote state (feeling engaged but not challenged), they subsequently spend more time on FB and check FB more, as well as having more F2F interaction. However, when people are in a focused state, they are more likely to then spend a longer time on email. Email use is also associated with arousal. Thus, when people are aroused and in a focused state, they then spend a longer period of time doing email.

Throughout the day: Multitasking and communication

We next looked at a second temporal perspective with respect to multitasking: how workplace communications (FB, F2F and email) interleave with multitasking throughout the day. We used the variable of frequency of switching applications and websites as a proxy for multitasking. We also considered project count as we expect that the more projects one is involved in, the more opportunity one has to switch between projects. Activity switches were in turn separated into two categories: application switches and Internet switching. We reasoned that focusing on application switches (App Switches) might involve more different operations than Internet switching, and thus would involve more cognitive shifts, e.g., from a Word document (writing) to Excel

Application Switching						
		App	PC	WR	PC x WR	Adj. R^2
FB (sec.)	F	7.71	17.43	2.73	5.15	0.22
	df	1,161	1,161	2,161	2,161	
	p	0.006	0.0001	0.07	0.007	
Email (sec.)	F	4.36	1.98	2.87	3.99	0.09
	df	1,161	1,161	2,161	2,161	
	p	0.04	0.16	0.06	0.02	
F2F (counts)	F	2.51	1.97	1.9	1.95	N/A
	df	1,161	1,161	2,161	2,161	
	p	0.12	0.16	0.15	0.15	

Table 4. Model showing how average daily application switches (App), project count (PC) and work role (WR) affect average daily duration of FB, Email, and F2F counts.

Internet Switching						
		Int	PC	WR	PC x WR	Adj. R^2
FB (sec.)	F	12.85	19.06	2.51	4.77	0.24
	df	1,161	1,161	2,161	2,161	
	p	0.0001	0.0001	0.08	0.01	
Email (sec)	F	5.71	2.25	3.72	5.99	0.10
	df	1,161	1,161	2,161	2,161	
	p	0.02	0.14	0.03	0.003	
F2F (counts)	F	9.54	2.33	1.88	1.56	0.10
	df	1,161	1,161	2,161	2,161	
	p	0.002	0.13	0.16	0.21	

Table 5. Model showing how average internet switches (Int), project count (PC) and work role (WR) affect average daily duration of FB, Email, and F2F counts.

Application Switching						
		App	PC	WR	PC x WR	Adj. R^2
FB	F	25.1	22.53	0.45	1.06	0.24
	df	1,161	1,161	2,161	2, 161	
	p	0.0001	0.0001	0.64	0.35	
Email	F	56.23	7.21	29.34	20.41	0.49
	df	1,161	1,161	2,161	2, 161	
	p	0.0001	0.008	.0001	.0001	

Table 6. Model showing how average daily application switches (App), project count (PC) and work role (WR) affect frequency of FB and Email visits.

Internet Switching						
		Int	PC	WR	PCx WR	Adj. R^2
FB	F	22.88	24.1	0.05	0.16	0.23
	df	1,161	1,161	2,161	2, 161	
	p	0.0001	0.0001	0.95	0.86	
Email	F	60.32	5.81	38.28	30.39	0.50
	df	1,161	1,161	2,161	2, 161	
	p	0.0001	0.02	.0001	.0001	

Table 7. Model showing how average daily Internet switches (Int), project count (PC) and work role (WR) affect frequency of FB and Email visits.

(calculations), to the Internet (search and reading) to email (reading/writing). We also examined Internet switching, as this could reveal insight into whether checking email or FB might be frequent or habitual: when one switches Internet sites one might also check email and FB out of habit. We included Work Role in the model since we found significant differences in FB and F2F behavior with work role.

For all analyses we ran a separate GLM for FB, Email, and F2F, with duration of each communication type as a dependent variable, and with Project Count, App Switches (or Internet switches), and Work Role as independent variables. Since Project Count differs by Work Role, we included an interaction term of Project Count x Work Role.

Duration of FB, Email, F2F.

Table 4 shows a significant relationship of App Switches to both FB and email duration. Thus, the more application switches one does, the longer time one spends in FB and email. There is also a significant Project Count by Work Role interaction for FB and also for email duration. The role of Researcher results in having the fewest projects and spending the least amount of time in FB as well as email, compared to other work roles. F2F showed no significant effects, in contrast to email and FB which did show significant effects.

