

Notification System to Encourage a User to Refrain from Using Smartphone Before Going to Bed

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Abstract. Many people use their smartphone before going to bed. However, using a smartphone before sleeping can cause problems, such as difficulty falling asleep and light sleep. We propose a notification system to encourage a user to refrain from using smartphone before going to bed. The proposed system displays messages about influence of sleep on plans for the next day and health risks of smartphone use. In addition, the proposed system displays the time remaining before going to bed. We conducted an experiment to confirm the effectiveness of the proposed system and discuss the results of this experiment. The target of the proposed system is university students in Japan. From the experimental result, features of the proposed system motivate participants to think about not using their smartphones. However, the participants did not actually refrain from using them.

Keywords: Smartphone · Sleep · Notification system

1 Introduction

Many people often use their smartphone before going to bed. Some even use their own smartphones in bed. In Japan, over three-quarters of smartphone users use their device in bed just before falling asleep [1]. An Internet survey about quality of sleep in Japan [2] indicated that 48.6% of users who use a smartphone over 30 min before going to bed reported that they had difficulty falling asleep. Moreover, the survey indicated that 59.5% of those users reported light sleep.

A physiological study has reported the influence of blue light on the circadian system [3]. Blue light at night can be produced from not only computer screen, but also smartphone screen. The risks associated with blue light from a smartphone screen have increased due to the rapid increase in the duration and frequency of smartphone use [4]. Bauer et al. proposed ShutEye [5], which promotes awareness of activities that contribute to healthy sleep habits. ShutEye displays activities that are known to affect sleep, e.g., consuming caffeine and napping, on the smartphone's wall paper and lock screen. ShutEye could increase awareness of healthy sleep habits. However, using a smartphone before sleeping can cause problems, such as difficulty falling asleep and

light sleep. Thus, reducing the use of a smartphone before sleeping is needed to realize healthy sleep habits.

In this study, we propose a notification system that encourages users to refrain from using a smartphone before going to bed. The proposed system displays messages about influence of sleep on plans for the next day and health risks of smartphone use. These messages appear on the screen when the smartphone wakes from sleep mode. In addition, the proposed system displays the time remaining before going to bed. These messages are also shown in the notification bar. We conducted an experiment to confirm the effectiveness of the proposed system and discuss the results of this experiment.

A previous survey reported that 72% of university students in Japan have a smartphone and use it daily [6]. Another survey in Japan reported that approximately 30% of university students in Japan indicated that their amount of sleep decreased after they started using a smartphone [7]. Therefore, target of the proposed system is university students in Japan.

2 Notification System Design

We propose a notification system to encourage smartphone users to refrain from using their smartphones before going to bed. The following three types of messages are displayed on the smartphone.

- A message about the influence of sleep on plans for the next day
- A message about health risks of smartphone use.
- A messages about the time remaining before going to bed.

The first type of message is intended to strengthen the user's motivation to sleep early for the next day's plan. The user who saw this messages is expected to stop using the smartphone. The second type of message is intended to make the user aware of health risks of smartphone itself. The third type of message is intended to remind the user of his/her bed time and prevent the user from long-term use of smartphone unconsciously.

When using the proposed system, the user inputs his/her wake-up time, a plan for the next day, and desired hours of sleep. From this information, the system sets an estimated bedtime automatically. The notifications are displayed on the screen of smartphone each time it wakes from sleep mode from two hours prior to the estimated bedtime until the wake-up time or until the user stops using his/her smartphone, as shown in Fig. 1.

Figure 2(a) shows the screen used to input the wake-up time. When a user inputs their wake-up time and taps the "Next" button, the input screen for the next day's plan is displayed (Fig. 2(b)). This screen presents a list of activities selected with university students in mind, e.g., "playing sports", "going to class," and "taking test." The user can make multiple selections. After the user selects activities and taps the "Next" button, the input screen for hours of sleep is displayed, i.e., 6, 7.5, and 9 h (Fig. 2(c)). The user selects one item to set their hours of sleep. The hours of sleep options were determined from the fact that the average hours of sleep is approximately 7 to 8 h [8]

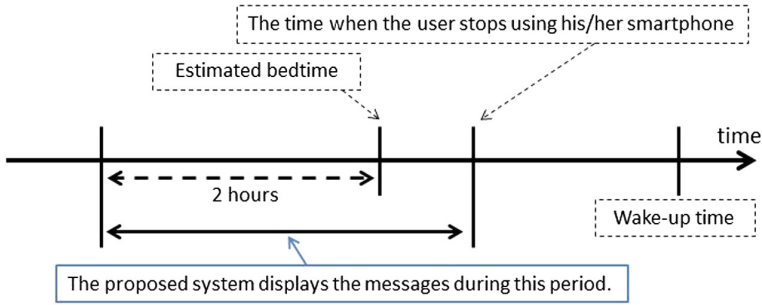


Fig. 1. Timing of notifications

and that the sleep cycle is approximately 90 min. When the user selects the hours of sleep and taps the “Next” button, an input screen to complete the process is displayed (Fig. 2(d)). When the user taps the “Completion” button, the system begins to display notifications.



