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ORIGINAL ARTICLE

The effects of the preference for music on sleep inertia after a short daytime nap

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Abstract

The effects of the preference for excitative music on sleep inertia after a daytime nap were examined. Sixteen young healthy adults took a 20-min nap at 14:00 after which half were exposed to excitative high- or low-preference music and half were not. Musical stimuli were applied for 20 min after napping, and the subjects rated their sleepiness and comfort by themselves and performed a selective reaction time task. The results showed that subjective sleepiness was reduced under both music conditions immediately after awakening. However, sleepiness was further reduced and results of successive performance improved when the participants were exposed to high-preference music. Subjective comfort also improved under the high-preference condition. These results suggest that excitative music, regardless of preference for the type, exhibits positive effects on sleep inertia, and that higher preference music further stimulates the daytime arousal level.

Key words: music, music preference, short nap, sleep inertia, sleepiness.

INTRODUCTION

Increased sleepiness often occurs during mid-afternoon, and causes the so-called 'post-lunch dip' in performance, along with sleepiness-related accidents.[1] The biological sleepiness cycle might reflect this type of sleepiness.[2]

Recently, it was reported that a short daytime nap of less than 30 min has positive effects on daytime alertness[3] and suppresses afternoon sleepiness.[4–7] However, 'sleep inertia', which is the enhancement of sleepiness or the temporary decline in performance immediately after awakening, occurs for several minutes even after a short nap of less than 20 min[6,7] Sleep inertia is a negative cause of napping strategies in the work place.[8] Some counter-measures against sleep inertia have been considered, such as physical or mental exercise, external noise, bright light, face washing, and psychostimulants.[9] However, the effects of these counter-measures on sleep inertia have not well been studied.[10] Regarding short naps, several counter-measures against sleep inertia were examined including caffeine,[7,11] bright light and face-washing,[7] the formation of napping habits,[6] and self-awakening techniques.[12,13] These counter-measures were effective in reducing sleepiness, but did not significantly improve comfort immediately after awakening from a short nap. The effects of a short nap may be further enhanced if comfort immediately after awakening could be improved.

To improve subjective mood, music stimuli are often used. One can feel relaxed or comfortable when listening to music.[14] Music preference is an important factor in eliciting an emotional response. High-preference music enhances feelings of refreshment and relaxation, and affects the evaluation of timbre and impression of the music.[15] Moreover, preferred music plays a beneficial role in maintaining arousal during sleep deprivation.[16] This arousal-modulating effect occurs when music which is subjectively

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evaluated as excitative is presented during low-arousal states.[17,18]

In the present study, the effects of preferred excitative music on sleep inertia immediately after awakening from a short daytime nap were examined.

METHODS

Participants

Sixteen university students in good health participated in the study. They were divided between an experimental group (nap + music) and control group (nap only). In the experimental group, eight students (7 females and 1 male, 21–23 years of age, mean 21.9 years) were exposed to music after taking a nap. In the control group, the other eight students (4 females and 4 males, 20–23 years of age, mean 21.5 years) took a nap, but were not exposed to music. All participants answered a sleep–wake habit inventory and reported that they slept 6–8 h nightly, had normal sleep–wake habits, and did not complain of sleep–wake problems. They took naps less than once per week, and gave informed consent prior to participation.

Musical stimuli

Two excitative music stimuli were selected as high- or low-preference. High-preference music was selected from a series of songs chosen from the participants' preferred music CD collection, all of which consisted of popular music. The participants reported that they often listened to these songs to wake up in the morning. Low-preference music was selected by the experimenter: 'Mars' from 'The Planets', by Gustav Holst. It was previously confirmed that 'Mars' induces excitative effects.[18] The mean sound level of the music stimuli was adjusted to 60 dB.

Task

For the experimental group, the participants performed a visual oddball task. Yellow (target) or white circles (non-target) were randomly displayed for 200 ms at intervals of between 1.0 and 1.4 s (mean 1.2 s), where the visual angle size of the stimulus was 1.2°. The participants were seated 60 cm from a computer screen and instructed to press a button with their dominant hand (all participants were right-handed) as quickly and accurately as possible when the target stimuli appeared. Two hundred stimuli were presented during a 4-min session, whereby 40 targets were presented in random order. For the control group, the participants performed a memory search task. In this task, two alphabets were set as target stimuli and were displayed for 1.0 s. Subsequently, an alphabet sequence was randomly displayed for 200 ms at intervals of 1.0–1.4 s. The participants pressed a button with their right hand as quickly and accurately as possible when the target stimuli appeared. Two hundred trials were presented per session. Forty target stimuli were presented in a random order. The results of the task for the control group are not presented in this paper.

