

Not Merely Deemed as Distraction: Investigating Smartphone Users' Motivations for Notification-Interaction

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ABSTRACT

Notifications are commonly considered a distraction when they arrive during a task, and consequently, prior research has consistently sought effective ways of deferring their arrival until task transitions. However, many smartphone users still interact with notifications during tasks. In our qualitative study combining diary study and semi-structured interviews, we examined 34 research participants' motivations for interacting with smartphone notifications at different times, including during tasks. Our findings resulted in a human-notification interaction framework comprised of 12 unique motivations frequently associated with three activity timings for interacting with notifications, including before-task, during-task, and after-task. Notably, participants frequently perceived interaction with notifications as a tool for improving task performance, making the most of their time, and promoting personal well-being, rather than only as a distraction. The before-the-task timing, in particular, has received little attention in previous research and deserves more attention as it was related to specific user motivations for notification interaction.

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CCS CONCEPTS

• **Human-centered computing** → **Empirical studies in HCI**.

KEYWORDS

Attention Management; Multitasking; Interruptions, Notifications; Opportune Moment

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1 INTRODUCTION

The growing popularity of smartphone use in recent years is not only due to the increasing availability and range of mobile Internet, but also to the variety of mobile applications that allow users to access a wide range of digital services [10, 13]. However, sharp increases in the average number of such applications installed on each phone have inescapably resulted in people receiving an increasing number of notifications, which has prompted debates over whether notifications have become distraction or even damaging to smartphone users [14, 15, 23, 56, 108]. As a result, a strand of research has attempted to identify moments for deferring notifications to, including opportune moments [35, 89], breakpoints [2, 45, 51, 81, 85], and task transitions [45, 53], for the purpose of reducing the distraction or disturbance they cause. Research has also shown, however, that smartphone users have a propensity to initiate notification-checking themselves [19], and that this behavior can occur even while a person is in the middle of a task [5, 27, 33, 36, 105]: a

phenomenon that has been widely presumed to harm task performance. Yet, if interacting with notifications during a task is harmful, why, and in what situations, would smartphone users want to do so? Answering this question will shed light on smartphone users' perceptions of notifications' benefits, as well as the situations in which such benefits are more or less evident to them: factors that have been neglected in the literature on notifications and interruptibility, presumably due to the dominant notion of notification-as-interruption [14, 15, 23, 37, 56, 108]. Accordingly, we ask:

RQ 1: What are smartphone users' motivations for interacting with notifications when they are performing another, primary task?

RQ 2: What factors trigger or influence such motivations?

We believe that the answers to these two questions will facilitate improvement of notification systems, by shedding light on the types of notifications users want to receive at different specific timings, including in the middle of their primary tasks. To answer them, we conducted a qualitative study that involved a week-long diary study and semi-structured interviews with 34 participants, with both these approaches focused on obtaining in-depth understanding of these individuals' motivations for reading and handling notifications at different timings in their daily lives. It makes the following four substantial contributions to the HCI literature.

- It identifies 12 distinct motivations for interacting with notifications and reveals that participants often associated these motivations with one of three specific points in time relative to the primary task - before, during, or after the task.
- It reveals that notifications were often perceived by participants as more than merely distractions, but instead, as a means to improve task performance, time utilization, and personal well-being.
- It distinguishes between before-task and after-task transition timings from the users' perspective, revealing that participants more frequently associated a specific set of motivations in the former vs. the latter. This has important implications for future research, insofar as more attention should be paid to the before-the-task transition timing, which has long been neglected in the literature.
- It proposes a human-notification interaction framework that includes, in addition to the aforementioned 12 motivations grouped by task timings, contextual factors that triggered and influenced these motivations, and can be used as a theoretical tool for analyzing the various functions and meanings of the notifications smartphone users wish to receive in a variety of task situations.

2 RELATED WORK

Notifications and opportune moments have been of interest to research communities. We first review HCI research at the opportune moments. We then discuss the literature related to the phenomenon of self-interruption and media multitasking. Lastly, we review the literature on digital well-being.

2.1 Perceptions of and Interaction with Notifications

Notifications have long been regarded as interruptions, disturbance, and/or distraction in the literature [14, 15, 23, 37, 56, 108], not only because numerous research has shown that ill-timed notifications could result in such negative impacts on workers' performance of the tasks at hand [2, 14, 59, 62, 109] and delay their task completion time [15, 108], but also because prior research has also shown that users perceive alerts of notifications as disrupting [19] and distracting them from the task at hand [15, 108]. An early study showed that compared to receiving notifications without any alerts, receiving notifications with ringtone alerts is likely result in symptoms of inattention and hyperactivity [59].

However, in addition to the negative impacts that arise due to the notifications' presence or arrival, being unaware of their presence or arrival is also likely to cause negative emotions. Pielot et al [92] has shown that disabling notifications is likely to provoke users' anxiety and worry about missing notifications. Probably because of this reason, Chang et al. [19] showed that smartphone users who adopted a silent ringer mode would proactively check their message notifications when their phones, of which the overall attentiveness to notifications is not less than that when the users' phones deliver sensible notification alerts. Smartphone users' high attentiveness to notifications has also been reported in [89], which shows that they are attentive to their phones on average every five minutes.

Prior research has provided some explanations for modern smartphone users' high attentiveness to and habitual use of their phones. For example, it is suggested that some individuals who have greater needs for being synchronized with their social contacts and the world, are likely to find it more challenging to turn off notifications, especially for those who tend to have the feeling of fear of missing out (FOMO) [37, 41] and greater need to belong (NtB) [9]. For example, Liao et al. [64] shows that for individuals who scored high NtB and FOMO, disabling notifications on the phone might make them more worried about missing important or urgent information. For them, notifications offers a practical function to them [118]; and as a result, turning notifications off may conversely distract them more. As a consequence, they may self-interrupt themselves and check their phone often to resolve their such feelings [29, 64]. Probably due to this reason, research has shown that these individuals are more likely to display problematic and addictive mobile phone usage [61, 97, 106].

On the other hand, despite the large body of research on the negative impacts of notifications, a few others argued that notifications could be beneficial in certain contexts and being highly receptive regardless of the task at hand is important to their work. For example, Kim et al. [86] showed that information workers whose works heavily rely on communication appreciated notifications that are relevant and beneficial to their task [16, 58, 86]. Mazmanian et al. [70] also argued that professional service providers (e.g. investment bankers, corporate lawyers, management consultants) desire to be highly available for notifications because their availability is an "integral aspect of the product" they should offer. Likewise, Chou et al. [25] also suggested that certain occupations such as sales or representatives deem it important to be available and responsive

for communication notifications because it is part of their job and duty.

In addition to users' experiences with and perceptions of notifications, a large body of research investigates how smartphone users attend to arriving notifications and manage existing ones in a notification drawer. Overall, although smartphone users have been shown to be highly attentive to their phones in prior research [19, 89], as mentioned earlier, other studies suggested that smartphone users' attendance to notifications is selective. For example, prior research consistently shows that smartphone users favor notifications related to communication more than the other types [11, 66, 76, 90, 100, 115]; they attend to urgent, important, useful, and attractive ones quicker than otherwise [66, 76, 93, 100, 115]; and they also attend to notifications from specific senders quicker [60]. Often, the decisions of whether to attend to the certain notifications have been made when they sensed the notifications, which is according to their speculation about the source and "aboutness" of the notifications [18]. For notifications that are already in their notification drawers, researchers have also investigated the users' dismissing [115], 'snoozing' [6, 85, 114], and deferral behavior [19, 59]. For example, Turner et al [111] found their participants generally deal with their notifications from top to bottom, but this strategy can be affected by how many notifications have resided in the drawer. Arguing that users may not always want to follow the top-bottom order to deal with notifications, Lin et al [65] shows that their participants sometimes desired to place unimportant notifications on the top because they served specific functions to them, such as a reminder or a portal; based on their results, they argue that nowadays notifications have served different roles and it is important to recognize their various roles when designing notification systems.

