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The Point-of-Choice Prompt or the Always-On Progress Bar?: A Pilot Study of Reminders for Prolonged Sedentary Behavior Change

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ABSTRACT

Prolonged sedentary behavior contributes to many chronic diseases. An appropriate reminder could help screen-based workers to reduce their prolonged sedentary behavior. The fixed-duration point-of-choice prompt has been frequently used in related work. However, this prompting system has several drawbacks. In this paper, we propose the SedentaryBar, a context-aware reminding system using an always-on progress bar to show the duration of a working session, as an alternative to the prompt. The new reminding system uses both users' keyboard/mouse events on the computer and the state-of-the-art computer vision algorithm with the webcam to detect users' presence, which makes the system more accurate and intelligent. Our evaluation study compared the SedentaryBar and the prompt using subjective and objective measurements. After using each method for a week respectively, more participants preferred the SedentaryBar. The participants' perceived interruption and usefulness also suggested the SedentaryBar was more popular during the study. However, the logged data of the participants' working durations indicated the prompt was more effective in reducing their sedentary behavior.

KEYWORDS

Sedentary behavior change; digital health intervention; point-of-choice prompts; progress bar; on-screen reminder

Table 1: Reasons for not taking breaks when receiving the prompts in [8]**.**

	Reason	*%*
1	busy working	40.6
2	in a meeting or class	18.9
3	coming back from a break	15.2
4	close to finishing something	8.8
5	heading to other places (e.g., home) soon	7.9
6	engaged in a conversation	3.7
7	engaged in a screen-based activity (e.g., video, game)	2.5
8	having lunch or dinner	2.4

INTRODUCTION

Prolonged sedentary behavior causes many health problems among screen-based workers. A 10-year study [7] showed that greater increase in sedentary behavior was associated with a more detrimental change in clustered cardiometabolic risk, waist circumference, high-density lipoprotein cholesterol, and triglycerides, independently of the change in moderate-to-vigorous physical activity. Correspondingly, evidence showed that frequently interrupting sedentary behavior with light-intensity (e.g., walking) or moderate-intensity physical activity (e.g., climbing stairs) can improve overall health [1,2].

For screen-based workers (e.g., office workers and college students), prolonged sedentary behavior is ubiquitous, prevalent, and routine. Both academia and industry have drawn attention to technologies to help users to reduce prolonged sedentary behavior. Our recent systematic review on persuasive technology in reducing prolonged sedentary behavior at work revealed that the fixed-duration point-of-choice prompt with motivational messages on PC was the most commonly used method among the reviewed empirical studies [14].

In a recent CHI paper, Luo and colleagues [8] reported their research on how screen-based workers interacted with a break prompting system on PC. The authors conducted a field study with 25 participants for three weeks. The participants responded 74% of the prompts, while 46% of the responses were “not to take a break at the moment.” They asked the participants to log the reasons if they did not take a break when they received a prompt. The user-logged information indicated eight reasons as shown in Table 1. These reasons implied two drawbacks of the prompt system: it is not aware of users’ working/breaking state (fixed-duration; see Reason 3); it does not allow users to prepare for a break (point-of-choice; see Reason 4 and 5). These drawbacks might increase users’ perceived interruption and decrease the user experience.

To solve the mentioned problems of fixed-duration point-of-choice prompts, we developed a new reminding system running on users’ working computers. We use the keyboard/mouse events and the webcam with the state-of-the-art deep learning algorithms to recognize users’ presence (working/breaking state). Besides, we choose an always-on progress bar to indicate the current working (sedentary) duration. In this paper, we will describe the details of our reminding system and the results of our pilot study to compare the point-of-choice prompt and the always-on progress bar.

RELATED WORK

We searched the ACM digital library to collect related work on technologies of sedentary behavior detection and intervention (see Table 2). Among the 11 listed papers from 2013 to 2018, smartphones, sit pads, computers, and extra motion trackers were used to detect users’ sedentary behavior. We think the working computer (desktops/laptops) is the best platform for sedentary behavior change intervention because: (1) screen-based workers focus on their working computers most of the time; (2) extra devices - including smartphones - might add unnecessary distraction or setup burdens to users. Therefore, we use the keyboard/mouse and the webcam as the context

Table 2: Related work.

