Differences in Sleep–Wake Habits and EEG Sleep Variables between Active Morning and Evening Subjects

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Summary: This article is a survey study, followed by an experimental study, examining the differences of sleep–wake habits and sleep electroencephalographic (EEG) variables between morning and evening type subjects (Ss). In the survey study, the Japanese version of the Horne and Östberg Morningness-Eveningness Questionnaire and Life Habits Inventory (LHI) were administered to approximately 1,500 university students. The survey results showed that the two types were significantly different from each other in terms of retiring and arising time, sleep latency, mood on arising, nap, adequate amount of sleep, number of times of staying awake all night, and variability in bedtime, arising time, and sleep length. These results suggested that evening type Ss had more irregular and/or flexible sleep–wake habits than morning type Ss. In the experimental study, 10 morning and 11 evening type Ss were selected from the population included in the survey study, and polysomnograms were obtained. The results showed that only in rapid eye movement (REM) latency did morning type Ss significantly differ from evening type Ss. REM latency might be related to personality factors, particularly to neuroticism and anxiety. **Key Words:** Circadian rhythm—Individual differences—Morning–evening types —Sleep–wake habits—Sleep variables—Personality.

There have been many studies of individual differences in circadian rhythms (e.g., amplitude, phase, and their relationship to personality). We have focused on the phase differences that are characterized by the differences in peaktime (acrophase) of the circadian psychological and physiological functions.

In 1939, Kleitman (1) indicated the existence of "morning" (early peak) and "evening" (late peak) type people (larks and owls) whose body temperature and efficiency curves peaked at different times. Later, Horne and Östberg (2) developed a Morningness–Eveningness Questionnaire (MEQ) based on a Swedish version (3). In our pre-

vious studies (4,5), we translated the English version of the MEQ to construct the Japanese version and reported that the questionnaire's reliability and validity were high. Furthermore, differences in various habits, including sleep–wake habits, were noted between the active morning and evening students (4,6).

The purpose of this article is to report the differences between morning and evening subjects in a student population. In the survey study, we compared morning and evening type subjects in regard to sleep–wake habits. In the experimental study, polysomnograms were obtained using morning and evening type students selected from the survey study. It is assumed that there will be few differences, except for a few sleep–wake habits, e.g., bedtime and arising time, if the difference between the two types is merely the circadian phase difference.

SURVEY STUDY

Methods

The Japanese version of the MEQ (4,5) was administered to students at two universities. The Life Habits Inventory (LHI) (4,6) was also administered simultaneously with the MEQ. The number of students surveyed was 1,459 (mean age 19.5 ± 1.2 years), and the numbers of men and women were 1,061 and 398, respectively. A single ME score was computed for each subject according to the scoring criteria of Horne and Östberg (2). We found 110 morning type subjects (Ss) (definitely and moderately morning types, ≥59 of ME score) and 339 evening type Ss (definitely and moderately evening types, ≤41 of ME score) and analyzed their responses to LHI questions regarding the following sleep–wake habits: bedtime and arising time, sleep length, subjective evaluation of sleep, nap (time, frequency, and length), and the variability in bedtime, arising time, and sleep length. The results of the other habits (e.g., time or frequency of meals, caffeine and alcoholic beverages, and smoking) and distribution of the Japanese version of the MEQ scores and associated descriptive statistics were reported elsewhere (4,6).

The level of significance was set to be 0.05 or better, two-tailed. The notation for 24-h clock time was used to express the local time (i.e., hr:min).

Results

Bedtime for the morning type (M-type) was 23:38 ± 56 min and for the evening type (E-type) was 1:08 ± 58 min); arising times were M-type, 6:55 ± 58, E-type, 8:12 ± 71; and sleep lengths were M-type, 6:53 ± 51 and E-type, 6:48 ± 70. Significant differences between these two groups were found in sleep parameters, except for sleep length (bedtime: $t = 14.26$, df = 447, p < 0.001; arising time: $t = 10.28$, df = 447, p < 0.001), where the larks went to bed earlier and got up earlier, as expected from the definition of the morning type.