Table 5 shows a significant relationship of frequency of Internet switching to the duration of time spent in email, FB, and F2F interaction. Thus, the more frequently one switches Internet sites, the more time one spends in the three communication types. A significant Work role by Project count interaction for FB indicates that as Project count increases, FB duration decreases more for Researchers than for Admins and Managers. The significant Work role by Project count interaction for email means that as the number of projects increase, email duration decreases for Admins, whereas for Researchers, email duration increases.

Frequency of FB, Email

We next ran a separate GLM for FB and Email with number of unique visits of each communication type as a dependent variable, and with Project Count, App Switches (or Internet Switches), and Work Role as independent variables. Tables 6 and 7 show the relationship of FB and email communications with multitasking, from the perspective of number of visits (note that F2F results, as measured by SenseCam counts, are not included here, but rather are shown in Tables 4 and 5).

Table 6 shows that both average daily frequency of visiting FB and email are strongly associated with frequency of App Switches. Also, the more projects one works on, the higher the frequency of checking FB and email. A Project Count x Work role interaction exists only for email: As the number of projects increase, Admins check email more frequently than Researchers or Managers.

Table 7 shows that Internet switching is highly associated with frequency of visiting FB and email. We interpret the significant project count effect for both FB and email as: the more projects one has, the more switching between projects one does, and the more opportunities there are for checking FB and email while switching. Note that both models for email have a very high value of R^2 (.49 and .50) which indicates that project switching and Internet site switching contribute quite a bit to explaining email checking behavior.

In summary, both application switching and Internet site switching are associated with higher FB and email use, in terms of both duration and unique visits. Internet site switching, but not application switching, is associated with more F2F interaction.

End of day: Productivity and interaction.

Finally, we looked at the consequence of interactions and multitasking on the end of the day self-reported productivity. Here we addressed whether the amount of

Model	Parameter estimate	Wald statistic (df=1)	P
Email duration	-.007	4.83	.03
Total switches	-.00001	4.56	.03
F2F	-.009	3.27	.07
Email duration x F2F	.004	4.30	.04
FB duration x F2F	.001	6.18	.01

Table 8. Model of end-of-day self-report of productivity: chi-square (6)=25.61, p<.0001.

different types of workplace communications, along with multitasking, were related to assessing productivity. Remember that productivity self-reports were taken at the end of each day. First, a GLM showed no significant effect of Work Role. Next we looked at mood and productivity. Based on the PANAS scale [29] (see Table 1), people who reported being more productive also scored higher on their rating of positive mood at the end of the day r=.30, p<.001, and scored lower on their rating of negative mood at the end of the day: r=-.19, p<.04. In terms of mood change over the course of the day, (PANAS end of day - PANAS beginning of day), there was a significant correlation of feeling productive and developing a more positive mood over the course of the day: r=.28, p<.004. Thus, the more productive people felt their day was, the higher was their positive affect.

As productivity was measured as a Likert-scale item, we conducted an ordinal regression with productivity as the dependent measure. We created a variable of Total Switches (i.e., all computer screen switches) by combining App switches and Internet switches. We tested a model using the independent variables of FB duration, Email duration, F2F counts, and Total switches, and included all 2-way interactions. We included Project Count as a control variable.

Table 8 shows the significant variables that predict end-of-day feeling of productivity, in the overall model. The Cox and Snell pseudo R^2 is .18. We note that the parameter estimates are not strong. There was a significant negative relationship of email duration and self-reported productivity: the more time spent on email throughout the day, the *less productive* one feels. There was also a negative relation of Total switches and productivity: the more computer screen switches one does over the course of the day, the *lower* the reported productivity. F2F also shows a strong trend of a negative relationship: the more F2F interaction one has over the day, the *less* productive one feels.