	Platform	*Study*
Hirano et al. [6], 2013	Smartphone	A pilot field study (N=8, four weeks)
Wang and Yu [13], 2013	Sit pad	None
Dantzig et al. [3], 2013	Smartphone; accelerometer -based motion tracker; computer	A feasibility study (N=8, one day); An evaluation study (86 participants, seven weeks)
Mateevitsi et al. [9], 2014	Infrared motion sensor	A feasibility study (N=8, five days)
Ferreira et al. [4], 2014	Computer with webcam	None
Min et al. [10], 2015	Sit pad; smartphone	None
Schagen et al. [12], 2015	Smartphone	None
Pinder et al. [11], 2015	Smartphone	None
Grundgeiger et al. [5], 2017	Smartphone	A pilot study (N=5, five days)
Wölfel [15], 2017	Kinect	A feasibility lab study (N=16, 3 hours)
Luo et al., [8], 2018	Computer	An exploratory field study (N=25, three weeks)

detection tools, while we use a screen widget as the intervention cue.

We base our design on some prior work. In 2014, Mateevitsi et al. [9] proposed the HealthBar, an ambient persuasive device that helped users to break up their prolonged sedentary habits. The HealthBar used a passive infrared motion sensor to detect users' presence/absence from their working desks. It used a three-foot plastic diffuser light-tube to provide feedback to users. The color of the HealthBar changed along with users' working duration. The authors conducted a five-day pilot study with eight office workers to evaluate the HealthBar. Qualitative results showed that the HealthBar could be a non-distracting and effective solution for reducing the sedentary behavior of office workers. However, the hardware setup of the HealthBar might hinder its deployment in large-scale use. Therefore, we use a screen widget instead of a physical light-tube as the reminder (see Section 3.2 for details).

Also in 2014, Ferreira et al. [4] presented the BreakOut, a desktop system aiming to infer users' posture, stress level, and engagement with computer-related tasks for recommending breaks at the appropriate time. However, there is no following intervention study to evaluate its effectiveness. The BreakOut used the keyboard/mouse events and the webcam to detect users' working engagement and posture simultaneously. Using the same hardware setting, we detect users' presence by combining advanced computer vision algorithms and the keyboard/mouse events in a more efficient way.

As should be noticed, only one [3] of the reviewed work listed in Table 2 used control studies to evaluate their intervention approach. The others focused on the system description and validation. To evaluate our proposed system, we conducted a three-week field study (See Section 4 for details).

INTERVENTION SYSTEM

Context Detection

The awareness of users' presence could help the system to decrease unnecessary reminders. E.g., if a user takes a break before the prompt appears, the system should reset the timer to avoid the surplus reminding (Reason 4 in Table 1). Only using the keyboard/mouse events to determine working state is efficient, but could be inaccurate when a user reads documents or watches videos that require no keyboard/mouse interaction. Therefore, we also use the webcam to detect users' presence. We adopt the state-of-art person-detection and face-detection computer vision algorithms based on the deep neural network (DNN) module in OpenCV library. Detecting the user's presence using the computer vision algorithm requires much more computation load than the using the keyboard/mouse events. Therefore, we combine the two methods: we only run the computer vision algorithm when there are no keyboard/mouse events for half a minute; if the user is absent for the following half minute, the state changes to breaking (see Figure 1). The computer vision algorithm does not run in the breaking state. No video or picture will be recorded for privacy consideration.

Intervention Cues

A point-of-choice prompt (see Figure 2) on PC is usually an alert window with a short message showing up for a short period, which was frequently used in related work. Upon receiving a prompt, a user is expected to decide on whether taking a break or not. One drawback of the prompt is that it does not allow users to prepare for breaks because it is invisible until the pre-defined time is up. Also, the sudden appearance of the prompt might cause users' pressure and distraction. If a user is busy

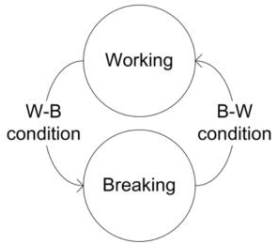

Figure 1: The state transitions between working and breaking. W-B condition: a user is absent for more than a minute in the working state. B-W condition: a user starts to use the mouse or the keyboard in the breaking state.

Figure 2: The prompt interface. In our study, it shows up when the current duration of working state exceeds the pre-defined duration. It disappears when the user clicks on the button or after 30 seconds without interaction.