The current paper resonates with the tendency of self-initiated phone checking behavior, and adds to the literature that there are four motivations that may be prominent to the user for doing so if it happens during a primary task. In addition, it resonates with the multiple functions of notifications to users and further adds that people's utilization for these functions of notifications is influenced by their situation, such as relative to a primary task, before it, during, or after it.

2.2 Interruptions and Receptivity

Interruptions have received definitions in different domains, and in the context of a person attempting to perform a primary task in HCI, Mcfarlane [71, 74] defined human interruption as "the process of coordinating abrupt changes in people's activities," which was believed to be a general and interdisciplinary definition. It was assumed that four elements are involved, including "(P) the people involved in the interruption; (T) the task(s) the person is attempting; (In) the interruption itself; and (C) the working context or environment" [71, p. 4]. Similarly, in the context of multitasking in HCI, interruptions are referred to as unanticipated requests for switching between different tasks during multitasking [71, 96]. Given the notion that the presence of an interruption is established when there is a primary task being interrupted, interruptions have long been regarded as harmful. This is expected, as research has consistently shown that interruptions may be costly to people's

primary tasks and decrease their task performance [8, 42, 47, 72]. For example, interruptions may draw people's attention and distract them from the primary task [4, 40]; and it is not always easy to resume the original task [43, 50, 62, 69]. In addition to cognitive and performance costs, it also can lead to emotional ones, such as increased stress [67] and pressure to respond quickly [7, 26, 67].

As mentioned earlier, notifications have long been considered as interruptions, especially when they arrive during a primary task. To reduce the interruptions and perceived disturbance caused by them, a large body of research has sought to study users' high-receptivity moments for delivering interruptions/notifications, including factors that affect their receptivity to notifications, and the use of machine learning techniques to detect such moments for delivering notifications. In the former line of research, a number of studies have identified factors that affect users' receptivity to notifications. Factors that have been identified include but are not limited to: the characteristics of the interrupted task/situation [24, 34, 52, 76], the characteristics of the interruption [28, 35, 44, 52, 60, 79, 100, 116], the level of engagement the interrupted people have in the interrupted task [38, 88], and other personal context [78], social context [85], and environmental factors [32, 76].

In the second line of research, many researchers have developed machine-learning models to predict moments at which users would be receptive to notifications (e.g. [21, 75, 83, 84, 87, 89, 95, 107, 112]). Several similar concepts that describe users' such moments have been developed and become targets of prediction, including interruptible moments [39, 46, 49, 50, 57, 113], breakpoints [2, 80–82, 85], transitions [98], opportune moments [17, 21, 22, 31, 89, 95], bored moment [91] and so on. By delivering notifications at such detected moments, Park et al. [85], for example, showed a 54.1% decrease in perceptions that notifications were interruptive. Likewise, Okoshi et al. [81] showed 71.8% greater reduction of users' perception of workload when sending notifications during detected breakpoints.

On the other hand, despite the negative influences of notifications and/or interruptions, research regarding the multitasking practices and interruptions in organizations has also shown that they may provide some benefits in some situations. For example, Hudson et al. [48] showed that although interruptions may delay the task at hand, they allows people to firstly deal with problems that may have become overwhelming later. In addition, interruptions themselves may carry useful information that assists other tasks/activities. Carroll et al. [16], likewise, showed that for individuals who collaborate in an activity with shared goals, resources, deadlines, to-do items, social roles, and work practices, interruptions that carry information about updates and changes can help these individuals react to those changes and keep track of and integrate them in their own work. Other studies investigate self-interruptions, causes, and their benefits. For example, Dabbish et al.[29] found their study participants sometimes self-interrupted themselves in order to switch to work for which they are accountable. In another work, Jin and Dabbish [55] identified seven categories of self-interruptions on the computers that occurred to their study participants, including: adjustment, break, inquiry, recollection, routine, trigger, and wait. For example, it was found that taking breaks could help the participants refresh their minds so that they could concentration when they returned to the primary

task. Inquiries were also found to positively impact the participants' primary tasks because these help them find the information they needed. Taking small breaks during work has also been suggested as positive to increase focus and creativity at work [1].

3 METHODOLOGY

3.1 Recruitment and Participants

Our initial pool of eleven participants was recruited via word of mouth and advertisements posted on social-networking sites in our country. Each advertisement was linked to a screening questionnaire that asked respondents to self-report their demographic information, work schedules, lifestyle, and multitasking propensity, along with some questions relating to notifications reading behavior, including the devices they typically used for reading/handling notifications and their familiarity of technology. Multitasking propensity was measured using the polychronicity scale developed by Poposki and Oswald (2010) [94]. The notification-related questions included what kind of devices they had that could be used for interacting with notifications, and their familiarity with technology products.

Then, guided by a sampling strategy referred to as theoretical sampling [20], in which research participants are recruited, interviews are conducted, and interview data are analyzed concurrently [101], nine participants were recruited in the second wave of recruitment. In this wave, the focus of sampling was on diversifying the sample's demographic backgrounds, lifestyles, busyness, and multitasking propensity. For instance, most participants recruited in our initial wave were on-site office workers. When we found that some of them who worked at home on some days interacted with notifications at quite different frequencies than when in the office, and also exhibited different multitasking behavior, we decided to recruit more participants with flexible schedules in the next wave. Aside from these behavioral aspects, we also sought more gender and occupational diversity. Therefore, in the last two waves of recruitment, in which we recruited 10 and four participants, respectively, we recruited participants who had demographic backgrounds, occupations, and/or work styles different from those in the previous waves. In practice, this meant that more of the later recruits had flexible work schedules and were relatively senior.

We continued recruiting as long as we were obtaining new experiences, ideas, and meanings from each newly interviewed participant, and stopped sampling when we deemed that theoretical saturation had been achieved [20], i.e., that no new concepts and meanings had arisen in the latest round of interviews. The final sample of 34 participants (see Table 1) included 10 students and 24 non-students, and 20 females and 14 males, aged between 22 and 64 ($M = 28$, $SD = 10.9$). Half self-reported having flexible work schedules, and the other half, fixed schedules. Just over half ($n=18$) had high polychronicity scores (i.e., above 43.20 on Poposki and Oswald's scale), and the remainder, lower levels of polychronicity. All participants received US\$23 for their participation, and the study was approved by our university's Institutional Review Board.

3.2 Study Design

Each participant completed a week-long digital diary [12] and two semi-structured interviews: one before the diary-writing phase, and the other, after it. The pre-diary interviews were aimed at gaining

a broad understanding of the participants' lifestyles, multitasking practices, and notification management. In the post-diary interview, in contrast, the researcher walked the participants through their diary entries, seeking more context about each one, and explanations for their choices and actions. The main themes that both interviews were intended to capture were the interviewees' intent behind and practices around attending to notifications while they were about to start, had been engaged in, and had finished their main task at hand. Due to the COVID-19 pandemic, all the semi-structured interviews took place remotely via Google Meet, Microsoft Teams, or Zoom (at the interviewee's option), and all participants consented to these interviews being recorded.