Subjective measures

The participants rated their subjective sleepiness and comfort using a 100-mm-long visual analog scale immediately before engaging in the oddball task. The values for sleepiness and comfort ranged from 0 (very alert or very comfortable) to 100 (very sleepy or very uncomfortable).

Physiological measures

Electroencephalograms (EEG) ($Fz - A_1$, $Cz - A_1$, $Pz - A_1$, $C_3 - A_2$ and $C_4 - A_1$), horizontal electrooculograms (EOG) for both eyes, vertical EOG for the left eye and submentalis electromyogram (EMG) were recorded using an electroencephalograph (1A97, NEC San-ei, Tokyo, Japan) and portable data recorder (SR-51, TEAC, Tokyo, Japan). Interelectrode impedance was below 5 kΩ. Electroencephalograms of the Fz, Cz and Pz areas were amplified using a time constant of 3.2 s for the measurement for event-related potentials (ERP). The ERP data is not presented in this paper since no significant effect was observed in the ERP components. A time constant of 0.3 s was used to measure the EEGs of the C3 and O1 areas for scoring the sleep stages. The EOG and EMG were amplified by 1.5 s and 0.03 s, respectively. Sleep stages during nap were scored in 30-s epochs using standard criteria.[19]

Experimental procedure

The control group participated under one condition (nap only), while the experimental group participated under two conditions (nap + high-preference music or nap + low-preference music) with an interval of more than 1 day. The order of the conditions for the experimental group was randomized across the participants. The student's *t*-test showed that there were no significant differences between the first and second experimental days in the sleep variables associated with a daytime nap, prior nocturnal sleep length, and subjective and behavioral measures for the experimental group. Therefore, any habituation to the experimental situations or learning effects due to repeat testing over 2 days were negligible for this group.

The day before the experiment, the participants practiced the performance task. Actigraphical recordings (Actiwatch AW64, Mini-Mitter Co. Inc., Bend, OR, USA) confirmed that they underwent normal nocturnal sleep the previous night. The mean nocturnal sleep times were 359 and 385 min for the high- and low-preference conditions for the experimental group, and 374 min for the control group, respectively. There was no significant difference among them.

A schedule of the experimental conditions is illustrated in Figure 1. The participants reported to the laboratory by 12:30. After eating lunch, electrodes were attached to monitor EEG, EOG and EMG activities. At 13:45, they sat in a chair in a soundproof and air-conditioned isolation unit and engaged in prenap sessions for 10 min (2 × 5 min). Each 5 min session included subjective ratings of sleepiness and comfort using a visual analog scale, and a 4-min oddball task (experimental group) or a 4-min memory search task (control group). They then lay in a bed at 14:00. The experimental group was awakened by presentation with high- or low-preference music after 20 min had elapsed from the onset of sleep stage 1.[19] Music was presented until termination of the post-nap sessions. The control group was awakened using an intercom. Immediately upon waking, all participants sat in a chair and answered questions about their estimated nap time (min), sleep latency (min), and depth of the nap (5: very deep to 1: very light). They engaged in the post-nap session for 20 min (4 × 5 min) from 1 min after awakening from the nap. At the end of each experiment, the experimental group evaluated their impression of the music with regard to excitement (5: exiting to 1: calm) and preference (11: extremely preferable to 1: not preferable).