Fig. 2. Proposed system’s input screens

2.1 Messages About the Influence of Sleep on Plans for the Next Day

The list of messages about the influence of sleep on plans for the next day is shown below. In this type of message, the topic of messages is changed according to plans for the next day. Therefore, the topic of message that the user sees can change every day.

- The plan for the next day is “playing sports”
 - “Sufficient sleep increased basketball shooting accuracy (9% improvement for free throws and three-point field goals).” [9]
 - “Sufficient sleep increased speed resulting in faster sprint times.” [9]
 - “Sufficient sleep remarkably improves physical and mental performance.”
 - Approximately 85% of athletes place importance on sleeping for physical condition management.” [10]
- The plan for the next day is “going to class”
 - “At this rate, you will be late for class.”
 - “At this rate, you will fall asleep in class.”
 - “Lack of sleep reduces concentration in class.”
 - “Lack of sleep reduces the ability to think in class.”
- The plan for the next day is “taking a test”
 - “If you do not go to sleep as soon as you memorize information, you may forget it.”
 - “Sacrificing sleep for extra study time is counterproductive.” [11]
 - “You will be sleepy during tests.”
 - “Your brain will not be working during tests.”

2.2 Messages About the Health Risks of Smartphone Use

The list of messages about the health risks of smartphone use is shown below. In this type of message, the topic of messages that the user sees is the same every day.

- “Using a smartphone deteriorates of visual acuity and causes inflammation of the retina.”
- “Using a smartphone increases weight gain.”
- “Using a smartphone causes poor sleep.”
- “Using a smartphone causes lifestyle disease.”
- “Using a smartphone causes eye fatigue.”
- “Using a smartphone increases stress and risk of depression.”

2.3 Messages About the Remaining Time Until the Time of Going to Sleep

The remaining time until going to sleep is notified by the following notification methods.

- Display the remaining time while simultaneously showing messages about the influence of sleep on plans for the next day
- Display the remaining time on the notification bar at the top of the screen

Figure 3 shows an example notification message when the smartphone wakes from sleep mode. There are messages about the health risk and the time remaining until going to sleep.

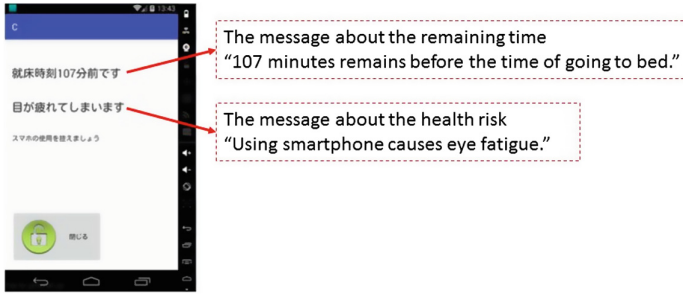


Fig. 3. Example notification message when the smartphone wakes from sleep mode

It is possible that a user may be doing important work on his/her smartphone. Therefore, the notification message for the remaining time is displayed on the notification bar to not interrupt the user’s tasks. This type of message is displayed on the notification bar as a blue, yellow, or red icon (Table 1). When the user swipes the notification bar down, details about the remaining time are displayed (Fig. 4).

Table 1. Icon color and timing of notification messages

Color of icon	Start timing of notifying messages	End timing of notifying messages
Blue	2 h prior to estimated bedtime	0.5 h prior to estimated bedtime
Yellow	0.5 h prior to estimated bedtime	Just estimated bedtime
Red	After estimated bedtime	The time when the user stops using his/her smartphone

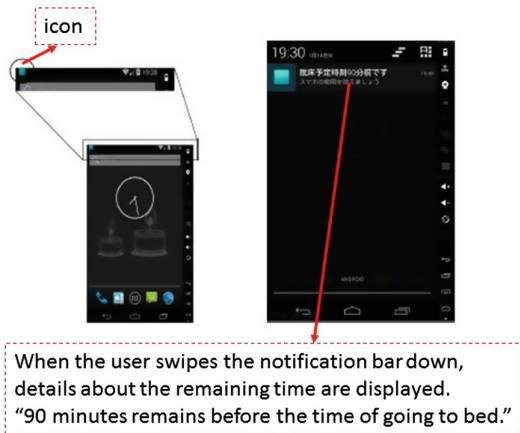


Fig. 4. Example notification message for the remaining time

3 Experiment

We conducted an experiment to confirm that participants refrained from using smartphone when using the proposed notification system. Four volunteers (age 19–23, male) were recruited from Kyoto Institute of Technology. The experimental period was eight days. All participants installed three types of notification system (Table 2) onto their own smartphone. Two of the four participants used each notification system in the following order.