3.3 Study Procedure

Each participant was allowed to select the day of their pre-diary interview, which on average lasted 15 minutes; and the week-long diary period started the following day. During that period, the participants were to record all occasions on which they multitasked by handling smartphone notifications plus some other task at hand – including scenarios in which they were about to start, were in the middle of, and had recently finished that task – as well as how they acted upon those notifications they saw. A link to the digital diary was sent out once, later on the same day that the first interview was held. The diary template was structured as a top half and a bottom half. The top half listed some questions about the participant's general habits and self-imposed rules for interacting with notifications, including which apps they deemed important, and the modalities of their notification settings. The bottom half, on the other hand, asked participants to record their relevant daily-life events, separated into the morning, lunchtime, afternoon, and night. However, the participants could modify the template based on their own habits. For example, some participants who normally woke up in the afternoon could skip the template's morning section. We also told our participants that they had the option (if they had time to do so, and their workplaces allowed it) of uploading photos to help us understand their multitasking environment. We checked daily whether each participant had written in their diary, and sent them reminders if they had forgotten to do so.

When each person's diary period ended, the research team contacted them to schedule their second interview. All second interviews took place within one week following the end of the diary-writing phase, to ensure that the participants' memories remained relatively fresh [12].

In the post-diary interviews, as well as probing the diary entries themselves as described above, the researcher asked about the interviewees' other experiences of and attitudes towards dealing with notifications outside and within a main task; and followed this up with questions about why they had made particular choices about notifications (i.e., ignoring, glancing at, attending to, or responding to them) in particular task situations. On average, the post-diary interviews lasted 62 minutes.

3.4 Data Analysis

All diary entries, photographs taken during the diary period (Fig. 1), and transcripts were analyzed in parallel with the data-collection process using Atlas.ti, an online collaborative qualitative-analysis

ID	Age	Occupation	LifeStyle	Preference
P01	27 F	Designer	Flexible - Freelance	Poly-chronic
P02	33 M	Engineer	Structured	Poly-chronic
P03	31 F	Customer Service	Structured	Mono-chronic
P04	37 F	Museum Staff	Structured	Mono-chronic
P05	26 M	Banker	Structured	Poly-chronic
P06	41 M	Travel Agent	Flexible - Slash(Travel Agent/Tutor)	Poly-chronic
P07	36 M	Engineer	Structured	Mono-chronic
P08	32 F	Administrative Assistant	Structured	Poly-chronic
P09	25 F	Designer	Flexible - Freelance	Poly-chronic
P10	29 M	UX Researcher	Structured	Mono-chronic
P11	24 M	Student	Flexible	Mono-chronic
P12	28 F	Engineer	Structured - Work-from-home	Mono-chronic
P13	26 F	Product Manager	Structured	Poly-chronic
P14	22 F	Administrative Assistant	Structured	Mono-chronic
P15	28 F	Product Designer	Structured - Work-from-home	Mono-chronic
P16	25 F	Product Manager	Structured	Mono-chronic
P17	38 F	Product Manager	Flexible - Work-from-home	Mono-chronic
P18	46 M	Product Manager	Structured	Poly-chronic
P19	22 F	Student	Flexible	Poly-chronic
P20	25 M	Student	Flexible	Mono-chronic
P21	24 F	Student	Flexible	Poly-chronic
P22	24 M	Product Manager	Flexible - Slash(Student / Product Manager)	Poly-chronic
P23	24 F	Purchasing Specialist	Flexible - Work-from-home	Poly-chronic
P24	23 F	Student	Flexible	Poly-chronic
P25	64 M	Artist	Flexible	Mono-chronic
P26	35 F	Political Worker	Flexible - Slash (Student / Political worker)	Poly-chronic
P27	38 M	Engineer	Structured	Poly-chronic
P28	22 M	Student	Flexible	Mono-chronic
P29	26 M	Student	Flexible	Mono-chronic
P30	27 M	Student	Flexible	Poly-chronic
P31	64 F	Retired	Flexible	Poly-chronic
P32	45 F	Administrative Assistant	Structured	Mono-chronic
P33	46 F	Administrative Assistant	Structured	Mono-chronic
P34	44 F	Library faculty	Structured	Mono-chronic

Table 1: Demographics of the participants.

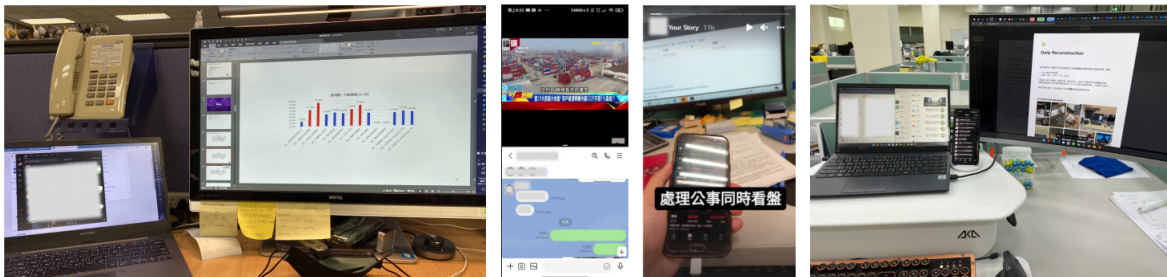


Figure 1: Sample photographs provided by four different study participants in their diary entries that showed their multitasking practices of reading notifications during their work. All these images were approved by the participants who offered them.

software. Specifically, we adopted the grounded approach suggested by Charmaz [20], in which, as mentioned earlier, sampling, data collection, and data analysis take place in parallel. Our data analysis began with open coding, to explore important concepts in the data gathered from the initial wave of participants. Generation of the initial codebook was guided by our interview protocol. Later, the research team regularly met and discussed the emerging codes and categories that the team felt they needed to focus on during focused coding, as well as the new concepts (or the lack thereof, i.e., theoretical saturation) obtained from the latest group of participants. Codes and categories were regularly compared against new data from new participants; and when new codes emerged or existing codes were revised, they were compared against existing transcripts for validation.

This process resulted in the following four main theoretical coding categories: 1) motivations behind actions upon receiving notifications; 2) personal, work, and lifestyle characteristics (including polychronicity); 3) in-the-moment context (personal, situational, relational, activity); and 4) timing (i.e., before, during or after the primary task). It should be noted here that our coding of timing –, i.e., whether an instance of notification-reading was pre-task, post-task, or during-task –, depended on how the participant regarded that instance when we talked about it in his/her interview. We observed that the participants' self-reported timings reflected a clear relationship with the relative demands, in terms of time and cognitive resources, of the just-completed task and the upcoming task. That is, when they perceived that they were reading notifications before a demanding upcoming task, they described that moment as a pre-task timing; but when the more demanding of the two tasks was already finished, they described the moment as post-task. In the following sections, we present our study's key findings.

4 KEY FINDINGS

This section is structured as follows. The first subsection presents the framework we employed to analyze and showcase the motivations that participants frequently associated with specific activity timings for interacting with notifications. Then, the second subsection describes the participants' motivations for attending to and dealing with notifications in these timings in greater detail.

4.1 Human-Notifications Interaction: Timings, User Motivations, and Factors

The conceptual framework we developed for analyzing and depicting participants' motivations for interacting with their notifications, and two levels of factors that triggered or influenced their decisions about when to interact with notifications, is shown in Figure 2.

4.1.1 Personal, Work, and Lifestyle Characteristics.

We found that participants' decisions about when to interact with notifications were strongly affected by their personal, work, and lifestyle characteristics. For instance, we found that participants who described themselves as being in relatively flexible and relaxing daily-life routines – e.g., who worked remotely, were freelancers, or had retired – tended to be more flexible about when they read notifications. For participants who tended to follow a structured daily rhythm and discipline, on the other hand, catching up with

notifications was deemed part of this structure, and the timings for doing so were more or less embedded in it. These participants were mostly office workers with fixed work schedules. Specific features of their work also led participants to prefer reading notifications at specific moments. For example, some participants' jobs involved intensive interpersonal communication, and thus they had to engage in frequent notification-checking to accomplish their work. Some others, whose jobs were creative, felt that checking notifications periodically allowed them to gain inspiration. And others mentioned that their companies' cultures, social norms, and regulations affected when they felt it was appropriate to check their phones. Personality traits, habits, ability for sustained concentration, and level of polychronicity also impacted notification-checking behavior. For example, some participants said they easily experienced fear of missing out (FOMO), which made it hard for them to delay checking notifications until opportune moments. Also, in terms of polychronicity, whereas some participants claimed that concentrating on one thing at a time was best for their productivity, others argued that their productivity was highest when they quickly switched among multiple tasks, or let them proceed simultaneously. Notably, our participants were quite diverse in these dimensions, and not all of them mentioned all of these dimensions during their interviews. Nevertheless, these characteristics offer important explanations of why participants differed in their preferences for certain timings over others, despite their situations being similar.

