



Using Sensors to Measure Inbox Stress

Email notifications are constantly calling for our attention, and the volume of emails is ever-increasing. A research group at the University of California, Irvine explores how managing the inbox affects stress for different working populations.

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Imagine life without disruptive notifications—working on your computer with no pop-ups or being able to have a nice dinner without your phone going “PING!” and diverting your attention. Would you feel relaxed, with peace of mind, or maybe focused? Or would you have FOMO (fear of missing out)? Researchers have long studied how notifications can affect our mood, focus, and stress. And particularly, how emails are a major source of the notifications (and interruptions) in our daily lives.

Email is an integral part of everyday life for many in knowledge work professions. The benefits of email in the workplace go beyond providing a means for communication, as we rely more and more on email for information sharing, archiving, and delegating tasks.

Despite these benefits, previous research on patterns of email use in the workplace consistently noted the considerable time and attention that email management requires. Email has been associated with stress and burnout due to the time it takes to go through an ever-increasing volume of messages, the task demands associated with emails, and the interruptions they create. A 2016 study found

during business hours, employees spent an average of almost one and a half hours on email per workday and checked their emails on average 77 times [1]. There was high variability among employees in how long and how often they checked email, but no difference in the average email duration was found between employees who checked email based on external notifications and those

who checked email on their own. However, differences in email duration existed between employees who check their emails all at once or a few times (batching) versus consistently throughout the day, with the latter group having a longer average email duration.

Physicians are a working population with increasing inbox management demands. Email has been in-



troduced into physicians' workload relatively recently as part of Electronic Health Record systems (EHRs), which are used in clinical care. Tasks that used to be done through other means, such as paper and face-to-face communication, are now integrated into the EHR inbox. These tasks include communication with patients, receiving lab results, and approving medication refills. This inbox integration has a lot of advantages such as allowing for more streamlined and automated tasks, enhancing access to physicians, and fostering better communication between patients and doctors. Patients are also increasingly adopting secure

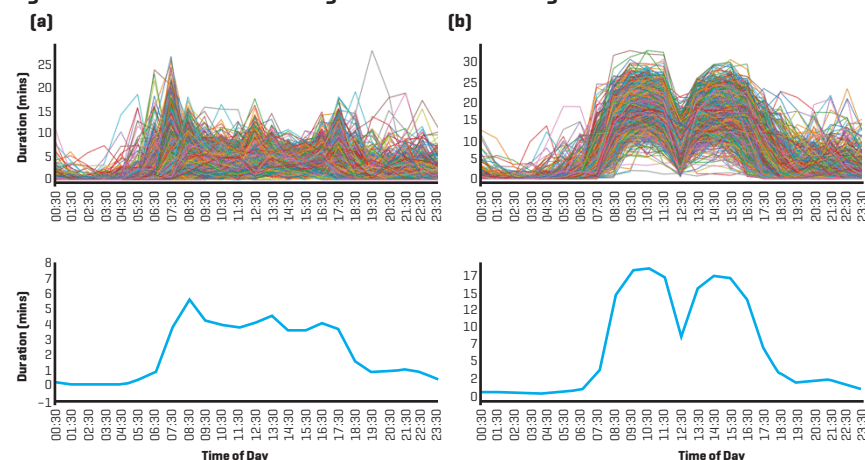
messaging to communicate with physicians. In 2015, 64 percent of physicians had an EHR with the capability to exchange secure messages with patients, a more than 50 percent increase from 2013 [2]. The adoption, use, and integration of the inbox into physicians' daily work is expected to increase further.

As with office employees, email has been associated with increased interruptions and burnout for physicians [3, 4]. The nature of physicians' work makes the patterns of interaction with email different from other types of office employees. For physicians, clinic time is dedicated mostly to patient appointments and using

EHR functionality related to patient data/orders. This workday structure exacerbates the challenge of managing inbox work because of the lack of dedicated or flexible time to manage their inbox. Thus, the patterns of physicians' email use might not be the same as those seen in other office environments where employees have more flexibility and control over when to check their inbox.

Researchers, including myself, from the University of California, Irvine had the opportunity to work with physicians and researchers from a large medical group to study physicians' inbox work. In this new context of working with physicians, we applied our background in human-computer interaction and our experience studying email work patterns of office employees. Among other findings, an analysis of one month of EHR logs from 1,257 physicians (internists and family practitioners) showed temporal patterns of EHR inbox work were different from patterns of other EHR work activities [5]. Specifically, as Figure 1 shows, the use of EHR functionality other than the inbox generally mirrored typical work hours, while inbox time extended beyond work hours, increasing before and after hours, and during the lunch hour. This study was the first to investigate physicians' daily EHR email use patterns using log data, reflecting real system usage for a large population

Figure 1. Time spent on [a] the EHR inbox and [b] EHR functionality other than the inbox. Top figures show daily averages for each user [1,257 users] and the bottom figures show an overall average across user averages.





