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Validity of Subjective Reports of Sleep Latency in Normal Subjects

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The validity of subjective reports of sleep latency was tested in 28 normal subjects aged 20 to 55 yr who answered a general questionnaire about their sleep habits, described their sleep latency at home in a series of daily reports, and also slept in the laboratory for 3 to 12 nights each enabling objective measurements of their sleep latency to be made from the electro encephalogram. The geometric mean of the log-normally distributed sleep latencies for all 118 nights in the laboratory was 12·7 min, measured objectively, and was 13·3 min reported subjectively. After adapting to the laboratory, the mean subjective latency for each subject was highly correlated with ($r = 0{\cdot}6$ to $0{\cdot}8$) and was not significantly different from either the mean objective latency in the laboratory or the subjective latency at home. The results indicate that subjective reports of habitual sleep latency are valid as well as reasonably reliable and accurate for groups of normal subjects, but are not very accurate for individual subjects.

1. Introduction

The subjective reports of various groups of subjects have been used in the past to describe their habitual patterns of sleep and wakefulness. Two different methods have been adopted for collecting such data—a sleep questionnaire answered once about sleep habits in general (McGhie and Russell 1962, Johns *et al.* 1971) and a sleep-log or series of daily reports about sleep on particular nights (*e.g.*, Tune 1969). By comparison, other investigations of sleep habits in which the electroencephalogram (EEG) is recorded throughout the night in the laboratory may be more accurate than subjective reports in describing sleep on particular nights but are much more time-consuming, expensive and laborious.

Habitual sleep latency, or the usual delay before falling asleep at night, is an important aspect of a subject's sleep habits (Johns *et al.* 1974, Johns 1975 a). It has been reported previously that subjective reports made by normal subjects of their sleep latency on particular nights in the laboratory are related significantly to the corresponding objective measurements derived from EEG recordings (Lewis 1969, Baekeland and Hoy 1971, Johns 1975 b). However, the reports of insomniacs often overestimate their objective latencies (Monroe 1967, Frankel *et al.* 1973). The present investigation was concerned with the validity and to some extent also the reliability of subjective reports of habitual sleep latency in normal subjects using (*a*) a general sleep questionnaire, and (*b*) a series of daily reports about sleep at home and in the laboratory where their sleep was also recorded objectively by means of the EEG.

2. Method

2.1. *Subjects and Laboratory Procedures*

All subjects were healthy, paid volunteers who did not take any medication during the experiment. The numbers who participated in various parts of the investigation, their sex and their ages are shown in Table 1. A total of 28 subjects, aged 20 to 55 yr, slept in the laboratory for 3 to 12 nights each—a total of 118 nights. They came to the laboratory about an hour before their usual bed-time and all-night recordings were made of the EEG (electrode positions C_4–A_1), electrooculogram and, in some

Table 1. The subjects in different phases of the investigation; their age, sex, and number of nights' sleep in the laboratory.

No. and sex	Age (yr)	No. of nights in laboratory	No. of subjects who described their sleep at home: Sleep questionnaire	Daily reports
21 male	20–24	70 (3–11 each)	16	16
2 male	28, 30	7 (3–4 each)	2	2
2 female	26, 35	6 (3 each)	2	1
3 male	43–55	35 (11–12 each)	3	3
Additional Ss				
37 male	20–25	None	37	37

cases, other physiological variables. The subjects slept alone and undisturbed in warm, dark and quiet bedrooms at times that were comparable to their usual times of sleeping at home. The objective sleep latency was taken as the time (to the nearest minute) between lights-out and the appearance of the first spindle in the EEG of stage 2 sleep. In the calculation of the mean sleep latency for each subject in the laboratory the results from the first night were omitted because sleep was often unusually disturbed, as in the 'first-night effect' described by Agnew *et al.* (1966).

Another 37 healthy young men (called additional subjects) did not sleep in the laboratory but gave subjective reports of their sleep at home (see below).

2.2. *Sleep Questionnaire*

Twenty-three of the 28 subjects who slept in the laboratory and all 37 additional subjects answered a general sleep questionnaire which referred to their usual sleep at home during the preceding few weeks (Johns *et al.* 1971). One question asked "How long after putting the light out does it usually take you to fall asleep at night on week-nights?". Answers were written in hours and minutes and were later converted to minutes where necessary.

2.3. *Daily Sleep Reports*

Each morning after sleeping in the laboratory the subjects responded in writing to another brief questionnaire about the previous night's sleep. One question asked "How long did it take you to fall asleep last night?". The questions were answered without discussion and without the subjects' knowledge of the results of any of the objective measurements. Twenty-two of the 28 subjects and all 37 additional subjects also gave daily reports about 3 to 11 nights' sleep at home over periods which varied from 3 nights to 3 weeks. The particular nights referred to were either during the 2 weeks before sleeping in the laboratory (4 subjects) or at times which varied between 6 weeks and 7 months later.

2.4. *Statistical Methods*

The frequency distribution of sleep latencies was skewed to the right and was normalised by $\log_e$ *transformation.* Thus, the mean latency for each subject, measured objectively or reported subjectively, was calculated as the geometric mean, in minutes, rather than the arithmetic mean. Comparisons between the $\log_e$-transformed subjective and objective sleep latencies under different circumstances were made by means of *product-moment correlation coefficients* and *linear regression* with *analysis of variance. Student's t-tests* for paired differences were performed on untransformed data, accepting $p < 0{\cdot}05$ as significant in 2-tailed tests.