Figures 1 and 2 show various sleep–wake habits. Vertical axes represent frequency transformed into percentage. To clarify different tendencies between the two types, chi-square tests were used to evaluate whether or not a distribution of the morning type responses to a question in LHI was significantly different from that of evening type Ss. Significant differences existed between the larks and owls in answers to all the questions in the LHI, except for number of awakenings (Fig. 1B), depth of sleep (Fig. 1D), and experience of insomnia (Fig. 1H). From these results of sleep–wake habits, the morning type Ss evaluated themselves as going to bed earlier, falling asleep more easily (Fig. 1A: $\chi^2 = 39.63$, df = 4, p < 0.001), and getting up earlier than the evening
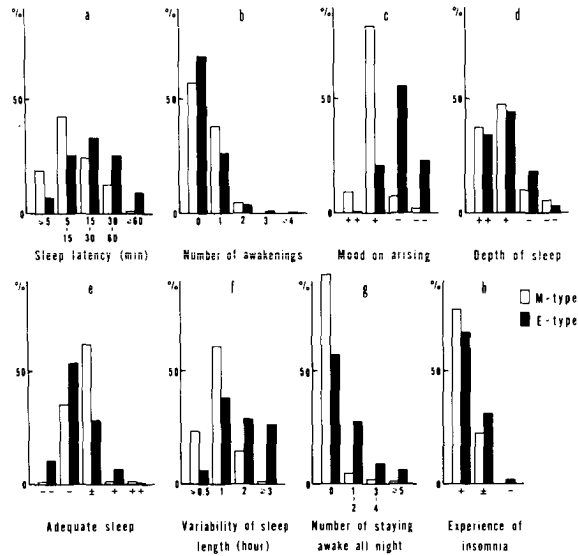
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FIG. 1. Comparisons between chronotypes of sleep-wake habits. (A) sleep latency; (B) number of awakenings during sleep; (C) mood on arising: + + very good, + fairly good, − fairly bad, − − very bad; (D) depth of sleep: + + very deep, + fairly deep, − fairly light, − − very light; (E) adequate amount of sleep: − − very short, − fairly sort, ± adequate, + fairly long, + + very long; (F) variability of sleep length; (G) number of times of staying awake all night per month: (H) experience of insomnia: + no experience, ± having experience but no medical treatment, − having experience with medical treatment.
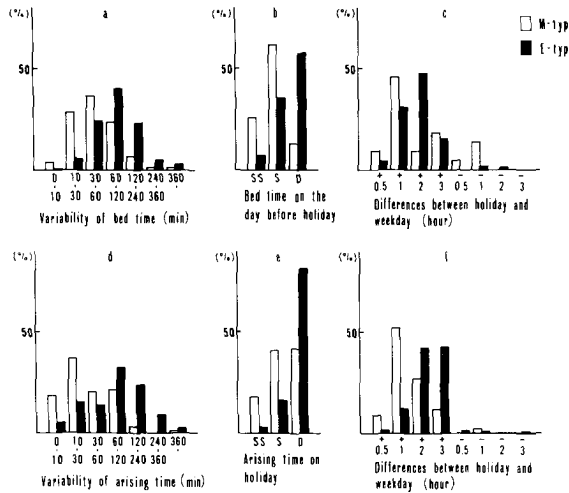
FIG. 2. Comparisons between chronotypes of sleep-wake habits. (A) variability of bedtime (weekday); (B) bedtime on the day before holiday and weekend: SS, almost the same bedtime as on weekday, S, slightly different, D, different; (C) differences between holiday and weekday (bedtime): + delay, − advance; (D) variability of arising time (weekday); (E) arising time on holiday and weekend: SS, almost the same arising time as weekday, S, slightly different, D, different; (F) differences between holiday and weekday (arising time): + delay, − advance.

type. In addition, the morning type Ss were in a better mood on arising (Fig. 1C: $\chi^2 =$ 177.48, df = 3, p < 0.001) and had a more adequate amount of sleep than the evening type (Figs. 1E: $\chi^2 = 45.21$, df = 4, p < 0.001). In contrast, the evening type Ss reported not only later bedtime and arising time, but also greater variability in bedtime (Fig. 2A: $\chi^2 = 73.68$, df = 6, p < 0.001), arising time (Fig. 2D: $\chi^2 = 73.50$, df = 6, p < 0.001), and sleep length (Fig. 1F: $\chi^2 = 67.46$, df = 3, p < 0.001) than the morning type. In particular, bedtime on the day before holidays and weekends and arising time on holidays and weekends were delayed for the evening type or were shifted to a later time compared with weekdays (Fig. 2B: $\chi^2 = 73.33$, df = 2, p < 0.001; Fig. 2C: $\chi^2 =$ 29.12, df = 7, p < 0.001; Fig. 2E: $\chi^2 = 69.88$, df = 2, p < 0.001; Fig. 2F: $\chi^2 = 62.99$, df = 7, p < 0.001).