4.1.2 In-the-moment Context.

Contextual factors also influenced participants' decisions about whether to read notifications at a given moment. Our results suggested that these occurred in four categories, i.e., personal, situational, relational and activity factors. Personal factors include, but are not limited to, one's attentional, emotional, and physical states. For example, some participants mentioned that feeling bored made them want to read notifications in that moment. Situational factors included social surroundings and locations: e.g., some participants mentioned if they had a meal with their friends, they would prefer not to use their phone, as doing so might be deemed disrespectful. Relational factors involved their relationships and patterns of interaction with particular people, typically the senders of the instant messages and emails that had resulted in notifications being delivered. For example, some participants thought that it was important to address their superiors' messages in a timely manner, regardless of their timing. Finally, activity factors described the participants' primary tasks in terms of their familiarity; continuity; divisibility; cost of resumption; requirement for waiting; demands on cognitive, physical, and emotional resources; anticipation of subsequent events' resource demands; and social consciousness. For example, some participants mentioned that cooking occupied both their hands and was difficult to pause, and thus it was perceived as not a good time at which to act on notifications. Attending a meeting that they were not closely involved in, on the other hand, was deemed undemanding of their attention, and thus they felt able to read notifications while waiting for it to begin.

In the following subsections, we first present our participants' reasons for deferring their interaction with their notifications until after they have completed tasks, i.e., interacting with notifications after tasks, as these reasons seem the most straightforward and

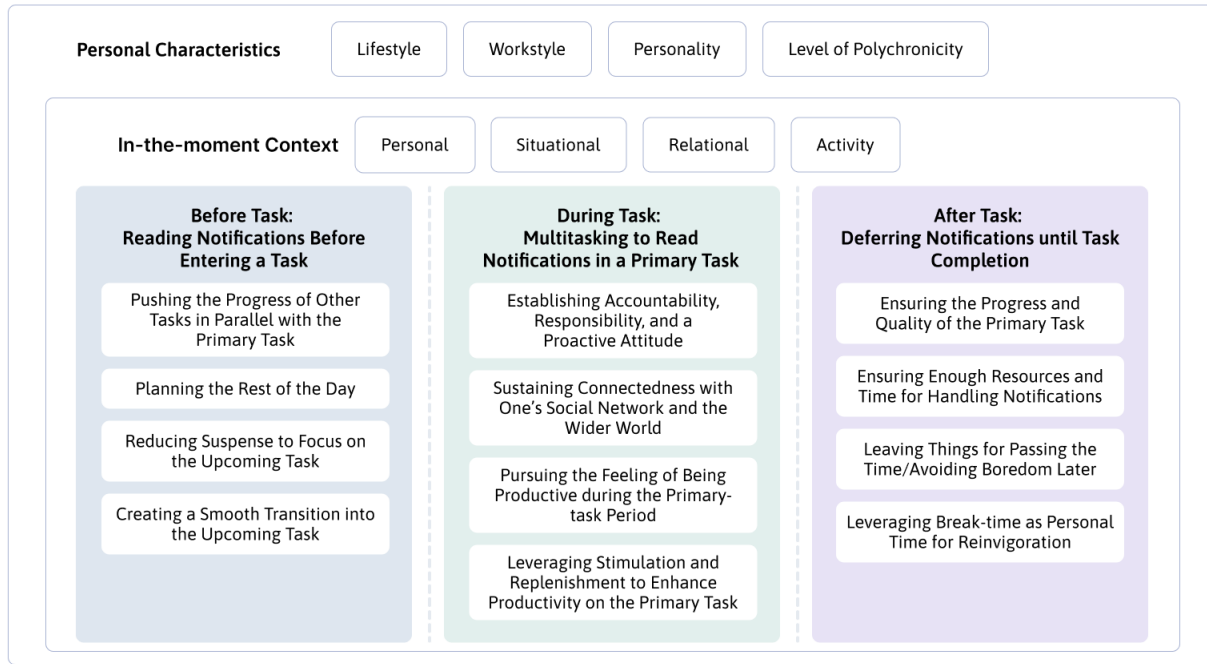


Figure 2: Analytical framework for notification-management strategies: The visual grouping of the 12 motivations into three activity timings, namely before-task, during-task, and after-task, represents the most commonly identified and prominent associations that participants made between the motivations and the activity timings.

resonant with the findings of prior research that sought to reduce interruptions to tasks. Then, we present the participants’ various motivations for interacting with notifications during and before tasks. Again, it is important to note that these timings were not mutually exclusive. That is, the assignment of a moment to a before-task, after-task, or during-task timing depended on the participants’ perceptions, and it was possible, and indeed not unusual, for a moment between two tasks to be deemed both before-task and after-task, or for notification-reading to also be associated with multiple motivations. Additionally, it is important to note that our framework does not rigidly define the relationship between activity timings and motivations. That is, it does not necessarily imply that these are the only activity timings during which a motivation can occur. The framework mainly indicates that participants predominantly associated certain motivations with specific activity timings. It is possible that in actual practice, a user may experience a motivation at a different activity timing than what was observed in our study.

4.2 Participants’ Main Motivations for Interacting with Notifications after the Primary Task

4.2.1 Ensuring the Progress and Quality of the Primary Task. The most common reason our participants mentioned for wanting to interact with their notifications after completing a task was to protect their performance of the primary task, which can be further broken down into task progress and task quality [58]. This

motivation resonates strongly with prior research that sought to identify task transitions and opportune moments for delivering notifications [45]. Our participants often mentioned this motivation in combination with an assessment that the task was continuous and could not be paused (i.e., that they would need to start over if interrupted), and/or that they themselves needed to concentrate on it to complete it efficiently. As P14 mentioned, “*I was working on this problem set and if someone interrupted me, I would forget what I was supposed to do next.*” There were also cases where the primary task was perceived as divisible, but the participants preferred not to interrupt it because it would delay their progress; and they were especially likely to avoid interrupting tasks when they perceived that resuming them would take extra effort. For example, P10 noted in his diary, “*I was at work in the afternoon and messages kept coming in. I’d have delayed my work if I had distracted myself with the messages. So I didn’t read them until I finished my work.*” Participants also sometimes perceived that a certain level of task quality could only be ensured and/or achieved when they were fully focused on the task, as P18 commented about working on high-quality presentation slides: “*I need to be very focused and can’t do anything else. [...] This is because this level of focus can make me think more deeply when I work on certain issues.*”

4.2.2 Ensuring Enough Resources and Time for Handling Notifications. A second reason participants read notifications after completing their primary tasks was to enable them to allocate more of their cognitive resources and time to dealing with them. They mentioned

this reason in connection with a perception that particular notifications would demand relatively large amounts of time and/or effort to read, think about, and deal with. P11, for instance, noted that he would not look at email during a task, *“even if it’s just trivial or in one sentence.”* The same participant reported not reading news notifications, because *“I might encounter some vocabulary that I don’t know and need to look it up, and this would take me lots of time. So I’d wait until I had more time for that.”* Some notifications did not demand an articulate response, but nevertheless took up time. P02 told us: *“Once I start to watch YouTube videos, it’d just take me ten, twenty minutes. So I’d just glance at what’s there [in the notification drawer] but watch them during my break or after work.”*