- 1st period (two days): No-notification system
- 2nd period (two days): Proposed system
- 3rd period (two days): Common-notification system
- 4th period (two days): No-notification system

Table 2. Notification systems

	No-notification system	Common-notification system	Proposed system
Influence of sleep on plans for the next day	No	No	Yes
Health risks of smartphone use	No	Yes	Yes
Time remaining before going to bed	No	Yes	Yes

The other two participants used each notification system in a different (the second and the third periods were switched). During the overall experimental period, the participants were not forced to complete any specific tasks without answering the following questionnaire at wake-up time each day.

- Q1. How carefully did you read the notification message? (1: Not carefully, 2: Slightly carefully, 3: Moderately carefully, 4: Very carefully)
- Q2. Did you think that you should refrain from using the smartphone two hours before the estimated bedtime until the estimated time? (1: Not at all, 2: Slightly yes; 3: Yes, 4: Strongly yes)
- Q3. Did you refrain from using the smartphone two hours before the estimated bedtime? (1: Not at all, 2: Slightly yes, 3: yes, 4: Strongly yes)
- Q4. Did you think that you should refrain from using the smartphone between the estimated bedtime and the actual bedtime? (1: Not at all, 2: Slightly yes; 3: Yes, 4: Strongly yes)
- Q5. Did you refrain from using the smartphone from the estimated bedtime until the actual bedtime? (1: Not at all, 2: Slightly yes, 3: yes, 4: Strongly yes)
- Q6. Did you think that you should refrain from using the smartphone after the actual bedtime? (1: Not at all, 2: Slightly yes; 3: Yes, 4: Strongly yes)
- Q7. Did you refrain from using smartphone after the actual bedtime? (1: Not at all, 2: Slightly yes, 3: yes, 4: Strongly yes)

Moreover, there were free description forms to provide reasons for the replies to Q2 to Q7. Note that Q1 was omitted when the participant used the no-notification system (first and fourth periods).

After finishing the fourth period, the participants were asked to answer the following final questionnaire. In addition, they were asked to provide reasons for their replies to each question.

- Q1. Please arrange the systems you used first, second, and third in order of effectiveness relative to refraining from using the smartphone.
- Q2. Please arrange the systems in the order you would prefer for actual use.

The operation time was defined as the time since the smartphone woke from sleep mode until it shifted to sleep mode again. The total operation time was defined as the summation of the operation time. The total operation time before the estimated bedtime was measured. In addition, the total operation time after the estimated bedtime until falling asleep was also measured.

4 Experimental Results

Questionnaire at Wake-up Time

Figure 5 shows the mean scores for Q1 to Q7. A Friedman test revealed significant differences among the mean scores for each notification system for Q4 and Q7 ($p < 0.05$).

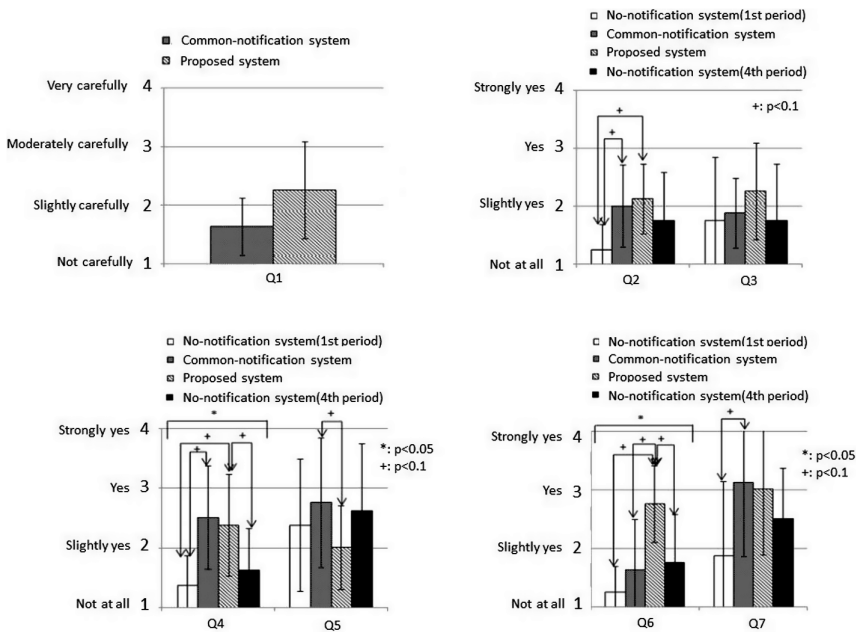


Fig. 5. Results of wake-up questionnaire

Final Questionnaire

Figure 6 shows the ranking results for Q1 and Q2. The proposed system was ranked first for both Q1 and Q2. However, a Friedman test revealed no significant differences.