Concerning nap and number of times of staying awake all night per month, the evening type Ss took longer and more frequent naps at a later time of day (frequency: $\chi^2 =$ 20.89, df = 2, p < 0.001; duration: $\chi^2 = 14.83$, df = 3, p < 0.005; time of day: $\chi^2 =$ 32.34, df = 5, p < 0.001), and stayed awake all night more often (Fig. 1G: $\chi^2 = 46.62$, df = 3, p < 0.001) than did the morning type Ss.

Discussion

The present results support previous studies reporting significant differences in retiring and arising time between morning and evening types (2,7–11). Table 1 presents mean values of each sleep parameter obtained from previous and present studies per-

TABLE 1. *Sleep parameters for morning and evening types in the previous and present studies*

	Bedtime		Arising time		Time in bed	
	M	E	M	E	M	E
Horne and Östberg (2, 7)	23:16[a]	1:03	7:14	9:11	7:34	7:13
	42[b]	27	45	68	54	47
	n = 18	n = 20				
Webb and Bonnet (8)	0:15	1:37	7:55	9:06	7:42	7:30
	57	72	54	95	33	56
	n = 11	n = 10				
Foret et al. (9)	22:38	0:05	7:08	7:47		
	46	36	41	35		
	n = 8	n = 12				
Mecacci and Zani (10)						
Students	22:24	0:21	7:21	9:19	8:33	8:42
	28	44	44	54	38	40
	n = 39	n = 54				
Workers	22:31	23:26	6:35	7:06	8:06	7:28
	30	36	11	13	24	35
	n = 32	n = 30				
Kerkhof (11)	0:03	1:29	7:58	9:01	7:56	7:34
	43	49	37	55	41	49
	n = 21	n = 30				
					Sleep length	
Present study	23:38	1:08	6:55	8:12	6:53	6:48
	56	58	58	71	51	70
	n = 110	n = 339				

[a] Mean values in h:min.
[b] SD in minutes.

formed in Sweden, America, France, Italy, The Netherlands, and Japan. It is of interest that six studies showed strong evidence for cross-cultural similarity, i.e., the evening type Ss go to bed and arise later than the morning type Ss. However, these values of sleep parameters differ slightly from one study to another. The differences can be explained by the following three reasons: (A) these studies differed from each other as to season when the data were collected, i.e., the data are contaminated by internal seasonal variations (circannual rhythm) (12) and/or external seasonal variations (winter- or summertime); (B) these studies were conducted in different countries; thus, data were perhaps confounded with cross-cultural differences; and (C) there were some methodological differences in collecting data, e.g., in our study, the Ss checked habitual bedtime and arising time on the time scale measured in 30-min periods and sleep length on a time scale measured in hours. Thus, sleep length in particular had a tendency to be minimized.

As Webb and Bonnet (8) have reported more extensively on sleep habits, using the Post-Sleep Inventory (13), than the other studies, we were able to compare the results of the present study with theirs. Concerning sleep latency, mood on arising, adequate amount of sleep, and nap, the present results have been consistent with Webb and Bonnet's study. They showed that the morning type could be characterized as a good sleeper when compared with the evening type.

However, as shown in Figs. 1 and 2, variability in bedtime, arising time, and sleep length for the evening type Ss was greater than for the morning type Ss, especially in terms of the differences between weekday and weekend. When we take frequency of nap and of staying awake all night into consideration, sleep–wake habits of the evening type are found to be more irregular, in other words, more flexible than those of the morning type. Thus, the chronotypes may be better characterized by the extent of irregularity and/or flexibility of sleep than by labeling them as good or poor sleepers.

EXPERIMENTAL STUDY

Methods

Subjects. Twenty-one male students (10 morning type Ss and 11 evening type Ss) with a mean age of 20.0 years (range 18–25) were selected from a population of the survey study and were paid for their participation. Two types of Ss were selected by the same criteria as in the survey study. At least one week before the experiment, they were instructed to maintain habitual sleep schedules and to abstain from all drugs, including alcohol, from 1 day before and during the experiment.