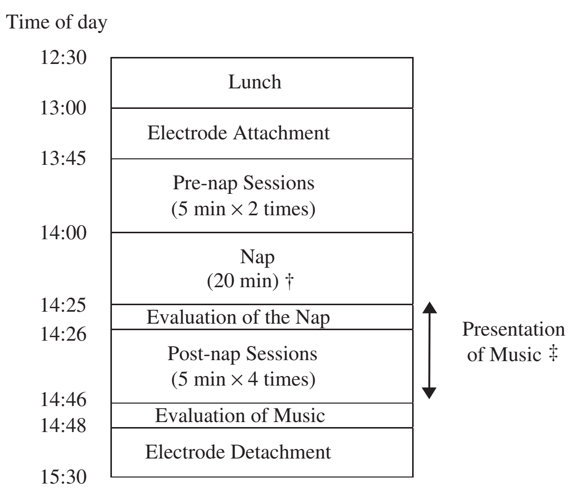

Figure 1 Schedule on the experimental day. †Although the total sleep time for the nap was 20 min, the total time in bed averaged 25 min. ‡Music was not presented for the control group.

Statistical analysis

Sleep variables of naps under each condition for the experimental group were compared using the Student's *t*-test. Comparisons between the experimental and control groups were also conducted using the *t*-test.

The effects of sleep inertia were evaluated by comparing the values immediately before and after napping. If performance or subjective ratings deteriorated immediately after napping, this was regarded as being the results of sleep inertia. In addition, if excitative music was effective on sleep inertia, performance or subjective ratings were improved when the participants were exposed to music. To evaluate the differences immediately before and after napping, two-way ANOVAs were performed [2 (group: low- or high-preference conditions for the experimental vs. control groups) × 2 (time: immediately before and after napping)]. In addition, to evaluate differences between the music conditions, a two-way [2 (condition: high- and low-preference) × 2 (time: immediately before and after napping)] ANOVA with repeated measures was performed.

To evaluate differences in subjective ratings between the experimental and control groups during the 30 min post-nap sessions, two-way [2 (group: low- or high-preference conditions in the experimental group vs. control group) × 4 (time: 5-min sessions after napping)] ANOVAs were also performed. In addition, to evaluate the effects of music preference, a two-way [2 (condition: high- and low-preference) × 4 (time: 5-min sessions after napping)] ANOVA with repeated measures was performed on the subjective ratings and performance measures. The degrees of freedom were adjusted by Huynh and Feldt's epsilon. To accommodate for interparticipant variations, the data were first transformed and the mean values of prenap sessions set to 0. Post-hoc comparisons were performed between the conditions using the Student's *t*-test and within the sessions using the Tukey's HSD test.

RESULTS

Subjective evaluation of music

At the end of the experiment, the experimental group evaluated that both high- and low-preference music gave impressions of a moderately arousing effect (high-preference: mean = 3.8, SD = 0.8; low-preference: mean = 4.2, SD = 0.5). These values were not significantly different (t (7) = 1.07, NS). The preference was significantly higher (t = 7.99, d.f. = 7, $P < 0.001$) for the high-preference condition (mean = 10.6, SD = 0.5) than the low-preference condition (mean = 4.5, SD = 1.9). Thus, experimental control over the selection of musical stimuli was successful.

Sleep variables during napping

Sleep variables during napping are shown in Table 1. Sleep began 3 min after lights out, and the participants slept for 20 min The nap consisted of approximately 10 min of Stage 1 and 10 min of Stage 2 sleep. Neither the sleep variables or subjective ratings associated with the naps were significantly different between the two conditions for the experimental group. Although time in bed (t = 2.16, d.f. = 14, $P = 0.049$) and waking time after Stage 1 onset (t = 2.53, d.f. = 14, $P = 0.024$) was significantly shorter for the control group than for the low-preference condition of the experimental group, other sleep variables and subjective ratings were not significantly different between the experimental and control groups. Thus, experimental control over the content of the nap was successful.

All participants were awakened during light sleep stages except for three participants who were awakened during Stage 3 sleep. Of these three participants, one belonged to the control group, and the other two people belonged to the experimental group; one was awakened under high-preference condition and the other was under low-preference condition. For the high-preference condition, four and three people were awakened during Stage 1 and Stage 2 sleep, respectively. For the low-preference condition, three and four people were awakened during Stage 1 and 2 sleep, respectively. For the control group, 7 people were awakened during Stage 2 sleep.

