Research Letter

Proposal of a comfortable wake-up support method according to individual characteristics

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Abstract

The problem of sleep deprivation has become a global concern. People in Japan, in particular, sleep the least of all OECD countries. Many East Asian countries are sleep deprived, therefore, it is necessary to consider measures to address the problem of sleep in Asia. It has been pointed out that better awakening and waking time is good sleep. Today, many people are stressed about waking up, therefore, there is a need to build an environment that allows people to comfortably transition to a waking state. In hotels as well, companies pursuing high-quality sleep and wake-up services are attracting attention. This study aims to develop a wake-up support method and service that can support comfortable awakening according to individual characteristics.

Keywords

individual support method, wake-up support method, comfortable wake-up support service, EEG, arousal level

1. Introduction

Sleep deprivation has been reported worldwide, and in particular, Japan has the shortest sleep duration among OECD countries. According to the National Health and Nutrition Survey conducted by the Ministry of Health, Labour and Welfare in 2019, the proportion of people who have not had enough rest during sleep in the past month is 21.7 %, which has significantly increased since 2009. By average daily sleep duration, the proportion of people who sleep between 6 and 7 hours is the highest. The percentages of those who slept less than 6 hours were 34.5 % for men and 34.7 % for women; and those who slept more than 6 hours were 36.1 % for men and 39.6 % for women. In addition, according to the 2015 National Health and Nutrition Survey, the percentage of men and women who felt sleepy during the day was very high for those who slept less than 6 hours: 44.5 % for men and 48.7 % for women.

Various studies have been conducted to develop support methods for better sleep. We have also developed a sleep support method in previous research [Ogoshi et al., 2018]. A good night's sleep and a good awakening are important for the quality of life.

Therefore, we decided to develop a wake-up support method based on individual characteristics. A questionnaire survey was conducted to determine what kind of problems people have with sleep and what kind of intervention is necessary, and we conducted an experimental verification using biometric data. In this paper, an experiment was conducted on a tea service to support nap time, the results are discussed and a new service is proposed.

2. Survey of individual characteristics and needs related to sleep

Twenty-eight healthy men and women aged 19-21 years old without sleep disorders were divided into two groups, one sleeping less than 6 hours a night and the other sleeping more than 6 hours a night. A questionnaire on daily activities (see in Table 1) was administered to determine what activities differed in their daily lives, and the characteristics of each group were

Table 1: Questionnaire on everyday life

Q1. How do you usually wake up?
Q2. What is the most comfortable way for you to wake up?
Q3. How many days a week do you have trouble waking up?
Q4. How many hours a day do you spend studying at home?
Q5. How many hours a week do you work part-time?
Q6. How many hours a week do you spend on extracurricular activities?
Q7. How many hours of leisure time do you have in a day?

analyzed.

- Regarding Q1, about the usual method of waking up: the sound of an alarm (24 respondents), music (4 respondents), sunlight (3 respondents), waking up naturally at a fixed time (7 respondents), and being woken up by a family member (9 respondents) (multiple choice).
- For Q2, the most comfortable way to wake up was: light (10 respondents), waking up naturally at a fixed time (23 respondents), and the smell of breakfast or coffee (1 respondent).
- For Q3, the number of days in a week that they were unable to wake up clearly was: less than 1 day (7 respondents), 2-3 days (6 respondents), 4-5 days (4 respondents), and almost every day (11 respondents). Comparing the percentage of the short and long sleep duration groups, 2 out of 16 in the short group and 4 out of 12 in the long group answered that they wake up spontaneously.

Most of the respondents woke up with an alarm, but none of them chose an alarm as the most comfortable way to wake up. It was found that there is a high need to wake up naturally at a fixed time. The largest number of respondents indicated that they could not wake up at a regular time almost every day.

The results of the questionnaire on activities of daily life divided by sleep duration for items Q4 to Q7 showed significant differences. The group with the longest sleep time in Q7 had more leisure time than the group with the shortest sleep time ($p < 0.01$). The mean leisure time of the long sleep group was 4.5 hours, and that of the short sleep group was 3.18 hours. There were no significant differences among the other groups.

In addition, as a result of the interview survey, the following two functions were identified as supporting sleep and wakefulness.

- Consumption of beverages such as tea

  "Cold beverages seem to be better."

  "Warm drinks seem to be more awakening."

  "Drinking or eating is good for waking up."
- Support for the next action

  "I would like to be given instructions when I can't think straight right after waking up."

  "For example, a function that prompts an avatar (an image character that acts like a living being in a virtual reality space) to wake up (i.e., guides the avatar to the next action)."

  "If you just prompt the avatar to wake up, it will probably fall asleep again, so we would like you to prompt it by opening the curtains, turning on the lights automatically, etc."

  "Conversations with avatars"

  "Have the avatar check the day's schedule and afternoon plans."

  "Watching TV, smart phone, etc."

As an intervention for waking up, which was derived from the needs identified in the above survey results, the following is an example of an intervention that could be used. We decided to conduct an experiment to see what effect cold and hot drinks, and caffeinated and non-caffeinated drinks would have on waking up. The experiment is described in the next section.

3. Experimental method

3.1 Equipment used in the experiment

An electroencephalograph (EEG) with Bluetooth connection was used in this experiment, and the device name is NeuroBelt Model number: NB1-EEG8.

3.2 Position of EEG measurement

C3 and C4 of the 10-20 method were measured as shown in Figure 1.

3.3 Participants

Six male and five female participants, aged 18-22.