Procedures. The Ss slept uninterrupted in the laboratory for 4 or 6 consecutive nights. The first and second nights were adaptation, and third and fourth (or third to sixth) nights were experimental nights. Each night's sleep was monitored using standard techniques, and all records were scored in 30-s epochs according to the usual criteria (14). Rectal temperature was also monitored and recorded at 5-min intervals during sleep. The laboratory was sound attenuated, and room temperature and humidity were kept constant at $23.0 \pm 0.5°C$ and $60 \pm 10\%$, respectively.

All morning type Ss were asked to sleep during the same time of day. The sleep period was determined by mean clock times, which were calculated from Ss' habitual bedtime and arising time. Similarly, all evening type Ss slept during the same time of day. The sleep period of the morning type was approximately 11:00 p.m. to 7:00 a.m.

and that of the evening type was 1:00 a.m. to 9:00 a.m. All Ss were awakened after at least 7.5 h of sleep. Immediately after the Ss were awakened in the morning, the Kwansei Gakuin Sleepiness Scale (KSS) (15) (developed by using Thurstone's method and made up of 22 questions) and the Mood Adjective Check List (MACL) (16) were administered, and critical fusion frequency (CFF) and blood pressure were measured. During the experimental period, the Maudsley Personality Inventory (MPI) and the Manifest Anxiety Scale (MAS) were administered to all subjects. In this study, subjects lived in the laboratory for 48 h, and KSS, MACL, and performance tasks were carried out at a fixed interval during the waking period (i.e., every 30 min for KSS and MACL and every 90 min for tasks). However, the results of these indices will be reported elsewhere.

Sleep cycle. Since the non-REM (NREM) cycle was adopted, sleep cycle, except for the first sleep cycle, was defined as the period from the end of a REM episode to end of the next REM. The first cycle was measured from sleep onset (stage 1) to the end of the first REM episode. We defined sleep onset as at least 5 or more consecutive minutes of stage 1 and 2. A REM episode interrupted by less than 20 min of continuous NREM sequence was treated as a single episode. For the first NREM episode (from sleep onset to the onset of the first REM episode), any NREM episode of more than 120 min or less than 20 min duration was excluded from analysis of the sleep cycle (17,18).

Results

Third and fourth night data (in the case of four consecutive nights) or third to sixth night data were analyzed.

Sleep variables. Table 2 presents latencies and stages of both types. As for the results of one-way Analysis of Variance (ANOVA) for each sleep variable, the only significant difference between the morning and evening types was for REM latency ($F_{(1/18)}$ = 7.20, p < 0.025). REM latency in the morning type Ss was on the average 11.5 min shorter than that of the evening type Ss. With regard to those sleep variables similar to the questionnaires of the LHI in the survey study [for example, sleep latency and

TABLE 2. *Nocturnal sleep parameters for morning and evening types*

	M-type (n = 10)		E-type (n = 11)	
	Mean	SD	Mean	SD
Latency to stage 1 (min)	13.8	6.42	16.8	17.25
Latency to stage 2	3.0	0.82	3.9	2.47
Latency to stage 3	13.2	4.44	12.8	2.38
Latency to stage 4	22.2	12.14	18.1	2.97
Latency to stage REM	62.8	5.88[a]	74.3	10.97
Stage W (%)	2.2	2.14	1.3	0.92
Stage 1	7.9	3.04	8.4	2.07
Stage 2	47.0	5.68	47.0	3.63
Stage 3	9.4	2.28	10.5	2.80
Stage 4	9.0	4.99	9.4	3.47
Stage REM	24.5	3.29	23.4	2.74

[a] n = 9.

amounts of stage W (% stage W) and deep sleep (% stages 3 and 4)], no statistical differences were found between the two types.

Hourly distribution and sleep cycle. For the sequential hourly change of the mean times of slow wave sleep (SWS) (stages 3 + 4) and REM, the results of two-way ANOVA (chronotype and hour) showed that there were significant effects of hours (conservative test) for SWS and REM (SWS: $F_{1/19} = 84.46$, p < 0.001; REM: $F_{1/19} = 25.60$, p < 0.001), but the main effect of chronotype and the chronotype-by-hour interactions were not significant (19).