Subjective sleepiness and comfort

Figure 2 shows the evaluations for subjective sleepiness and comfort. Sleepiness declined immediately after

Table 1 Sleep variables and subjective ratings of a nap (*n* = 8). Mean (SD)

	Experimental group Preference of music		
	High	Low	Control group
Sleep variables (min)			
Time in bed	24.6 (3.9)	25.1 (3.4)*	22.3 (1.4)
Total sleep time	20.0 (0.3)	20.6 (1.3)	19.8 (0.5)
Stage 1	11.4 (5.1)	9.4 (4.3)	6.8 (3.5)
Stage 2	8.6 (4.9)	10.1 (4.0)	10.7 (3.8)
Stage 3	0.1 (0.2)	1.1 (2.2)	1.0 (1.9)
Stage 4	–	–	–
Stage REM	–	–	1.4 (3.9)
Waking time after stage 1 onset	2.1 (2.7)	1.6 (1.6)*	0.1 (0.2)
Latency to stage 1	2.6 (1.4)	2.9 (2.9)	2.3 (1.4)
Subjective ratings (min)			
Nap time	15.5 (8.2)	12.9 (6.7)	14.1 (3.8)
Sleep latency	8.1 (4.1)	7.5 (5.5)	6.4 (6.8)
Depth of the nap†	3.1 (1.6)	3.3 (1.3)	3.8 (0.9)

†5, Very deep; 1, very light.
*Significantly different from the control group, as seen using the Student's *t*-test.

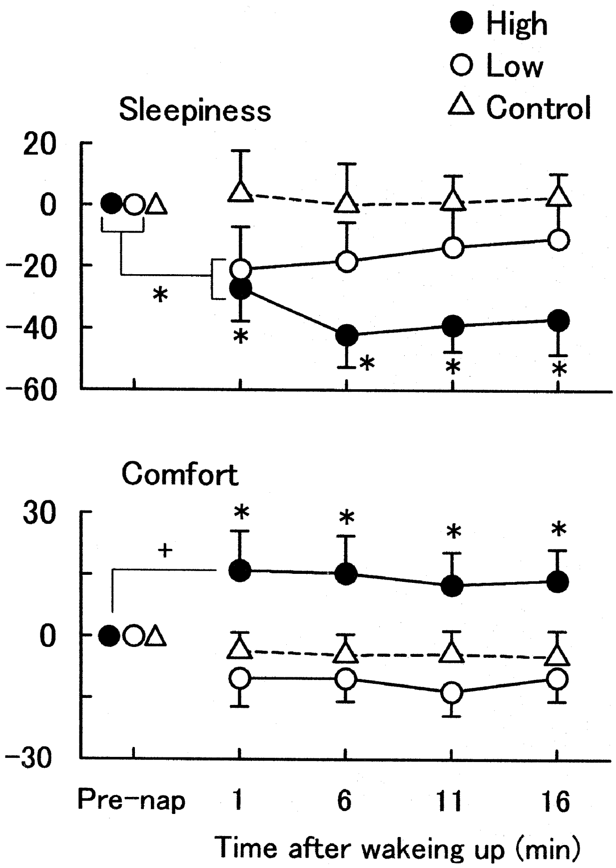

Figure 2 Subjective (a) sleepiness and (b) comfort during pre- and post-nap sessions for high- (closed circles) and low-preference conditions (open circles) for the experimental (nap + music) and control groups (nap only; open triangles) (mean ± SE). The data were transformed as the mean values of prenap sessions set to 0. The asterisks at the top or bottom of the closed circles represent significant differences between the high-preference condition for the experimental and control groups. *$P < 0.05$, +$P < 0.10$.

