Stress and Human-Computer Interaction at the Workplace: Unobtrusive Tracking With Wearable Sensors and Computer Logs

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Abstract

The relationship between workplace stress and computer use has mostly been investigated with self-reports or in controlled environments. However, self-report methods are prone to biases, and can be interruptive to employees when implemented for continuous stress tracking in real workplace environments. This abstract presents novel findings on computer use and stress at the workplace by employing computational methods leveraging computer activity logging and wearable devices that unobtrusively and continuously measured physiological stress through heart-rate variability in two real-world workplace settings: information work and medical work. We found that tracking computer use factors explained 15% of the variation in daily stress, and identified the computer interactions related to stress, such as window switching patterns, email checking patterns, and time spent outside of work hours.

Objectives

With information workers, we aimed to uncover everyday computer interactions that are associated with daily objective measures of stress, and to identify individual factors that influence this association. We also aimed to introduce a novel measure related to computer use, which is the regularity of work-related computer use that reflects day-to-day fluctuations in workload, and we assessed the association between this measure and various perceived and objective stress measures. With physicians, we focused on an emerging stressor in their Electronic Health Record (EHR) systems work, which is increased inbox management demands. We aimed to quantify the time primary care physicians spend managing inboxes, describe daily patterns of their inbox use, investigate which types of messages consume the most time and identify factors associated with inbox work duration. We also aimed to cluster distinct patterns of EHR inbox work, identify physicians' daily stress patterns, and evaluate the association between EHR inbox work patterns and physicians' physiological stress.

Methodology

The methods used in this work combine unobtrusive sensing of physiological stress through wearable sensors and tracking computer activity through computer activity logging software. These methods were used in two real-world workplace contexts: information (i.e. office) work and medical work, with 51 and 47 participants, respectively.

Physiological stress through a wearable sensor: Participants were given a wrist-worn device with an optical heart-rate sensor to measure HRV-based stress. The wearable device produces a real-time "stress score" based on HRV in still moments (i.e. excluding times with physical activity that interfere with HRV readings) and accounts for the physiological norm of each user.

Computer activity logging: we tracked computer activity to collect data including continuous timestamped logs of pages visited and actions performed. For office employees, we used a computer activity logging software and for physicians we used EHR system access logs provided by the medical group. From these logs, we created variables to quantify how time was attributed to different activities and characterize computer or EHR use patterns.

Analysis: The relationship between daily computer interactions and stress was investigated through a generalized linear mixed model with employees as random effects. Independent variables included the duration of computer activity, the percentage of computer work after-hours to all-day computer time, computer work patterns and time spent on different computer activities. Employee's age, sex and education were included as controls. We used the Gaussian Mixture Models clustering algorithm (Reynolds, 2009) to find distinct patterns of work.

Main Findings

In both study populations, we found that computer use factors explain 14-15% of the variability in daily stress. This is a considerable proportion given that stress is a complex affective and physiological state affected by many individual and situational factors that are not yet fully understood (Izard, 2010). Employees experienced medium to high stress for 22.11% (SD 17.02%) of the workday.

Window switching rate was associated with higher stress for physicians, as well as information workers who scored high on neuroticism. Physicians had almost 3 times higher window switching rate than information workers, switching windows 4-4.5 times per minute of computer use. Increased window switching during computer work could indicate interruptions and multitasking. The email checking pattern of "batching" was associated with less stress for information workers while batching was associated with more stress for physicians. Both study populations spent around a third of their computer time on emails, on average.

For information workers, time on non-work applications (e.g. social media, news, music, sports, shopping) was negatively associated with daily stress, even when controlling for time spent in productivity applications.

Working outside of typical work hours was associated with more stress for employees who indicated problems with work-life balance. For physicians, Inbox work outside of work hours was positively associated with stress during work hours.

Implications

Computer interactions at the workplace can reveal information about an employee's stress. To our knowledge, this work is the first to quantify this range of computer use factors and identify their independent association with physiological stress in two working populations. We used unobtrusive and continuous measures that can be automated and incorporated in real-time applications such as visualizations and interventions.

Our findings, along with previous findings on the effects of digital interruptions, suggest that dispositional and job-related factors dictate whether and how computer-use factors relate to stress. Organizational interventions to reduce stress should consider how policies around working outside of work hours, email checking norms, and non-work computer activities could affect different employees differently.

In context-aware computing (Dey, 2001), researchers and developers try to study and develop interactive systems that adapt to users' context, including their affect and mental state such as stress (Picard et al., 2001). Besides interest in the methods, affective computing and context-aware computing can be an area of application for stress sensing, where the study and understanding of user stress state and related behaviors inform the design of interactive context-aware systems, and more complex forms of human-computer interaction (Picard et al., 2001).

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