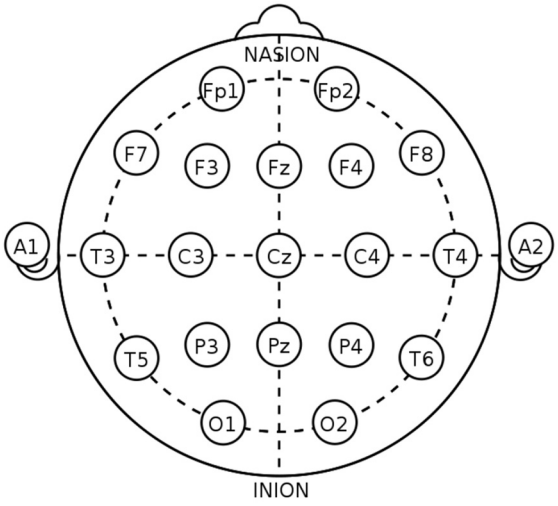

Figure 1: Measurement position using the 10-20 method

3.4 Data analysis method

Data analysis is performed using Octave. The EEGs to be analyzed are the α, β, and θ waves. First, FFT (Fast Fourier Transform) is performed on the obtained EEG data, and the power spectra of the α, β, and θ wave bands are calculated. Then, the sum of the power spectrum values for each frequency band is derived. The total value is then the power spectrum of the α, β, and θ wavebands, divided by the total, and the occupancy of each frequency band is the percentage of each band. This is used to compare the state of the participants in the experiment.

Experimental Procedure:

- Respond to a questionnaire before the experiment.
- Attach the experimental equipment and move to the experimental environment.
- Sleep for 20 minutes in the experimental environment.
- Wake up and perform the task (water drinking task, hot water drinking task, mulberry tea drinking task, coffee drinking task).

An image of the procedure and the time schedule of the experiment is shown in Figure 2.

4. Experimental results and discussion

In the experiment, mulberry tea (a caffeine-free tea with an astringent aroma) had the strongest arousal effect in one case. Coffee was thought to have an arousing effect, but it was found that even once aroused, the relaxation effect made the participants sleepy again. 3 participants performed the experiment and the results were similar for all 3. The results of the experiments conducted with water, hot water, mulberry tea, and coffee are shown in Table 2. One participant performed the experiment with water, two with hot water, two with mulberry tea, and three with hot coffee. β occupancy / θ occupancy was used as the degree of arousal. The first half (0-5 minutes), middle (5-10 minutes), and second half (10-15 minutes) were used. An increase of 1 or more from the previous step is indicated by "↑" and a decrease of 1 or more by "↓," and a change of less than 1 from the previous phase was denoted by "→." The arousal level of less than 2 is indicated by "L," the arousal level of 2 to 2.5 by "M," and the arousal level of 2.5 to 2.5 by "↑." The higher the value, the higher the participant's arousal level.

Arousal level increased immediately after drinking water, hot water, mulberry tea, and coffee. Thereafter, arousal decreased slightly. Coffee initially caused arousal, but the arousal level gradually decreased. The higher arousal level with water than with hot water may be due to the tendency to increase sympathetic tone. It has been confirmed that drinking ice water when waking up in the morning awakens the body and stimulates the gastrointestinal tract, making it easier to eat breakfast. The reason why mulberry tea is more arousing than hot water is thought to be due to the stimulation of the aroma.

In addition, mulberry tea was a previously inexperienced drink for the participants. However, when the participants were interviewed about the lower arousal level despite the stronger aroma of coffee, they answered that "I like coffee," and "The aroma of coffee relaxes me," indicating that even caffeine may reduce arousal level due to its relaxing effect. Caffeine is absorbed and distributed in the bloodstream at least 30 minutes after ingestion, so the arousal effect of coffee in this experiment was not due to caffeine itself. On the other hand, considering the absorption of caffeine and its reach to the brain, it is recommended to drink coffee before naps, during so-called 'power naps', so if a coffee service is offered, it is better to offer it before naps. After a nap, it may be better to serve drinks with unusual flavors, such as mulberry tea or other locally derived drinks.

4. Future tasks

We plan to develop a system that promotes awakening by

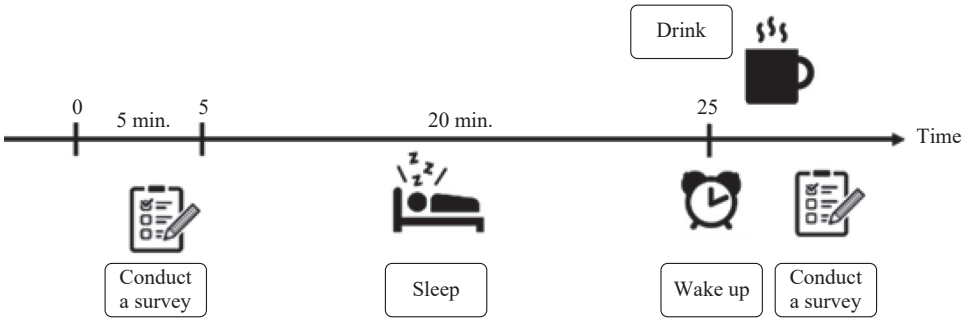

Figure 2: Time schedule of experiment

Table 2: Arousal level value when taking beverages upon waking

β/θ wave occupancy	First half	Middle	Second half
Water	M	→H	→M
Hot water	H	↑H	↓M
Mulberry tea	M	↑H	→H
Coffee	H	→H	↓L

utilizing the effect of non-caffeine tea. We have already developed a method that blends medicinal tea according to one's physical condition [Takama et al., 2020]. We would like to start developing a method that promotes waking up by linking these systems. In addition, we have identified a need for a method in which an avatar guides the user's next action upon waking up. We would like to develop a wake-up support method by applying IoT pot [Tanaka et al., 2021] to regulate the rhythm of life.

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