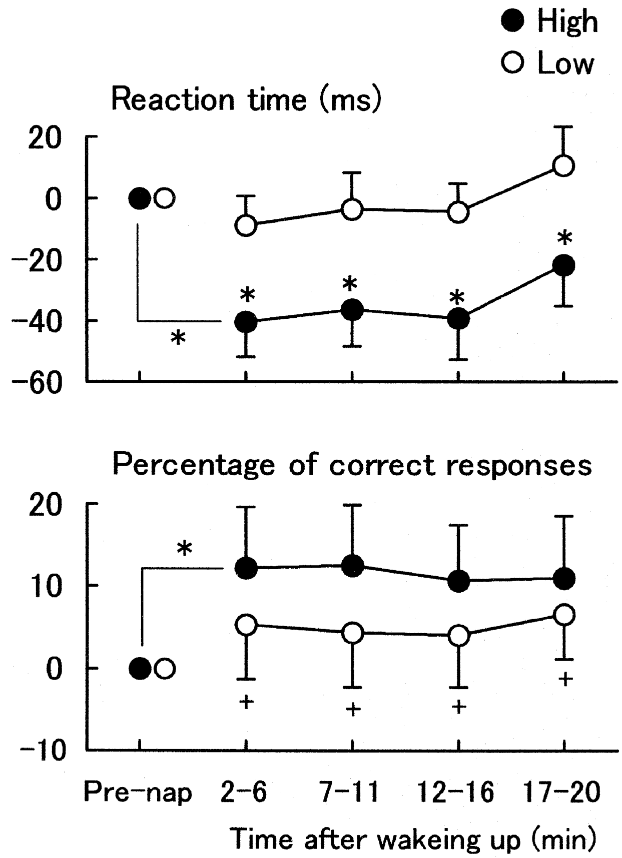

Figure 3 (a) Reaction time and (b) percentage of correct responses for the visual oddball task during prenap and post-nap sessions for high- (closed circles) and low-preference conditions (open circles) for the experimental group (nap + music) (mean ± SE). The data were transformed as the mean values of prenap sessions set to 0. The asterisks at the top of the closed circles represents significant differences between the high- and low-preference conditions. *$P < 0.05$, +$P < 0.10$.

napping for the experimental group (–27 and –21 points for the high- and low-preference conditions, respectively), but not for the control group (+4). Comfort was enhanced for the high-preference condition (+16), but not for the low-preference condition (–10) and control group (–4). ANOVAs showed that no significant main effects or interactions were found between the low-preference condition and the control group for sleepiness and comfort. Between the high-preference condition and the control group, interaction of group × time was significant for sleepiness [$F(1, 14) = 6.736$, $P = 0.021$] and was marginally significant for comfort [$F(1, 14) = 4.086$, $P = 0.063$]. Post-hoc comparisons showed that sleepiness ($P = 0.006$) and comfort ($P = 0.085$) under the high-preference condition improved immediately after napping in comparison with immediately before napping.

Between the high- and low-preference conditions, no main effect of condition nor interaction were significant, while the main effect of time was significant for sleepiness [$F(1, 7) = 6.836$, $P = 0.035$]. Sleepiness immediately after napping significantly decreased for both music conditions in comparison with before napping. In addition, main effect of time was not significant, while main effect of condition [$F(1, 7) = 6.219$, $P = 0.041$] and interaction of the condition × time [F (1,

7) = 6.219, $P = 0.041$] were significant for comfort. Post-hoc comparison showed that the participants were more comfortable under the high-preference condition than the low-preference condition immediately after napping ($P = 0.038$).

During the post-nap sessions, sleepiness was low and comfort was high under the high-preference condition. Two-way [2 (group: low- or high-preference conditions for experimental group vs. control group) × 4 (time: 5-min sessions after napping)] ANOVAs showed that the main effects of group were significant for sleepiness [$F_{(1, 14)} = 14.403$, $P = 0.002$] and comfort [$F_{(1, 14)} = 4.888$, $P = 0.044$] between the high-preference condition and the control group. These subjective ratings significantly improved during the post-nap sessions under the high-preference condition compared to the control group. No significant main effects or interaction were observed between the low-preference condition and the control group.

Between the high- and low-preference conditions during the 30 min post–nap sessions, interaction of the condition × time was significant for sleepiness [$F_{(3, 21)} = 3.615$, $\epsilon = 0.83$, $P = 0.040$]. Post-hoc comparisons showed that sleepiness significantly declined from 6 to 16 min after waking under the high-preference condition compared to the low-preference condition (ps < 0.002). The main effect of condition was also significant for comfort [$F_{(1, 7)} = 8.003$, $P = 0.025$]. Comfort was significantly higher during the post-nap sessions under the high-preference condition than under the low-preference condition.