Mean sleep cycle durations of first to fifth cycles were calculated for the morning and evening types. Although there were no significant differences between the two types in each cycle, the first cycle duration of the evening type Ss was longer than that of the morning type (p < 0.1). The shapes of the trends for both types were similar, and these shapes represented the "umbrella-shaped" trend that had been reported by Feinberg and Floyd's study (20). As the result of the regression analysis, cycle durations were significantly curvilinear for both types (M-type: $F_{(1/14)} = 6.38$, p < 0.025; E-type: $F_{(1/16)} = 6.29$, p < 0.025). The duration of the first NREM episode (which is the same as REM latency as defined in this paper) of the morning type was significantly shorter than that of the evening type. However, there were no significant differences between the morning and evening types for the other cycles.

Body temperature. Phase difference of body temperature between the morning and evening types was about 113 min by using cosinor method (21), i.e., temperature trough of the morning type was 4:17 and that of the evening type 6:10. However, with respect to the other circadian parameters, there were no significant differences. Mean body temperature curves of the two types with the time course from sleep onset are shown in Fig. 3. Significant main effect of the chronotype and the chronotype-by-hour interactions were not obtained (ANOVA), and there was only a significant effect of hours ($F_{(1/19)} = 21.89$, p < 0.001) using the conservative test. Although the body temperature data with the time course from lights off were also analyzed by ANOVA, significant effects of the chronotype and the chronotype-by-hour interactions were not found, except for the effect of hours.
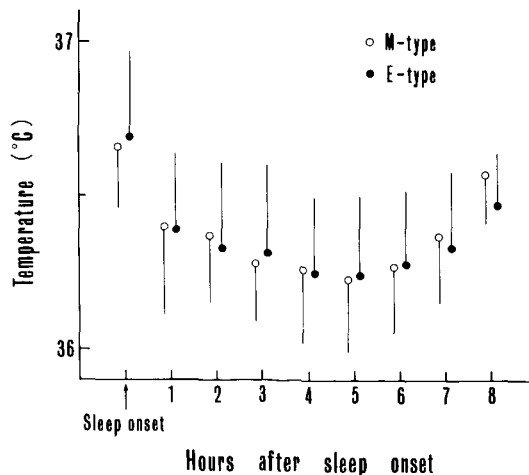

FIG. 3. Hourly changes in the mean body temperatures for morning and evening types.

Self-ratings on arising. Figure 4 shows the mean as well as individual scores of sleepiness (KSS) and mental efficiency (MACL) on arising. The higher KSS rating indicates that the subject feels greater sleepiness, and for MACL, a higher score indicates greater efficiency. There were no significant differences between the morning and evening types by t test. However, the morning type was less sleepy and more efficient than the evening type by median test (KSS: $\chi^2 = 5.84$, df = 1, p < 0.02; MACL: $\chi^2 = 8.03$, df = 1, p < 0.005), as shown evidently from the distribution of individual scores.

Personality. Individual scores and means of MPI and MAS are shown in Fig. 5. Although there were no significant differences between the two types in extroversion (E), neuroticism (N), and anxiety (A) scores, there were trends in E and N scores (E: $t = 1.73$, df = 19, p < 0.1; N: $t = 1.92$, df = 19, p < 0.1). The evening type has more extravert and neurotic trends than the morning type. Table 3 shows correlation coefficients of ME score, personality scores, and REM latency using the Spearman rank-order correlation. ME score significantly correlated with REM latency. ME scores correlated with personality scores, but nonsignificantly (p < 0.1). REM latency significantly correlated with N score. These results indicated that eveningness was related to longer REM latency and was more "extrovert," "neurotic," and "anxious."

Discussion

Judging from the EEG sleep parameters obtained from our experimental study, there were no differences in the polysomnographic quality of sleep between the morning and evening type Ss, except for REM latency, for which the morning type Ss showed significantly shorter latency than the evening type Ss. Concerning the other physiological functions (e.g., CFF and blood pressure) measured on arising, there were no differences between the two types. According to the questionnaire (KSS, MACL) on arising, however, the morning type Ss estimated their mood more positively than the evening type Ss. The morning type Ss' more positive feeling on arising (i.e., less sleepiness and more mental efficiency) compared with the evening type Ss did not result from better polysomnographically defined quality of sleep, as no differences in the quality of sleep between the two chronotype Ss were observed.
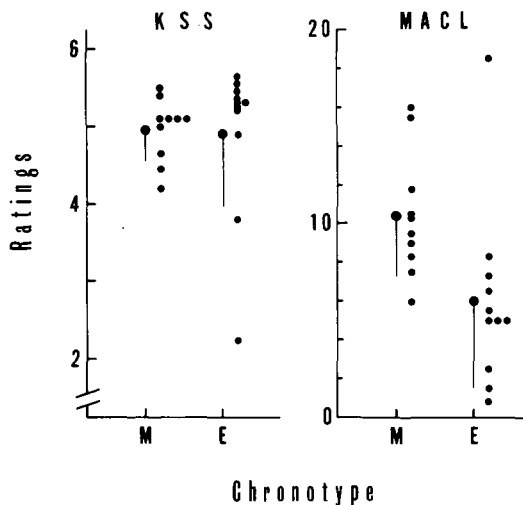