We interpret the significant interaction of email and F2F as follows. Though email duration and F2F duration alone each had a negative relation with productivity, perhaps F2F interaction that is work related is a catalyst to sending emails that are work related, leading one to feel more productive. F2F and FB also interact in a positive relationship with productivity. One interpretation is that though F2F alone is negatively related to productivity,

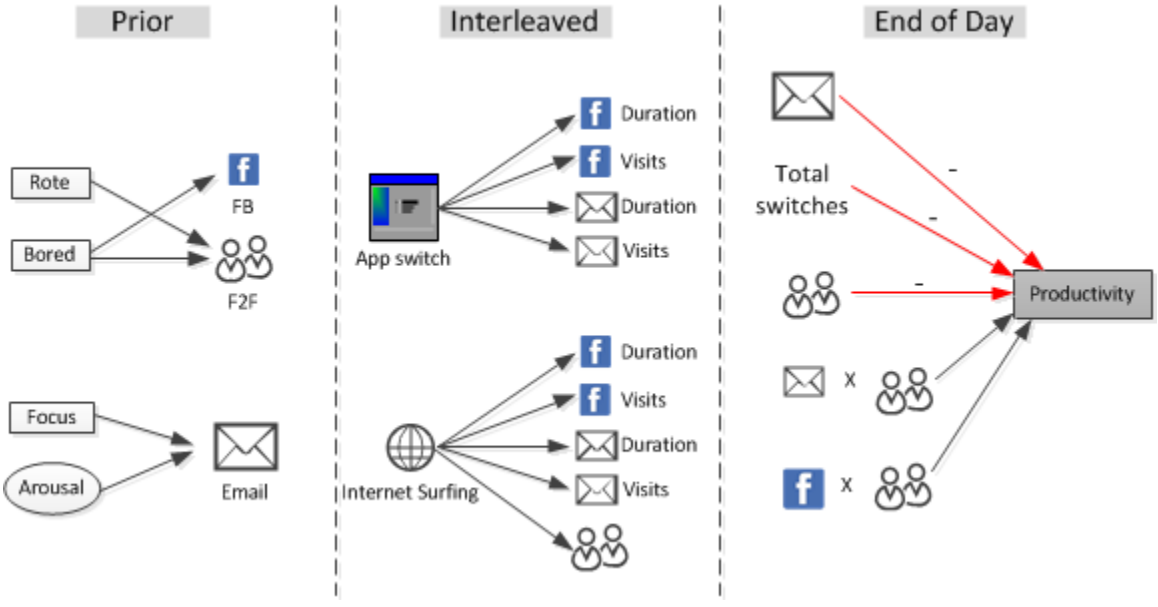

Figure 2. A visual summary of the results of the three temporal perspectives. To simplify, only the results of the interactions are presented. Red arrows indicate a negative association.

when people are engaged in work (along with higher FB use [23]), then perhaps F2F interactions that are work related lead to a higher feeling of productivity. Project count as a control variable showed no significant effect; the results hold irrespective of the number of projects one works on.

Summary of interaction and multitasking

Based on our results, we present a visual summary of our results (Fig. 2) showing the relationship of communication and multitasking according to the three temporal perspectives we examined.

DISCUSSION

In this paper we examined the relationship of multitasking and communication from three different temporal perspectives. First, we examined the attentional state of people *prior* to a communication event. In HCI, it is generally assumed that people work on tasks, are engaged in them, and are then distracted by stimuli, such as email or other people. Our results suggest a reverse perspective for thinking about distractions. People may first be in a certain attentional state which makes them *susceptible* to distractions. We found that when people were in a rote state (high engagement, low challenge), they were more likely to do FB and have more F2F interaction. When they were focused and aroused, they were likely to do more email. We still found these relationships after controlling for the same communication behavior prior to the probe. In other words, our results suggest that distractions could be explained by the current state of one's mind, i.e., one first experiences a particular attentional state and then one is distracted by stimuli.

Our results in particular suggest that certain attentional states are associated with different workplace communication behaviors. FB interactions differ from email interactions in that they are predominantly social and casual. Therefore, when people are not challenged, it makes sense that they might be susceptible to the distractions of FB, which involve low effort. Email, on the other hand, generally involves work, or as Barley [3] claims, email can be regarded as a *symbol* of work (and stress). It also makes sense then that when people are focused and aroused, as we found, they are then in a state where they are prepared to do email. We would like to mention that we cannot claim causality; it is possible that there are other underlying factors that could be associated with activity and subsequent communication behaviors.