4.2.3 Leaving Things for Passing the Time/Avoiding Boredom Later.

A third reason participants gave for reading notifications after a primary task related neither to that task nor to the notifications; instead, they purposely left notifications unread until their free/idle time, specifically to fill it. P16 explained: *“I postponed reading the ads sent from my company to some other time [...] Like when I was waiting for the elevator, I would read newsletters, or emails about training sent by our company.”* In her diary, P08 noted about her after-work commute that *“reviewing notifications one by one after I get on the bus is something I must do every day, until I get out of the vehicle and walk home.”* Later, in her second interview, she reflected on this diary entry as follows: *“Those are the things that you do every day, something that would not take you much time. And you can’t do anything else on the bus. It’s crowded and so you can’t read books, unless you have a seat. So it’s phone time. Compared to looking at Facebook, or Instagram feeds, doing this is more meaningful. It’s making better use of my time.”* P18 likewise commented on deferring notifications to commute time. *“This is a period when you can’t do anything but use your phone. What else can you do, watch people? So I’d feel that at least you can [...] review your emails, Facebook posts, messages, and so on.”* To sum up, this motivation reflected participants’ widespread aspiration to use their free time wisely.

4.2.4 Leveraging Break-time as Personal Time for Reinvigoration.

Finally, several participants mentioned that they would aggregate all notifications they considered personal (as opposed to business-related) and postpone dealing with them until their *“private time”*, especially after a period of hard work, often as a means of reinvigorating themselves. P16, for example, noted in her diary that after a meeting, she went to a break room on her office building’s 21st floor, her *“ritual space for dealing with private business”* and for *“relaxation and private time”* such as scrolling Facebook. In her subsequent interview, when reflecting on this diary entry, she said: *“I don’t use my phone during my work. I do it in that break room.”*

Several participants said they often needed to work overtime, which resulted in their personal time being sacrificed. Taking small breaks and dealing with personal business between primary tasks made them feel that they had earned some *“lost”* personal time back. Several mentioned that these interruptions to work were important to them sustaining their well-being and subsequent work performance. Some even praised its positive impact on their work performance, not only because small breaks were refreshing in themselves, but because during them, they found incentives among their notifications to work more efficiently.

4.3 Participants’ Main Motivations for Interacting with Notifications During the Primary Task

We will now address the primary question of this study: What are smartphone users’ main motivations for interacting with notifications during a primary task? As the following subsections will show, many of our participants often did not regard notifications as distractions, but rather, as fulfilling their momentary functional and psychological needs, which again, included improving their utilization of time and personal well-being. As a result, as opposed to passive feelings of being disturbed or distracted, participants proactively sought to satisfy these needs by using notifications as an instrument.

4.3.1 Establishing Accountability, Responsibility, and a Proactive Attitude.

One of the most common motivations participants mentioned for reading notifications during their primary tasks was to establish a sense of accountability, responsibility and/or proactiveness. As also discussed in prior research, this was often driven by a need to fulfill obligations due to their work, duty, or position [54]. Our own participants mentioned that frequently checking for notifications was necessary because some of their duties involved other stakeholders, and failing to act on certain notifications promptly would result in negative outcomes, such as delaying other people’s decisions or harming their performance. Therefore, they intermittently attended to their phone to check if there were any incoming duties or tasks, accompanied by worry that they might have missed something urgent. As P04 mentioned in her diary, *“In my Yoga class, I would wear my Mi Smart Band, to sense its vibration and ensure I would not miss important notifications. If it could not receive notifications, it made me anxious. The class is supposed to be relaxing. So doing this is not good. But I’ve had bad experiences of missing important notifications during the class.”*

Sometimes, however, the motivation to check notifications during a primary task was not rooted in the avoidance of negative outcomes, but rather, in a desire to feel like a responsible, spontaneous, or proactive person. That is, we observed that the act of proactively checking and responding to notifications was particularly meaningful to these participants, not only because it helped them become aware of which tasks might require their attention sooner, but also because the act itself helped them fulfill their self-expectations. P04 explained, *“It happens a lot. [...] When I was focusing on something and my family or colleagues suddenly messaged me to do something, I’d just stop my work and work on theirs. [...] I feel it’s like a sense of responsibility.”* In another example, P13 explained, *“If the message was a question, I presume that it would be more urgent to respond, so I tended to check if there was any question. Or, if the message came from my boss, I would assume it to be more important too, which is also typically true. If you didn’t respond, he might wonder why you were gone for so long, because it is, after all, working hours.”* In other words, for these participants, it was important to look at arriving notifications because they could involve duties – not necessarily because such duties required urgent execution in and of themselves, but because being attentive to their duties was vital to their self-images and value systems.

4.3.2 Sustaining Connectedness with One's Social Network and the Wider World.

The second motivation participants often mentioned for this behavior was related to FOMO: a finding that resonates with many earlier investigations of the reasons behind high notification attendance [64], phubbing [3], addictive smartphone use [61, 97, 106], and distraction [40, 85]. As in many of those prior studies, a common theme of FOMO in our study was related to social interactions and a sense of belonging. For example, P24 commented on her desire to take part in her friends' chat group, despite its overwhelming number of notifications. *"They were friends I'm close to and want to know more about their updates or gossip, like small secrets about their professors. There are a lot of conversations going on [...]. It's a feeling of convergence, a feeling like my friends are around me."*

However, in addition to social connectedness, several participants' worries on these lines involved informational connectedness. That is, they were anxious about becoming *"outdated"* by missing breaking news, live updates, and time-limited offers, which felt they needed to catch up with as soon as possible. Many of them reported being particularly alert when they received a burst of notifications in a short period of time, on the grounds that there might be something important happening. When this occurred, to resolve their worries and curiosity, they would proactively check these notifications. *"I was at work, and a lot of messages suddenly popped up from my friend's chat group. It makes me curious about what happened that made them send so many [messages ...]. The more messages, the more I'm curious, and want to check it out quickly"* (P13). Although these participants were aware that their performance on their primary tasks would be negatively affected as a result of their self-interruption for checking these notifications, they were more worried about becoming personally un-synchronized from the world. This pattern was especially evident when the cost of missing updates was perceived as greater than the cost of being distracted from the primary task. For example, P20 mentioned his close attention to his investment in cryptocurrency, which led him to frequently check related news and the latest prices so that he could react quickly to market changes: *"If there's some news about the issue of certain items, and I didn't notice it in time, it'd have a large impact on me. [...] If it has problems, I'd also like to know what problems there are. [...] I'd try my best to keep myself posted on the latest news. It's never a bad thing."*

4.3.3 Pursuing the Feeling of Being Productive during the Primary-task Period.

Third, we observed that some participants switched back and forth between several tasks-at-hand and notifications because they wanted to pursue a feeling of being productive by pushing the progress of multiple tasks in parallel. Several participants reported that doing so made them feel that they were making full use of their time. This motivation was mentioned especially when participants felt that their primary task was not attention-demanding, and therefore, that if they did not divide their attention and devote some of it to other things during these *"attention surplus"* [68] or micro-moments [53], these participants felt that the time was not wasted and meaningfully used., they felt the available time had not been fully leveraged. P13, for example, told us: *"During my entertainment period at night, I'd play Switch and computer games at the same time. Meanwhile*

I'd have my phone next to me so that I can look at it and respond to messages while waiting for the game to load." P30, on the other hand, wrote in his diary that he read notifications related to NBA games while he was watching NBA, a phenomenon often referred to as media multitasking [103] or second screen [102, 117]. *"I see that hour as my NBA time. [...] The most efficient time to look at these notifications from the NBA app was during [...] boring transitions in the game itself."* P11 commented similarly on utilizing micro-moments for interacting with notifications while watching YouTube videos: *"I could roughly predict which segment was important or not, like transitions, trivial talk, something you wouldn't feel you'd missed out on if you skipped it. Those segments are short, and so you can't really use them for doing something else bigger, so I'd use them for doing these trivial things [reading notifications]."*