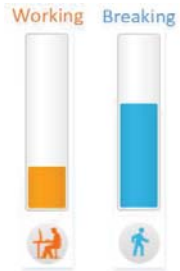

Figure 3: The SedentaryBar. In the working state, the progress bar color is orange by default, while the progress indicates the working duration. In the breaking state, the progress bar color is blue by default, while the progress loops like a battery charging animation.

(Reason 1 in Table 1) when receiving a prompt, it could also be a user burden to make a decision.

As an alternative, an always-on progress bar provides some superior features. We call it the SedentaryBar, as shown in Figure 3. Instead of the sudden appearance, the SedentaryBar is always on and glanceable, thus avoiding the time pressure of decision-making when using a prompt. Being aware of the working duration, a user has enough time to adjust the work and prepare for a break. It could be more interruptive than the prompt because it is always present. It could also be less interruptive because the progress bar grows so slowly that a user might not notice when it is full (time is up). Therefore, we need to study both their effectiveness and interruption.

EVALUATION STUDY

To compare the always-on progress bar with the point-of-choice prompt, we conducted a three-week field study with eight participants in a university in Germany during November and December in 2018. The study procedure is as shown in Figure 4. All the participants were students (five Ph.D. student; two master students; one bachelor student), and two of them were male. We assigned the participants to two groups alternatively according to the order they contacted us for the study. At each appointment, the participants filled questionnaires of their sedentary behavior intention, self-efficacy, habit strength of breaking sedentary behavior, and the Global Physical Activity Question (GPAQ). At appointment 1 (the first blue dot in Figure 4), the participants read the information sheet, signed the informed consent, and installed the software on their computers. At appointment 2, we showed them an educational video and a flyer to explain the potential health problems caused by the sedentary lifestyle. At appointment 4, we interviewed the participants and asked them about their preferences between the two intervention cues (reminders).

During the baseline week, the software run in the background and no intervention cue was shown to the participants. During the following two weeks, we asked them to fill two four-point Likert scales about their perceived usefulness and interruption of the reminders once a day.

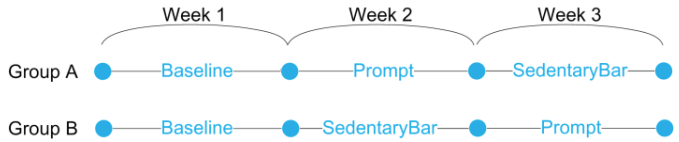

Figure 4: The study procedure. The SedentaryBar and the prompt use the same context detection method and follow the state transition conditions as shown in Figure 1.

Each participant set a reminder duration of 30-60 minutes and could adjust it during the study. For the SedentaryBar, the participants could also change its position, size, and color. We allowed them to stop the software whenever they wanted. Our software logged the participants' usage periods, state transitions, and settings. The software ran offline - all the data were stored locally. We collected the data by email from the participants at each appointment.

Table 3: Participants preferences, reported reasons, and perceived interruption and usefulness. SB - SedentaryBar; P - Prompt; I - Perceived Interruption; U - Perceived Usefulness. The score range is from 1 ("not at all") to 4 ("exactly") in four-point Likert scales.

A1: Prompt - The prompt is clearer and less annoying.			
SB-I	SB-U	P-I	P-U
2.8	2.8	2.3	3
A2: SedentaryBar - The bar allows preparation for breaks.			
SB-I	SB-U	P-I	P-U
1	4	1.4	3.6
A3: SedentaryBar - The SedentaryBar shows more information than the prompt.			
SB-I	SB-U	P-I	P-U
2	3.2	2	2.8
A4: Prompt - The SedentaryBar covers some content on the screen. The bar sometimes turns blue (breaking state) when I head down to write something, which is wired to me.			
SB-I	SB-U	P-I	P-U
1	3	1.5	2.8
B1: SedentaryBar - I can't see the prompt when using multiple screens on my MacBook. The SedentaryBar is always there that I can still see it after the busy time.			
SB-I	SB-U	P-I	P-U
1	3.2	1	1.3
B2: Prompt - The SedentaryBar is a little interruptive.			
SB-I	SB-U	P-I	P-U
1	3	1.3	3.5
B3: SedentaryBar - The SedentaryBar is more visible and stronger than the prompt.			
SB-I	SB-U	P-I	P-U
1.7	3.2	1	3
B4: SedentaryBar - The SedentaryBar is more interesting and more visible.			
SB-I	SB-U	P-I	P-U
1	2	1.5	2.5