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of physicians, and to show where inbox work fits temporally in the busy workdays of physicians. We argued that understanding how physicians use email is a first step in quantifying and researching factors that can lead to stress, such as the volume of emails and time spent after hours managing email. Other factors related to inbox stress include interruptions, attention switching, and individual differences in email management strategies. We designed studies to measure each of these factors.

AFTER-HOURS WORK CONNECTIVITY

Many working individuals continue to be connected to their workplace tasks outside of formal work hours, either by staying longer in the office to finish tasks or accessing workplace

systems on portable devices, such as mobile phones or laptops, while commuting or at home. The use of communications technologies after hours to perform job-related functions has been widely investigated across many job roles. Email is one of the top work activities that people engage in outside of work hours and on mobile devices [6, 7]. One study found time spent on email after formal work hours, as well as organizational expectations regarding monitoring work emails after hours, led to emotional exhaustion and a negative perception of work-life balance [8]. We might dislike working after hours, but we can't seem to stop ourselves from checking our emails as soon as we hear those email notifications. A study based on interviews with office employees reported participants view incoming messages less than an hour after they are received during non-work hours through their mobile phones [6]. For physicians, EHR systems are accessible through laptops and mobile phones, which creates the condition of constant connectivity.

We conducted a more detailed analysis of physicians' time on email after hours using log data analysis, rather than self-reports [5]. We found 37 percent of the physicians' total time spent on email occurred outside of formal work hours. On non-workdays, physicians accessed their inboxes through mobile devices,

with the average time spent varying from 0–93 minutes across the board. Not surprisingly, physicians with the highest average duration of inbox work were more likely to do inbox work after hours. Also, the more time physicians spent on their inbox during work hours, the less time they spent after hours. This could indicate that having scheduled time within work hours to manage one's inbox can reduce after-hours work.

After-hours work connectivity has long been associated with stress and negative feelings based on surveys, and we were able to confirm this association with objective stress measures. In a study where we tracked 47 physicians' stress with wearable sensors for a week, we found the proportion of inbox work done outside of

Figure 2. Unobtrusively measuring stress with a thermal camera during computer work in a simulated office environment.

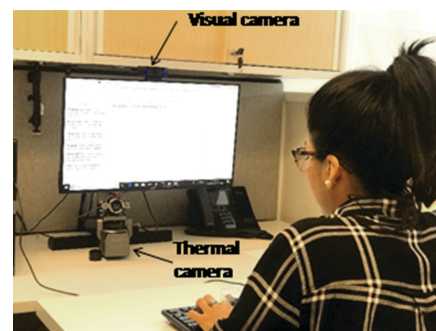


Figure 3. Some people work on emails in batches (left) while others check their emails intermittently throughout the day (right). Results are mixed as to whether and how these strategies are related to stress. We found differences based on the personality trait of neuroticism, where higher neuroticism was associated with higher stress when batching email.



work hours was associated with daily stress duration as measured by physiological factors (heart rate variability from wearable sensors) [9]. We also created clusters of physicians based on features of their typical work patterns. A total of three patterns of inbox work emerged: inbox work mostly outside work hours, inbox work mostly during work hours, and inbox work extending after hours that were mostly contiguous to work hours. Physicians in the first group, who worked on email mostly outside of work hours, had the longest average stress duration during work hours.

STRESS-INDUCING INTERRUPTIONS

We often reach for our phones the moment we hear them ping, or we

click an email notification immediately once it pops up on our desktops. Whether we hear or see these alerts, and whether we respond immediately or tend to them later, these alerts cause interruptions and force attention switching. While some interruptions can be beneficial for providing important information or social interaction, they can also be detrimental to productivity, lengthen the time to resume tasks, and cause errors. Interruptions also affect mood and stress as continual switching of attention increases cognitive workload.