When people are in a rote state, as with FB use, they seem to be more susceptible to F2F interactions. F2F interactions can certainly involve either work or social communications. As we did not record the content of F2F meetings, we cannot distinguish the proportions of communications of our participants that involved work. However, the fact that a rote state was likely to precede F2F interactions, and the fact that arousal showed no significant predictive effect (unlike email), suggests that most F2F communications of our sample may have been social.

Our second temporal perspective examined how workplace communications interleaved with multitasking throughout the day. It is also possible that the practice of Application and Internet site switching can also make people susceptible to distractions (in our case, concerning communications). Here we found that our three communication types were involved in multitasking in slightly different ways. Though imperfect, we used the measure of application switching as a proxy for task switching. The fact that both email and FB are associated with application switching suggests that in the course of switching between different applications, people take time to check their email or FB. We expect that when one is engaged in work-related projects, then they might seek email for information or as [23] found, use FB as a work break. It is possible then that application switching also makes people *susceptible* to checking email, or FB; if one is switching anyway, why not check to see if there are recent emails related to work or FB postings that can offer a break?

We offer possible explanations for the relationship of App switching and Internet switching and communications. First, App switching and Internet switching can introduce opportunities for people to self-interrupt. As people are exposed to a variety of different types of information while switching applications, it is likely that some information could trigger reminders that involve communications with people. A second explanation is that this behavior is habitual. People may simply check email, FB and have F2F interaction because they have developed patterns of such behavior over time. Habits can be triggered by context and become deeply ingrained [30]. A third explanation concerns emotional homeostasis which we shall discuss shortly.

Project count was associated with FB use, and with frequency of checking email. We would expect that the more projects one works on, the more social connections and dependencies one would have in the organization, and this could influence email interaction. Also, following the finding that FB might be a break from work [23], the more projects one has, the more one might turn to FB as a short relief from work. The fact that email duration was associated only with application switches and not project count, suggests that time spent on email is compelling irrespective of how many projects one has.

Though our results on productivity are not strong, they do suggest that computer screen switching, and amount of time spent on email and in F2F interaction is detrimental to feeling productive at the end of the day. Opportunity cost could be an explanation: the more time spent in workplace communications, the less time is available for doing other types of work. Also, switching tasks involves a cognitive cost of having to reorient [16] which could

result in a lower feeling of productivity. One might feel that they have wasted their time on email or F2F interaction, as people have a limited amount of time during the day. The more time one spends in one activity (e.g., email), the more time it takes away from another activity perhaps more directly associated with feeling productive (e.g., writing a research paper). This result suggests that the time spent on workplace communications via email, and F2F may not be considered by people to necessarily be productive, especially if the time spent on these communications was for social reasons. Such interactions, though, may well be associated with other productivity measures, and this calls for further research.

Though our measure of productivity involved subjective reports, this productivity measure actually can capture many other underlying attitudes. We found, for example, that productivity is highly correlated with positive affect. Thus, subjective productivity could be a barometer for happiness in the workplace.

Multitasking and homeostasis

Our results thus suggest that one's attentional state may make one susceptible to certain kinds of distractions. Further, application switching and Internet site switching are also associated with a higher use of some communication media. Our results lead us to return to our earlier discussion about emotional homeostasis. We put forth the following notion: people might move toward online or offline communications that lead them to be in a state where they are more balanced psychologically [4] [9, 12, 19]. Perhaps people prefer to continue those particular behaviors that will maintain their current psychological state. For example, as we found, if people are switching Internet sites (in a rote state, engaged but not challenged) then perhaps they seek to continue communication behavior in a similar type of attentional state (a casual F2F interaction or FB use). Similarly, it may be possible that, if people are already in a state of focus, they may want to continue doing work that requires a degree of focus. By continuing to experience this same attentional state, they are trying to attain a psychological balance, or emotional homeostasis. As claimed in prior work [9, 12, 19], people desire to reduce tension and maintain equilibrium.

However, switching activities could have varying consequences. In some cases, people may switch tasks and communication in order to try to attain emotional homeostasis. On the other hand, there may also be a cognitive cost to switching, as it may increase tension. The cognitive cost may not only be in switching contexts but also in switching attentional states. These different potential outcomes lead us to distinguish between external and internal interruptions and activity switching. External switches are triggered by sources outside of a person, e.g., another person, an email notification, or a telephone ringing. Internal switches are triggered by oneself, i.e., a person chooses to switch their activity due to their current needs and motivations. Some research suggests that external interruptions are associated with stress [21]. We propose that it is the internal switches due to one's own volition that could be explained by emotional homeostasis.