RESULTS

Participants' Preferences and Reasons

In the final interview, seven participants confirmed they would like to continue to use the software. In group A, two participants preferred the prompt, while the other two preferred the SedentaryBar. In group B, one participant preferred the prompt, while the others preferred the SedentaryBar. Overall, the SedentaryBar is more popular than the prompt for the following reasons: (1) it allows preparation for breaks (A2); (2) it provides more information (A3); (3) it is always visible (B1, B3 and B4); (4) it provides stronger intervention (B3); (5) it is more interesting (B4). The reasons why some participants chose the prompt includes: (1) it is clearer and less annoying (A1 and B2); (2) the SedentaryBar covers some content on the screen (A4); (3) the state-change of the SedentaryBar is inaccurate sometimes (A4).

Perceived Interruption and Usefulness

The scores of the perceived interruption and usefulness are shown in Table 3. We compare the scores of the SedentaryBar condition and the prompt condition for each participant: the smaller scores the better for the perceived interruption; the larger scores the better for the perceived usefulness. In Table 3, the green ones are the winners; the purple ones are the losers; the orange means a tie. We observe mixed patterns from the data. More participants thought the SedentaryBar is less interruptive and more useful. Only two participants perceived more interruption of the SedentaryBar, while three participants thought the prompt was more useful to them.

Working Periods

We regard the working state our software logged as the sedentary state of the participants because no participant used a standing desk during the study. Figure 5 shows the results of the one-way ANOVA and the post hoc test of the prolonged sedentary sessions ($t>30$ minutes) for each participant. For three participants (A3, B2, and B4), the decrease of the sedentary duration in the prompt condition is statistically significant. For most of the participants, the prompt tended to be more effective than the SedentaryBar. Even though we see no statistical significance between the SedentaryBar condition and the control condition, the data still show the effect trend of the SedentaryBar from some participants' data (A1, A3, A4, B1, and B2). The objectively measured working periods do not seem to match the perceived usefulness for the two intervention conditions.

DISCUSSION

The participants' preferences and the reported reasons in the final interview suggest that our design concept of the SedentaryBar is meaningful in reality: it does not push users when the time is up; it allows users to prepare for breaks. More participants preferred the SedentaryBar after using both methods. The perceived interruption and usefulness suggest the SedentaryBar was more popular during the study. However, the logged data of the participants' working durations showed the prompt was more effective in reducing their sedentary behavior. The disparity between the perceived usefulness and the actual effect deserves a further discussion.

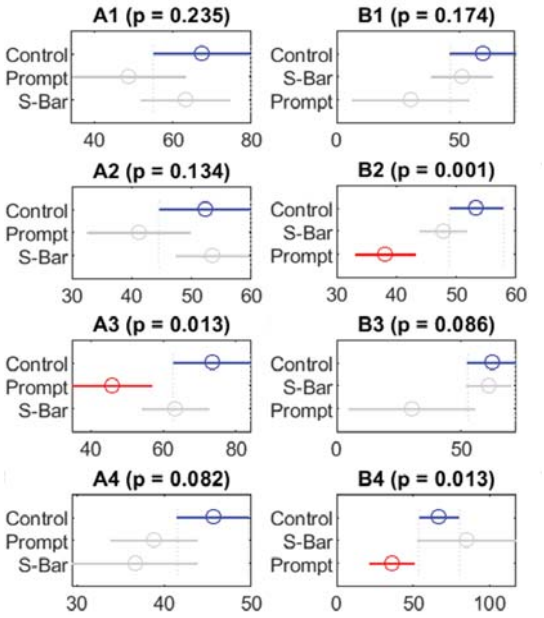

Figure 5: The one-way ANOVA and the post hoc test results of prolonged sedentary sessions (t>30 minutes) for each participant. S-Bar is short for SedentaryBar in the figure. The significance level was 0.05; the Tukey's honest significant difference criterion was used for the post hoc test. A red bar indicates a statistically significant difference between its condition and the control condition (the blue bar).

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Due to the small user size and short study duration, further studies are required to compare the effectiveness and user experience of the two reminding methods. Besides, it is worthy of investigating how to combine these two methods for better reminding users of breaking prolonged sedentary behavior in future work.

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