Performance measures

Figure 3 shows the reaction time and percentage of correct responses for the oddball task. Under the high-preference condition, reaction time (RT) was shortened (–40 ms) and the percentage of correct responses was enhanced (+12%) immediately after awakening in comparison with before napping. These changes were not salient under the low-preference condition (RT, –9 ms; correct responses, +5%). ANOVAs showed that interaction of the condition × time was significant for reaction time [$F_{(1, 7)} = 9.011$, $P = 0.020$] and was marginally significant for the percentage of correct responses [$F_{(1, 7)} = 4.840$, $P = 0.064$]. Post-hoc comparisons showed that reaction time ($P = 0.003$) and percentage of correct responses ($P = 0.004$) under the high-preference condition significantly improved immediately after napping in comparison with immediately before napping.

During the post-nap sessions, reaction time was shorter and the percentage of correct responses was higher for the high-preference condition than for the low-preference condition. ANOVAs showed that the main effect of the condition was significant for reaction time [$F_{(1, 7)} = 7.006$, $P = 0.033$] and was marginally significant for the percentage of correct responses [$F_{(1, 7)} = 4.546$, $P = 0.070$]. These performance measures improved during the post-nap sessions under the high-preference condition compared to the low preference condition.

DISCUSSION

The present study examined the effects of exposure to preferred excitative music on sleep inertia induced immediately after a short daytime nap. The results demonstrated that excitative music decreased subjective sleepiness immediately after napping, regardless of the music preference. However, preferred music further improved subjective sleepiness and comfort, and an achievement of the task performance.

Sleep inertia often occurs immediately after awakening and continues for several minutes up to 2 h.[9,10] Although sleep inertia is enhanced during sleep debt[9,10] (the cumulative hours of sleep loss with respect to an individual's specific daily need for sleep),[20] it occurs for several minutes even after a nap of less than 20 min.[6,7] For the control group, however, subjective sleepiness did not significantly increase immediately after awakening. Therefore, the negative effect induced by sleep inertia might have been trivial in the present study.

Although the naps were occupied by lighter sleep stages, Stage 1 sleep occurred within 2–3 min after lights out. This was the pathological level of sleepiness.[21] Prior nocturnal sleep occurred for 6.0–6.4 h, suggesting that the participants might have been under mild sleep deprivation. However, Kaida *et al*. reported that the mean sleep latency of a short nap at 14:00 after 7.7–7.8 h of prior nocturnal sleep was 1.6–1.7 min.[12,13] The participants in the present study took a nap at 14:00, when afternoon sleepiness often occurs. Such a biological sleepiness cycle[2] might also contribute to a shorter sleep latency of the nap.

Although subjective sleepiness did not remain in the control group, sleepiness significantly decreased immediately after napping by listening to excitative music, regardless of preference. These results could be the result of the alerting effects of excitative music.[17,18] In comparison with low-preference music, high-preference music further reduced sleepiness 6–16 min after awakening. These effects associated with preference were also observed for comfort and performance, and support the results of a previous study in which high-preference music enhanced relaxation and refreshment.[15]

It is not clear, however, whether such alerting effects can be observed without taking a nap, because only the music condition was not tested in the present study. In addition, it could not be demonstrated that a short nap helped reduce daytime sleepiness, because the no-nap condition was not examined. Although the present study demonstrated that high-preference music was likely to reduce sleepiness by enhancing comfort, single effects of excitative music,[17,18] music preference,[14,15] or a short nap[3–7] could not be shown for lack of these experimental conditions. It would be plausible that the present results might be due to the mixed effects of these factors, however, the further studies are required to examine single and mixed effects of these factors.

After listening to high-preference music, reaction time of the task was shortened. The speed of information processing might be affected by the level of arousal,[22] suggesting that preferred excitative music has positive effects on daytime arousal. These alerting effects have been confirmed.[16–18,23] However, Iwanaga & Ito[24] pointed out that music has contradictory effects; it enhances arousal but disturbs performance. Music interferes with the processing of linguistic information, such that verbal memory performance declines when listening to music.[24,25] The task used in the present study was simple and easy, so that performance improved because of elevated arousal associated with the music.

Music is also effective for maintaining arousal and motivation when performing easy tasks.[23] Further studies are required to examine whether the positive effects can be observed when performing more complex cognitive tasks. In addition, further studies are required to examine whether preferred excitative music can be a useful counter-measure against severe sleep inertia such as that associated with heavy sleep debt or being awakened from deeper sleep stages.

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