4.3.4 Leveraging Stimulation and Replenishment to Enhance Productivity on the Primary Task.

Finally, the fourth motivation participants mentioned was looking for stimulation and replenishment from notifications to boost their energy and improve their productivity on the primary task when bored, tired, sleepy, or simply finding the primary task tedious and mundane. Even while conceding that notifications on their phones were not necessarily entertaining, they perceived them as a space in which they could find diverse, and sometimes unexpected and rewarding, elements that helped them shift gears and replenish their minds. As a result, though spending time on notifications postponed the completion of their primary tasks, participants perceived this delay would be made up for, in the form of better productivity. For example, P09 noted in her diary: *"I went to a coffee shop and read my book. I wasn't very focused on it. I checked the notification center and read some emails I got. Then I read a newsletter in there, a couple of paragraphs, and then returned to my book."* In her subsequent interview, she reflected on this diary entry as follows: *I felt the book a little boring [... but] was still trying to be productive. So I did not open YouTube. I read newsletters, just to shift gears. I spent some time on that, and then went back to my book. Then I felt the book became more interesting."*

At other times, participants did not feel bored, or find their primary tasks tedious, but were struggling, stuck, or annoyed when encountering negative emotions during their primary task. Staying in this state bothered them and triggered them to look at notifications in the hope of sharpening their thinking, adjusting their mood, relieving pressure, gaining inspiration, or thinking outside the box. As P01 commented: *"My work is creative, and when I feel my ideas exhausted, I will read notifications to find some inspiring ideas or something interesting."* P02, on the other hand, found reading arriving notifications during a primary task vital to recovering from struggles. *"When you're exhausted or in a dead end and can't get out, and someone texts you and shares something interesting or pleasant about his life, it makes a difference to your mood. Sometimes you're in an infinite loop and just need external forces to pull you out. It's like seeing light at the end of the tunnel."* Similarly, P24 reported in her diary that exchanging messages with a close friend to release her negative emotions during work helped her calm down and continue. *"While I was eating my breakfast and modifying the slides for the election campaign, I received messages from Professor B that the slides needed significant revisions. So, to calm myself down, I*

turned to my two close friends to complain about it. Then I returned to check those slides that were seen as not good enough to see if it was on me. [...] I was kind of upset about my increased workload recently. It happened that another senior classmate texted me and complained about Professor B. Then I complained too, and worked on the slides at the same time. Doing these two things at the same time made me feel much better.”

To sum up, the four main motivations imply that notifications were not always deemed by the participants as an unwelcome distraction in task-completion contexts. Rather, participants sometimes need them to fulfill specific needs, two of which were related to improving their overall productivity and use of time and maintaining their well-being, in contrast to the widespread idea that notifications better be suppressed or delayed to prevent them from harming smartphone users' productivity.

4.4 Participants' Main Motivations for Interacting with Notifications Before the Primary Task.

Finally, participants associated four main motivations for interacting with their notifications with the before-task timing. We present them in turn below.

4.4.1 Pushing the Progress of Other Tasks in Parallel with the Primary Task. Several participants reported that they preferred to respond to all notifications that needed their responses before starting their primary tasks, specifically so that other people could make progress on other tasks. P03, for instance, said, “I understand the feeling of waiting until the last minute. I don't want other people to wait for me as well”. Others reported that their intention was to improve the overall efficiency of all tasks they were involved in, and that they did not want their engagement with their own tasks to become a bottleneck. For example, P13 noted in her diary, “Before I focused on my meal, I replied to all messages from my friends.” Later, she commented on this diary entry as follows: “I couldn't reply to these messages when I was having my meal. So I replied to all of them before I started eating and then my friends could reply to me while I was eating, and then I could reply to them after I finished. Life is short. Doing this can let us chat more.” She also reported replying to all messages before leaving her seat at work for an unknown amount of time. “I don't know how long it's gonna take. [...] If they didn't get my response, they might not be able to do their next step. Sometimes they just needed my confirmation. And I don't want them to freeze there without making any progress.”

4.4.2 Planning the Rest of the Day. Several participants mentioned that they preferred to be aware of what notifications were in their notification centers before starting any task. Their main motivation for this was a perceived need to plan the best use of their time for the rest of the day. Participants who mentioned this motivation also had a tendency to seek optimization of their use of time for dealing with every task-at-hand. Perceiving that notifications might bring to light certain tasks that had to be completed by a specific time, and that their original schedules would need adjustment as a result, they wanted to be aware of everything that they needed to act on before they started, such that time-allocation for all remaining tasks could be optimized and harmonized. P15, for example, said: “I

plan how to optimize my route when I go out. Some routes will take me more time, so I have to think.” Likewise, P11 mentioned that he addressed all notifications before a task because “I like to keep my schedule arrangement perfect. I'd check my notifications [before starting my activity] in case anything would change my schedule.” In short, checking notifications before their primary tasks made these participants feel as if they were using their time wisely and efficiently.

4.4.3 Reducing Suspense to Focus on the Upcoming Task. Several participants mentioned that they would check and address all of their notifications, sometimes clearing them all, so that they could go on to focus on their primary tasks without any lingering feelings of suspense. That is, if they did not clear their notifications, they would remain uncertain about whether there was some other task they should have dealt with, but had not. This motivation was mentioned mainly in the context of perceiving that their primary task would take up a relatively long period during which they would not be able to (or want to) check their phones. P11, for example, noted in his diary regarding clearing notifications before a big date, “I handled all my notifications before I went to the coffee shop. That day was a very special day to me. I hoped I could go in a perfect state without needing to worry about anything. [...] I was discussing her project with her, and left my phone alone without even giving it a look.”

4.4.4 Creating a Smooth Transition into the Upcoming Task. Finally, some participants mentioned that they sometimes read notifications before an upcoming primary task because they wanted to adjust their mindset or state of mind for that task. To them, these notification-checking periods were buffer zones that helped them transition into upcoming tasks more smoothly, as P05 reported. “You're transitioning to a state of working from a state of drowsiness. You need time to make that transition and prepare yourself for it. And what I usually do is check messages, or something related to my work, and gradually flow into that state.” Moreover, some felt that doing this helped improve the subsequent quality of their work, as P26 explained. “I am clever when I am working. But my brain is blank and operates slowly when I am not working. Like I put it in the diary that day, I ate my breakfast in my office and read some notifications to help me enter that working state in the morning.”

To sum up, our participants linked four main motivations for interacting with notifications before they started their primary tasks, all of which were related to productivity and/or improving their use of time. In the next section, we will discuss the research and design implications of the identified motivations.

5 DISCUSSION

Our curiosity about what made smartphone users want to interact with notifications during a primary task led us to analyze their motivations for reading notifications at different timings, as well as the contexts that triggered and influenced such motivations, via a diary study and semi-structured interviews. Through the resulting human-notification interaction framework, we were able to understand why, during primary tasks, our participants sometimes wanted to interact with notifications despite their supposed status as a distraction, and how these reasons differed from those given

for checking notifications before and after primary-task completion. Yet, despite such differences, the same core/fundamental needs underlay many of the 12 motivations we identified. Below, we discuss these findings and their implications in more detail.