Email work provides an interesting case to study interruptions because email is often managed while multitasking other work tasks. You might be working on email and have a concurrent task at hand, all the while anticipating an upcoming deadline or important appointment. There is scant research that explores this complex workplace dynamic as it relates to stress and performance. We modeled this complexity of a real-world work environment in a study that examined the interplay between email use patterns, stressors, and task performance [10]. We measured stress using thermal imaging, a non-contact alternative to wearable physiological sensors. Using a thermal camera, as shown in Figure 2, we recorded the faces of participants and used an algorithm to extract perinasal perspiration from the facial thermal imaging. In very simple terms, when you are even slightly stressed, the sweat glands in the area under your nose expand and the thermal

camera can pick up this stress reaction. This method provides objective and unobtrusive stress signals while people are working at a computer. One unique benefit of deploying this method is that it enables us to precisely synchronize the stress measure with time or tasks. We looked at stress reactions when participants worked on a task while receiving emails in one of two modes: high interruptions (intermittent email notifications) or low interruptions (getting a batch of emails to process all at once). Participants in the high email interruption mode spent more total time on email as their stress increased, perhaps due to the time it takes to refocus after being interrupted. Higher stress in the high interruption mode was associated with a higher use of anger-related words in email responses.

ATTENTION SWITCHING

Whenever we get interrupted by a notification, we switch our attention from the task at hand to check the notification before potentially returning to the original task. Frequent attention switching causes cognitive burden and is associated with inefficiency and feelings of diminished productivity.

In our study of physicians' inbox work, we found on average, physicians switch to view inbox messages 153 times a day [5]. That is a lot—even more than what has been reported for office employees who checked their emails 77 times a day [1]. We also found window switching is associated with stress measured through physiological sensors. Physicians might switch windows frequently because they receive emails that interrupt their work, and therefore switch from email work to other work. It is also possible physicians are switching windows during email work as they could be switching between the inbox and other parts of the EHR to find information to reply to messages or to take other actions initiated by the email message. To quantify task switching rather than window switching, we grouped all window switches within a period of inbox work as one task. We found physicians switched

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into inbox work 40 times a day, on average. Task switching or attempting to multitask is associated with cognitive burden, decrements in task performance, and potentially higher stress. In professions working with connected systems posing multiple competing demands on attention, we need systems that increase efficiency and reduce burden.

Many HCI design studies have investigated the issue of multitasking and window switching. Suggestions for increased efficiency include different design approaches such as ordering windows by importance, frequency of use or recency, in a grid, map, list, or tile styles. Another approach is semantic content extraction, which displays only the most relevant content in a window and has been found to enhance task flow [11]. Smart applications could interpret email content and extract relevant information from other pages to reduce the need to switch between windows to find information. Automatic screening and categorization of email messages might also help in managing frequent attention switching.

INDIVIDUAL DIFFERENCES WITH STRESS

There are many differences in the experience and expression of stress across individuals. Studies have tried to model individual stress at the workplace with varying levels of success. Personality factors, job-related factors, and contextual factors can affect whether and how we experience stress during inbox work. In our study of email-related stress, we found in low interruption mode (i.e., when participants received a batch of emails to process all at once, see Figure 3), stress increased for people who scored high on the personality trait of neuroticism [10]. A potential explanation for this is that neurotics are more susceptible to stress in general, and since handling emails in a batch requires a more sustained focus duration than addressing emails intermittently with breaks in between, this sustained focus could be causing stress. This is just one example of how individual differences affect the relationship between computer

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work and stress. These individual differences should not be overlooked as they might explain conflicting results from prior work on email stress.

HCI-SUPPORTED STRESS MANAGEMENT

While stress is a major issue in the workplace, there are many efforts to develop systems that help manage stress from computer work and address issues such as prolonged computer time, information overload, interruptions, and alert fatigue. Wearable devices detect when stress is increasing and can offer tips for stress management. Data from these wearable devices can be paired with contextual data, such as the computer activity the user is performing or calendar data about the user's day, to suggest appropriate stress interventions based on the person's stress level and context. One situation might call for suggesting breaks and going for a walk. Another situation might call for suggesting subtle guided breathing exercises.

Computing technologies can offer us novel methods to combat inbox stress. We might wonder: Could AI assistants that help us achieve our computing tasks also monitor our computing-related stressors, manage our computer interface to reduce interruptions and increase focus, communicate with our wearable sensors to measure our stress, and find opportune moments to introduce stress-management interventions? We believe so, but there are many challenges to overcome before we get there.

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Biography

Fatema Akbar is a Ph.D. graduate in informatics at the University of California Irvine. Her research investigates ways to unobtrusively track stress and HCI-related stressors at the workplace. She received her master's degree in social science of the internet from the Oxford Internet Institute at the University of Oxford and her bachelor's degree in information systems from Carnegie Mellon University.

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