Internal switches could be geared toward achieving equilibrium. We see two ways that the notion of homeostasis applies. First, perhaps people self-interrupt to reduce tension from their current activity, as reducing tension is geared towards achieving a balance, per Lewin's field theory notion [19]. Some support for this is suggested by [23] which found that Facebook use is associated with a more positive mood. People may turn to social media such as Facebook as a social break to thus reduce current tension that is experienced. A second way that emotional homeostasis could apply is that people may self-interrupt to a particular activity that enables them to continue their current attentional state. For example, if people are already in a focused state, then they are already in a state conducive to email use (see [23]). It may require effort to move from a state of low challenge to one of high challenge (a characteristic of focus, see Table 1). Thus, if people are already in a state of high challenge and high engagement, it is less effort to simply continue to do activities that maintain this attentional state. This would enable one to maintain a balanced emotional state.

We did not collect contextual information to enable us to distinguish self-interruptions from external interruptions. However, we believe that most FB use was due to self-interruption. We also polled our participants on their email behavior, and of the 15 who replied, 67% reported that they self-interrupt half or more of the time to check email, as opposed to being externally interrupted by an email notification. F2F interaction could be due to either a self-interruption or external interruption. Therefore, we believe that our results could be consistent with the idea that people self-interrupt to try to move towards a state of equilibrium.

We therefore propose the following hypothesis: people switch tasks (and consequently, attentional states) so as to attain an emotional equilibrium. Perhaps people seek out those communication media and those communication partners to attain a balanced state. Thus, perhaps we turn to our colleagues and friends for emotional homeostasis? This is a hypothesis that can be empirically tested in future research.

Implications for multitasking research

Our study can be used to inform other multitasking research. Our results could lead to further investigations about what other subsequent behaviors could be associated with attentional states, including the use of other types of digital and communication media. Moreover, an understanding of how state transitions occur

and what the associated activities are could be an interesting avenue to explore. Also, a wider range of attentional, as well as emotional states could also be examined. The idea of emotional homeostasis, a new idea in multitasking research, should be further studied as well.

Our results contrasting application switching and Internet switching could lead to other investigations around why Internet switching might lead people to check and spend more time on FB and Email, as well as engage in more F2F interactions. Is this behavior habitual or are there perhaps other factors involved, such as that Internet switching provides cues which lead one to switch more to these tasks? All of these questions invite further scrutiny.

Our goal is to understand the workplace experience so as to provide insight on how people can improve their experiences. Our results on productivity self-reports, coupled with our multitasking results, suggest that people could feel more productive (and consequently, happier) in the workplace if they could have a better understanding of their own workplace communication behavior. We feel that our results can be used to inform the design of workplace tools that could provide people with better feedback on their communication patterns and activity switching behaviors.

Limitations

Our participants all had at least a Bachelor's degree and half were researchers. Therefore, we can only generalize our results to highly educated information workers. It is very possible that the ESM probes could have led to switching behaviors, as they interrupted participants. Interruptions have been recognized as an issue with ESM [13]. However, the probe could be answered in a few seconds and the participants were instructed to cancel any probe that they could not answer due to it interrupting them. When asked after the study, some participants reported that this interruption side effect was a hindrance.

We used SenseCam photos as a proxy for face-to-face interaction. Our software could not distinguish unique faces--we can only use the counts as an estimate of amount of F2F interaction, not number of different interactants. Therefore, the F2F interaction measure should be regarded as a rough proxy of how much F2F interaction one had, not number of people. The SenseCam likely underestimated interaction counts since a photo was taken about every 15 seconds; an interaction that occurred between shots would not have been captured.

CONCLUSIONS

Our study raises new issues concerning multitasking and distractions. Our results suggest that, contrary to what has been assumed for some time in multitasking research, people may first be in a particular attentional state that makes them susceptible to being distracted. Our results of window switching due to attentional and interaction baselines also suggest that this type of multitasking behavior could encourage further communication behavior, some of which could be distractions from work. The relationship of multitasking and communications (as potential distractors or attractors) is very complex and we hope that our study can lead to new research directions to gain a deeper understanding of the topic.

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