5.1 More than as Distraction - Recognizing Various Functions of Notifications-Reading During the Primary Task

Notifications that arrive during a primary task have long been assumed to constitute interruptions, disturbances, or distractions [14, 15, 23, 37, 56, 108]. As a result, prior studies of interruptibility have focused on identifying good moments for delivering notifications, such as at activity transitions [45], breakpoints within an activity [2, 53, 80–82, 85], negotiated moments [73, 99, 114], and detected moments [31, 51]. This view of notifications as negative may be due to the fact that many of these studies were conducted in organizational or workplace settings where the primary tasks were work-related and productivity was a main concern. While the current study did not set out to challenge this widely held view of notifications, it aligns with several other studies that have shown the benefits of notifications for productivity [86] if they are relevant to the task [14, 16, 58], and the multiple roles notifications can serve [66].

That is, while all of our participants had experienced situations in which they preferred to interact with notifications before or after a primary task, as a means of protecting its progress and/or the quality of its outcome, all had also experienced situations in which they were eager to interact with notifications during it. The reasons behind such eagerness included not only worry about missing urgent tasks [66, 76, 93, 100, 115] and FOMO [37, 41], but also a desire to increase their productivity during the current primary-task period, whether by making use of idle time during the task, or by stimulating and replenishing themselves when they were struggling, stuck, or bored. The former motivation was related to a need to improve personal productivity and self-efficacy, while the latter concerned personal well-being, which resonated with recent studies on the benefits of taking small breaks to workers [1, 55]. Therefore, at least in certain circumstances, allowing smartphone users to easily access notifications may enhance their productivity and/or overall performance rather than reduce them.

It is noteworthy, however, that the varying perspectives on notifications observed in our study compared to previous research could be attributed to the diverse primary tasks included in our daily life situations, whereas prior studies primarily focused on organizational or workplace settings. This distinction in setting may have led to a less critical view of notifications as the primary tasks in our study were not solely work-related. Additionally, participants may have become more familiar with checking their phones in non-work situations, resulting in a potentially less negative outlook on notifications. It is also worth mentioning that even though participants may see notifications as a way to improve their productivity at times, these notifications might still be a source of distraction during these moments.

Furthermore, aside from productivity, participants were also motivated to create and maintain an image of accountability, responsibility, and proactivity towards their values. We observed that

for these participants, the purpose of checking notifications during a primary task went beyond simply keeping abreast of urgent tasks. Finally, many participants told us about the various types of information they valued and were excited about, and how they subscribed to channels and services that brought them these pieces of information. For example, several prioritized keeping in sync with the latest world events over their primary tasks, because they perceived the former as more consequential. Importantly, these participants included many who deemed their primary tasks merely routine or mundane. As a result, it is not surprising that some of their notifications, however disturbing, distracting, or interruptive, were more appreciated/welcome than the feeling of accomplishing the primary task.

One vital implication of these results taken as a whole is that designers of notification systems should consider the relative importance and value of a given task-at-hand and a given notification. That is, when a user considers certain notifications to be more valuable or consequential than their task-at-hand, blocking or otherwise regulating their notification use during that task may be counterproductive, not least because it might result in frequent self-interruption. In other words, if people opt to interact with their notifications despite being in the middle of performing a primary task, it is vital to recognize that they might be seeking updates that are important to them, improving their utilization of time, or recharging themselves, and therefore that suppressing or deferring notifications in such circumstances may undermine their work processes. In place of the current one-size-fits-all solution – deferring notifications until after a task is completed – a crucial next step in improving notification systems will be to learn smartphone users' motivations for reading notifications during primary tasks, and address such motivations head-on.

5.2 Reading Notifications Before vs. After the Task: Likely in the Same Transitions, but with Different Motivations

Task transitions are widely considered opportune moments for delivering notifications [45], and there is some recent evidence that recognizing these transitions and delivering notifications during them reduces disturbance [2, 63]. Importantly, from the viewpoint of the present study's structure, before-task and after-task timings can be one and the same, i.e., in cases where two primary tasks are executed back to back. Nevertheless, we found that participants' perceptions of whether they were reading notifications before or after a task, or both, depended on how demanding they perceived the just-completed and the upcoming tasks to be, relative to each other. Notably, based on our data about the participants' perceptions, it seems likely that all these motivations can arise in the same notification-reading situation if a person feels that the just-completed task and the upcoming task are more or less equally demanding. Regardless of their perceptions of these two timings' meanings, however, the participants' motivations for interacting with notifications during them can differ considerably. For instance, motivations for interacting with notifications after a task were often associated by the participants with task protection, whether it was the primary task or handling notifications themselves. On the other hand, motivations for interacting with notifications before a

task were often associated with planning and time management. Recognizing these differences – and indeed, the existence of the before-task timing – has at least two important implications.

First, despite the challenges associated with identifying it, the distinctness of the before-task timing is vitally important, because it could drive variation in the types of notifications users are looking for in a notification center at certain moments (see Table ?? for a list of examples). For instance, if a user's interaction with notifications during a task-transition period is mainly for the purpose of protecting the task they have just finished, they may not be looking for specific notifications. On the other hand, if they are mainly motivated by a need for sufficient time and resources to handle specific notifications, they are already targeting those notifications in that period. Either of these motivations may arise from the just-completed task's demands on the smartphone user's time and cognitive resources. However, if that person is mainly seeking to plan and improve their use of time, they may be looking out for notifications that will affect their future schedules, and/or that they need to handle before others if multiple tasks are to progress in parallel. In the latter case, the upcoming task may be perceived as demanding users' time and cognitive resources.

Second, prior research has primarily looked at the during-task and after-task timings, due to its narrow focus on protecting the progress and outcome quality of the task-at-hand. The present research, in contrast, shows that the perceived nature of upcoming tasks matters to how people interact with notifications before such tasks commence. Interestingly, some of our participants perceived that the presence of notifications might also affect their upcoming tasks, either by altering their existing schedule or by creating unwelcome feelings of suspense. These results suggest that researchers and practitioners should consider the joint influence of upcoming tasks and the presence of certain notifications on users' behavior.

5.3 From Behavior to Motivation: Implications for Human-notification Interaction

Our proposed human-notification interaction framework distinguishes among before-task, during-task, and after-task timings and tentatively suggests that in these different timings individuals may interact with notifications for a particular set of motivations than for others. We deem that this framework may serve as a possible basis for considering various approaches to meet users' needs for interacting with notifications and may also provide a useful analytical tool for furthering research in this field.

Table 2 presents a list of examples of approaches that designers of future notification systems might wish to consider incorporating into such systems to address each of the 12 notification-reading motivations we identified. This list is not intended to be exhaustive, as there can be numerous different ways of satisfying a given motivation; rather, it is intended to provide inspiration. Notably, looking beyond any such specific approaches, two common needs underlie all 12 motivations, and we recommend that practitioners bear these in mind when designing future notification systems. The first such need is for improvement of smartphone users' productivity and utilization of time; and the second is for personal well-being, albeit sometimes also for the purpose of improving overall performance. At a high level, then, we recommend that future notification systems take these two fundamental needs into account.

Among the approaches to satisfying the motivations listed in Table 2, one critical capability shared by several approaches is highlighting and/or sorting notifications that users want to see first. This resonates with Lin et al.'s [66] findings that smartphone users desire to see certain kinds of notifications in particular prominent locations, and/or that some notifications be distinguished from others in certain contexts.

Another useful capability would be for the system to automatically defer certain notifications until certain timings, which could reduce not only the overall number of notifications being presented at a given time, but also reduce the distraction that would likely be caused by presenting them at inappropriate times (e.g., before a task, causing unwelcome feelings of suspense). On the other hand, all these approaches will call for automated classification of notifications' content and/or roles before the two aforementioned capabilities can become fully fledged.