FIG. 4. Self-ratings (KSS and MACL) on arising for the chronotypes.
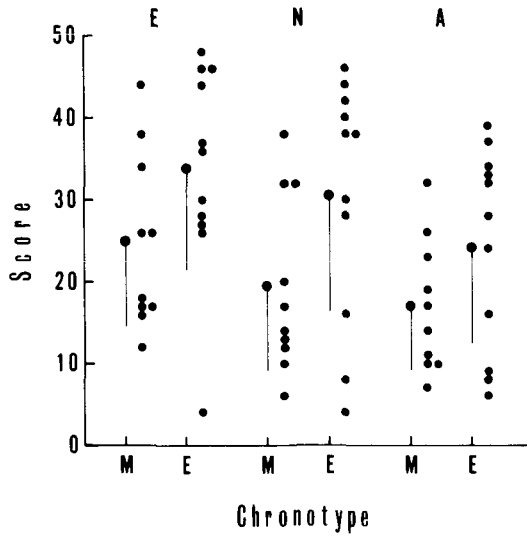
FIG. 5. Personality scores for the chronotypes. E, extroversion; N, neuroticism; A, anxiety.

The cause of this discrepancy between self-ratings and physiological measurements may be attributed to the following reasons. First, there may be a tendency for the evening type Ss (or the morning type Ss) to overestimate (or underestimate) their sleepiness and underestimate (overestimate) efficiency. Second, the physiological measures used in this study may not be sensitive enough to detect the differences in sleepiness and mood between the two types.

GENERAL DISCUSSION

The comparison of the results of the experimental study with those of the survey study showed that the results of these studies were consistent regarding awakening during sleep (the number of awakenings in the survey and the percent stage W in the experiment), quality of sleep (depth of sleep in survey and percent of stages 3 and 4 in the experiment), and mood on arising. However, the results of sleep latency did not correspond between the two studies, where the evening type Ss tended to overestimate sleep latency in the survey study. However, the standard deviation of sleep latency in

TABLE 3. *Correlation coefficients of ME score, personality trait, and REM latency using Spearman rank-order correlation*

	ME	E	N	A	REM latency[a]
ME score		-0.419^b	-0.432^b	-0.393^b	-0.607^d
E score			-0.137	-0.148	0.302
N score				0.891^d	0.484^c
A score					0.435^b

[a] n = 21, excluding REM latency, n = 20.
[b] $p < 0.1$.
[c] $p < 0.05$.
[d] $p < 0.01$.

the evening type Ss, as shown in Table 2, is evidently greater than that of the morning type. Examining the distributions of sleep latency of two types, sleep latency of the evening type Ss was found to be mainly distributed less than 10 min and more than 30 min. In contrast, the sleep latency of the morning type Ss was almost always found over a range from 0 to 20 min. These characteristics of distribution seem to be consistent with the result of the survey study (Fig. 1A).

If only the circadian phase difference had existed between the two types, there would not have been significant differences for sleep–wake habits, excluding bedtime and arising time, and polysomnographic quality of sleep. Our results are characterized not only by the differences of bedtimes and arising times, but also by the differences of irregularity/flexibility of sleep–wake habits and REM latency between two types. These results may suggest that there are some differences other than phase difference between the two types.

The difference between the two types regarding irregularity/flexibility can be assumed to reflect either that the morning type is more strongly influenced by social and environmental cues than the evening type (i.e., the synchronization mechanism of the evening type Ss is weak compared with the morning type Ss or the evening type has more autonomous circadian rhythm and its period is longer than that of the morning type), or that the morning type has more autonomous circadian rhythm than the evening type (22). However, we do not have enough data to choose one of these two working hypotheses.

Folkard et al. (23) have suggested that the flexibility of people's sleeping habits may be more important in predicting tolerance to shift work than the chronobiological type. The results of the present study suggest that the people who have flexible sleeping habits are most probably the owls or evening type individuals. Thus, as reported by previous studies (22,24,25), the tolerance of the owls to night and shift work may be greater than that of the larks.