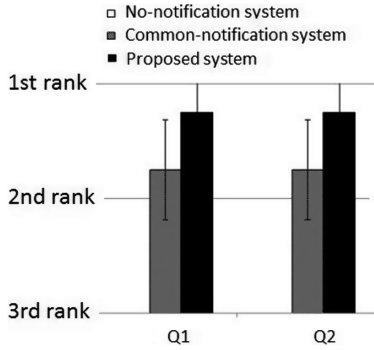


Fig. 6. Results of final questionnaire

Total Operation Time

Figure 7 shows the mean total operation time for each notification system. When the participant used the smartphone before the estimated bedtime, the mean total operation time for the common-notification system was less than that of the other notification systems. In contrast, when the participant used the smartphone after the estimated bedtime, the mean total operation time for the no-notification system in the first period was the shortest among all notification systems. However, a Friedman test revealed no significant difference among the notification systems.

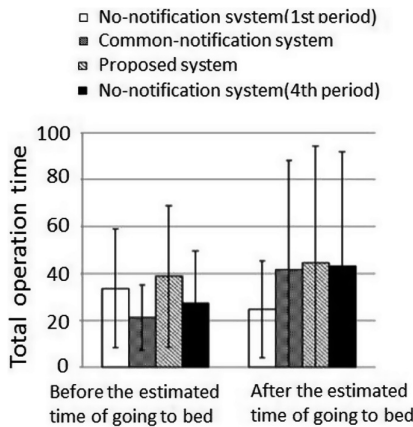


Fig. 7. Total operation time

5 Discussion

The results for Q1 indicate that the participants read the notification messages of the proposed system more carefully than that of the common-notification system. The topic of notification messages varies each day with the proposed system because the messages are related to plans for the next day. Therefore, the proposed system could gain more participant attention than the common-notification system which repeated the same topic of notification messages each day. However, the score was slightly over 2, i.e., “Slightly carefully.” Some participants indicated that they did not read the notification messages carefully because the messages were the same as the previous day’s messages. In these cases, they did not select a plan for the next day. We consider that these opinions indicate the effect of notification messages relative to plans for the next day.

In the results of Q2 and Q4, the mean scores of the proposed system and common-notification system were higher than those of the no-notification system, and there was no difference between the mean score of the proposed system and the common-notification system. In the free description for these questions, some participants indicated that they considered refraining from using smartphones when they saw the notification messages about health risks. These messages about health risks were notified by both the proposed system and the common-notification system. On the other hand, the participants did not mention messages related to plans for the next day. From these results for Q2 and Q4, we consider that messages about health risks were effective to make participants refrain from using the smartphone. However, it was not clear whether messages about plans for the next day were effective, although these messages were effective to gain the attention of the participants, as mentioned in the discussion related to Q1.

In the free description form for Q6, one participant indicated that he considered refraining from using the smartphone when he noticed a change in the color of the icon. Q6 was about the time after participants went to bed until they fell asleep. There was no description about icon changes in the questions about the time before going to bed because the participant concentrated on the smartphones while they were in bed, whereas they were often working on non-smartphone tasks before going to bed. From these results, we consider that the notification for remaining time until going to sleep was more effective after going to bed than before going to bed.

From the results for Q3, the mean score of the proposed system was greater than that of the other systems. However, there was no difference of the mean total operation time among notification systems. These results indicate that the participants did not refrain from using their smartphone even though they considered doing so with the proposed system. In the free description form for Q3, some participants indicated that they were communicating with friends using their smartphones, talking or chatting with SNS.

Notification messages about the influence of sleep and health risks were displayed only when the smartphone woke from sleep mode, and only the icon notification was performed while the participant was operating the smartphone. In the free description form for Q5, one participant indicated that he did not attempt to refrain from using the

smartphone because he saw the icon notification only and did not see other notification messages. Therefore, we consider that a mechanism to notify messages about the influence of sleep and health risks are required even while operating a smartphone.

As mentioned previously, the proposed system made users conscious about refraining from using smartphones. However, whether the participants actually refrain from using the smartphone depended on what the participants were doing at that time. In addition, many of smartphone users may have already recognized the negative effect of smartphone use such as health risks and these users may be feeling unpleasant with these notifications. We need to survey on this point in the future work.

6 Conclusion

Using a smartphone just before sleep can decrease the quality of sleep. We have proposed a notification system to encourage users to refrain from using a smartphone to obtain healthy sleep habits. Experimental results indicated that the features of the proposed system encouraged participants to think about refraining from using their smartphones. However, the participants did not actually refrain from using their smartphones. In future, we plan to implement a method to display messages about the influence of sleep and health risks while using smartphone. In addition, we plan to conduct a long-term experiment with more participants.

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