Finally, it will almost certainly be challenging to know how demanding users will think a task is, and thus whether they will conceive of themselves as being in a pre-task, post-task, or during-task moment. However, if a system has access to users' calendar events, it can infer its users' intentions/motivations, and further learn them over time, based on the features of their just-completed and upcoming tasks and of the notifications they interact with. It might be also worthwhile to verify such intentions/motivations via prompted questionnaires, a technique that has been employed not only by researchers [110] but in commercial smartphone apps such as Google Opinion Reward.¹ This would allow a system to learn patterns of when and how often a user has specific motivations for interacting with notifications and help it sort or highlight notifications based on the motivations it infers.

In terms of its significance for human-notification interaction research, our proposed framework extends and augments an existing body of literature that has hitherto mainly focused on users' preferences [66, 77, 90, 93, 100], perceptions [14, 15, 23, 37, 56, 108], and practices of interacting with notifications [6, 19, 59, 85, 111, 114, 115]. More specifically, our framework sheds new light on the varying likely motivations that underlie users' actions involving notifications, and has several important implications. First, it encourages researchers to revisit current understandings in the field of human-notification interaction and relate them to the motivations we identified. Taking users' prioritized and selective attendance to notifications, for example, previous work (e.g., [18, 66]) has consistently reported that users read and act upon notifications from certain apps, from certain senders, or of certain types first. It would therefore be worthwhile to examine how users' selective attendance and choices at different timings are associated with the 12 motivations. For instance, users may want to read social-media notifications due to FOMO, or a desire to replenish themselves, or a need to kill time. The latter two motivations could also be fulfilled by other notification types, e.g., those pertaining to news articles or educational content. In our framework, researchers have a new tool for explaining the notification-attendance behaviors and preferences they observed in their studies. The listed motivations can also be used as questionnaire items in studies using

¹Google Opinion Reward:
https://en.wikipedia.org/wiki/Google_Opinion_Rewards

Table 2: Examples of approaches to addressing each of the 12 notification-reading motivations

Associated Timing	Motivation	Possible Approaches to Satisfying the Motivation	Potentially Relevant Notifications Types and Content
Before-task	Planning the rest of day	Highlight notifications that would affect users' schedules and plans for the rest of the day.	e.g. notifications from IM, email, and work-related apps containing task or schedule information.
	Pushing the progress of other tasks in parallel with the primary task	Highlight notifications that users need to handle before others if multiple tasks are to progress in parallel.	e.g. notifications from IM, email, and collaboration apps containing time-critical task requests and inquiries.
	Reducing suspense to focus on the upcoming task	Highlight time-critical notifications but defer those among the other notifications that would demand users' significant cognitive effort and time until after they have completed the upcoming task.	(for deferral) e.g. notifications from IM, email, and work-related apps with time and cognitively demanding but non-time-critical task requests and inquiries.
	Creating a smooth transition into the upcoming task	Highlight notifications that provide context for or are otherwise relevant to the users' upcoming task.	e.g. notifications related to the users' upcoming task.
During-task	Establishing accountability, responsibility, and a proactive attitude	Alert users of time-critical tasks that need their immediate attention and allow them to specify such tasks by providing rules, such as about senders, apps, keywords, etc. Devise an area specifically for highlighting these types of notifications so that users can quickly notice their presence.	e.g. notifications from IM, email, and collaboration apps containing time-critical task requests and inquiries.
	Sustaining connectedness with one's social network and the wider world	Keep users posted with specified updates, likely be grouped, summarized, and presented separately from other notifications. Only send alerts for those updates that require users' immediate attention	e.g. notifications from IM, social media, news, financial, or others checked frequently for critical real-time updates.
	Pursuing the feeling of being productive during the primary-task period	Indicate notifications containing tasks that would (only) take users a short period of time to complete.	e.g. notifications from apps containing simple tasks requiring only prompt attention.
	Leveraging stimulation and replenishment to enhance productivity on the primary task	Indicate notifications or provide content that can help users distract themselves from the task-at-hand and recover from negative emotions.	e.g. notifications from social media, news, entertainment, or non-work-related apps.
After-task	Ensuring the progress and quality of the primary task	Mute or defer notifications that do not need users' immediate attention until they finish the task-at-hand.	(for deferral) e.g. notifications that are not time-critical and relevant to the task at hand
	Ensuring enough resources and time for handling notifications	Indicate notifications that would demand more of users' time and cognitive resources after they have fully completed the task-at-hand.	e.g. notifications from IM, email, and work-related apps with time and cognitively demanding but non-time-critical task, potentially also those "snoozed" by users.
	Leaving things for passing the time/avoiding boredom later	Highlight notifications needing less time to deal with.	e.g. notifications from apps containing simple tasks requiring only prompt attention.
	Leveraging break-time as personal time for reinvigoration	Indicate notifications that are personal and/or provide content that can revitalize users.	e.g. notifications from social media, news, entertainment, or non-work-related apps.

techniques such as experience sampling, to capture users' in-situ motivations and thus help the researchers make better sense of observed/sampled behaviors. The framework could also be utilized to provide quantitative information about the relative prevalence of the 12 motivations and their links to activity timings. Although it is likely that there are other, more nuanced motivations, we believe that the framework provides a good starting point for researchers and practitioners to make such associations.

6 RESEARCH LIMITATIONS AND FUTURE WORK

This work is subject to several limitations. First, it was conducted during the COVID-19 pandemic, and although we prolonged our study period in the hope of balancing out the pandemic's influence, and balanced the participant pool between remote and non-remote

workers, company policies around remote working are likely to have differed before, during and after the main phase of the pandemic. Second, although we aimed to recruit participants from diverse backgrounds, our study participants might not be representative. For example, it is reasonable to assume that perceptions of obligation vary sharply across the people's occupations and individual career paths; but there were no senior leaders or persons in their 50s among our participants. Although we had some participants aged 60+, they were few in number and not necessarily representative of people in their age bracket, either in behavior or points of view. Participants' cultural backgrounds might have also affected our dataset: due to the long work hours in Taiwan and the convenient culture, it may have cultural differences. We tried to recruit some people who live in different countries (one lived in the UK, and one lived in Canada), but they cannot represent all the

users in different countries. In addition, quantity of notifications may influence users' perceptions of and interaction with notifications. Given that these topics were crucial to our research, we emphasized them during the interviews and checked for theoretical saturation. However, if we had collected information on notification quantity during the recruitment stage, we could have used it to more effectively target our sample and potentially obtain a broader range of results.

Third, motivated by the literature and our observation that some people would self-interrupt to check notifications on their phone during a primary task, the motivations and factors we identified in this study have been primarily around *an existing primary task*; but in reality, people do not always have a primary task that is present and/or in their mind. As a result, the current paper's findings are limited to notification-interactions around a known existing task and cannot be applied to the situation in which smartphone users have no particular tasks to undertake, such as when they perceive themselves to be engaged in non-work mobile use [30]. Moreover, our methods – which were heavily reliant on self-reported data, including from diaries and interviews – limited our capture of in-situ experiences in various situations, which could have been logged and studied using a mixed-methods approach [30]. Therefore, we encourage future researchers to obtain objective behavioral data about their participants' mobile-phone usage in an ecologically valid manner [104], which will quantitatively confirm or disconfirm our findings. Finally, prior research has suggested an impact of users' emotions on their receptivity to notifications [78]. Our work, despite implicitly indicating emotions' roles in the occurrence or triggering of specific motivations (e.g., wanting to replenish when feeling bored or stuck), did not systematically investigate such roles. Future research is therefore needed to clarify how different human emotions relate to the various components of the motivational typology we identified.

7 CONCLUSION

In conclusion, our study provides new insights into the motivations behind human-notification interaction. Through diary and in-depth interview studies with 34 participants, we were able to shed light on why users interact with notifications at specific timings. Our findings indicate that notifications are not simply perceived as distractions, but rather as a means to improve performance, time utilization, and personal well-being. This highlights the importance of considering users' motivations in the design of intelligent notification systems. Future research should take these motivations into account in order to create systems that truly support users' needs.

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