We cannot adequately explain the reason why the REM latency of the morning type Ss (62.8 min) differed from that of the evening type Ss (74.3 min). Kobayashi (18) reported that the peak of the distribution of the NREM sequence was about 70 min. Comparing the REM latencies of the two types with his data, the REM latency of the morning type was slightly shorter than the peak value of distribution of NREM sequence; in contrast, that of the evening type was slightly longer than the peak value. Though the REM latency of the morning type tended to be shorter and that of the evening type longer than the peak value, the mean REM latencies of both types were within the normal range.

Previous studies have reported that REM sleep propensity presented endogenous circadian rhythm, and its rhythm was closely coupled to the body temperature rhythm (26–29). If the differences of the REM latency were caused by the differences of circadian phase, it may be inferred that the circadian phase relationship between sleep period and body temperature rhythm is different between the morning and evening types, i.e., temperature minima of the morning type occur in the first half of the sleep period, and in the case of the evening type, in the second half of the sleep period. Also, the amount of REM sleep ought to be greater in the morning type than in the evening type, and the temporal distribution of REM sleep in the morning type ought to differ from that in the evening type. The fact is, however, that there were no differences in the curves of body temperature and the temporal distributions of REM sleep as well as

total REM sleep between the two types. Thus, we cannot conclude that the differences of REM latency between the two types are due to the differences of circadian phase. Foret et al. (30) recently reported that the evening type Ss' temperatures tended to decrease more than that of the morning type, but their results might be influenced by the baseline bedtimes for both types, as the baseline night bedtime in the evening type Ss was more advanced than habitual bedtime reported in their 2-week sleep logs. Habitual and laboratory bedtimes of the morning type were 23:29 (± 77 min) and 23:30 (± 50 min), respectively, and equal each other. On the contrary, those of the evening type were 01:28 (± 40 min) and 00:00 (± 54 min). As the evening type Ss went to bed earlier than usual during the experiment, it is likely that the body temperature of the evening type decreased more than that of the morning type.

As postulated by Borbély (31,32), reciprocal interaction between SWS and REM sleep results from deficiency of the SWS propensity (sleep-dependent process: process S), and consequently, REM latency is shortened. In our study, there were no significant differences for temporal distributions of SWS and total amounts of SWS between the two types. Besides, the mean REM latencies of both types were within normal range. Thus, his hypothesis might explain shortened REM latency in some sleep disorders, but might not be suitable to explain the shortened REM latency obtained in our experiment.

As the variability of REM latency cannot always be explained by the circadian propensity of REM sleep or by reciprocal interaction, we suggest individual differences in REM latency, especially in the first REM latency. Although the physiological background of the variability of REM latency is unknown, it can be inferred from the matrix of Table 3 that the short REM latency is closely related to ME score (morningness preference) and personality scores (less neurotic and less anxious). As the evening type subjects had neurotic and anxious tendencies, and REM latency significantly correlated with N score, they might not completely adapt to the laboratory. Therefore, REM latency in the evening type might be longer than that in the morning type. However, whether or not these individual differences of REM latency are due to personality factors must be the subject of future study.

In the present study, we clarified the differences between the two types in terms of sleep–wake habits, mood on arising, REM latency, and personality. However, it is difficult to answer the question of whether the sleep–wake habits have been the cause of creating morning/evening types, or whether there are individual differences in endogenous circadian rhythm characteristics that determine their way of life. Mecacci and Zani (10) stated that workers had a distribution significantly skewed toward the morningness scores as compared with students and that the acquisition of a regular job seemed to induce a change in sleep–wake behavior, particularly in the evening workers. Thus, sleep–wake habits, particularly bedtime and arising time, may to some extent determine the chronotypes. They also reported, however, that differences were found between expressed preferences and the sleep–wake diary data from workers. This suggests that sleep–wake habits do not always create chronotypes. The workers (especially evening type workers) examined in Mecacci and Zani's study probably followed their sleep–wake time preferences only during the weekend or days off.

In the future, to clarify the relationship between sleep–wake habits and chronotypes, it will be necessary to compare the two types under isolated conditions and to investigate how the phases of circadian rhythms (e.g., body temperature and alertness)

and sleep–wake behavior change with development or aging. There may possibly be a critical period that determines the phase of circadian rhythm in some stage of development.

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