3. Results

3.1. *Subjective vs Objective Sleep Latencies in the Laboratory*

The log-normal frequency distribution of 118 objective sleep latencies in 28 subjects is shown in Figure 1. Individual latencies varied from 2 to 186 min. The geometric

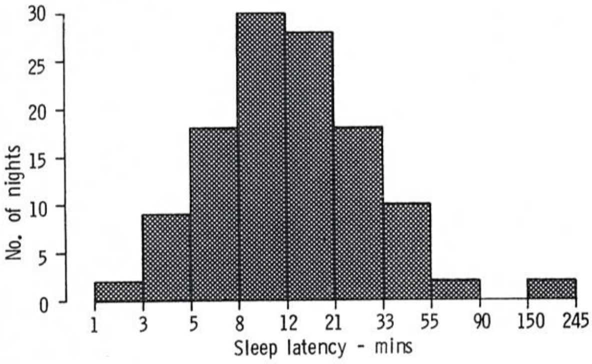

Figure 1. Frequency distribution for sleep latencies on 118 nights in 28 subjects. Note the logarithmic scale.

Table 2. Sleep latencies measured objectively and reported subjectively, and comparisons between them

Sleep latency:	n	Geometric mean (min)	Comparisons	Correlation r	p	Mean ± S.D. of differences (min)	p*
(*a*) measured objectively in lab. each night	118	12·7					
(*b*) reported subjectively in lab. each morning	118	13·3	*a–b*	0·69	<0·001	1·0 ± 12·1	>0·3
(*c*) measured objectively on 2nd night in lab.	28	13·2					
(*d*) measured objectively on 3rd night in lab.	28	10·7	*c–d*	0·61	<0·001	5·5 ± 23·0	>0·2
(*e*) reported subjectively about 3rd night in lab.	28	10·2	*d–e*	0·72	<0·001	0·1 ± 8·4	>0·9
(*f*) mean of objective latencies after 1st night in lab.	28	11·5	*f–g*	0·83	<0·001	0·1 ± 7·1	>0·9
(*g*) mean of subjective latencies after 1st night in lab.	28	11·5	*g–h*	0·79	<0·001	1·1 ± 10·5	>0·6
(*h*) subjective latency at home–sleep questionnaire	23	10·7	*f–h*	0·73	<0·001	1·2 ± 14·6	>0·6
(*i*) subjective latency at home–mean of daily reports	22	9·9	*f–i*	0·60	<0·005	4·3 ± 14·6	>0·1
			g–i	0·59	<0·01	4·0 ± 10·7	>0·05
			h–i	0·80	<0·001	2·9 ± 7·1	>0·05
Additional subjects							
(*j*) subjective latency at home–sleep questionnaire	37	15·2					
(*k*) subjective latency at home–mean of daily reports	37	13·4	*j–k*	0·73	<0·001	0·6 ± 12·3	>0·7

* Degrees of freedom = $n - 1$; 2-tailed t-test for paired observations

mean was 12·7 min and both the median and the mode were 12 min. By contrast the arithmetic mean was 18·7 min.

There was a highly significant correlation between the subjectively reported and objectively measured sleep latency for each night ($r = 0{\cdot}69$). Sometimes there were relatively large differences between these two measurements, as indicated by the standard deviation of the differences between them, which was 12·1 min. Nevertheless, the overall mean difference between them was only 1 min and was not statistically significant (Table 2, *a–b*).

On several occasions subjects woke up within 5 to 10 min of falling asleep initially. They were apparently unaware of having been asleep for those few minutes, for their subjective reports of sleep latency corresponded more closely to the total delay before 'finally' going to sleep than to the shorter delay before dozing initially.

For each subject, the geometric mean subjective latency after the first night in the laboratory was significantly related to the mean objective latency for the same nights ($r = 0{\cdot}83$; Table 2, *f-g*). This relationship is shown in Figure 2 with logarithmic

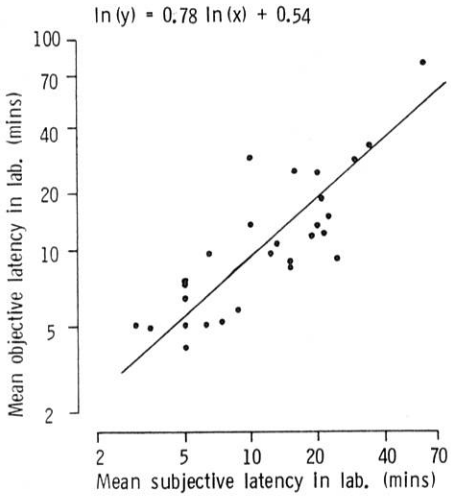

Figure 2. Relationship, in 28 subjects, between the mean of objective sleep latencies measured in the laboratory after the first night and the mean of subjective latencies for the same nights.

scales. The regression coefficient (0·78) was significantly less than 1·0 and the intercept (0·54) was significantly different from zero. Thus, there was a slight, but statistically significant tendency for relatively long objective latencies to be overestimated subjectively whereas short latencies tended to be underestimated. Assuming that the mean of objective latencies after the first night in the laboratory was a 'correct' measurement of habitual sleep latency for each subject, then the range of 'errors' involved with their individual subjective estimates can be measured by the standard deviation of the differences between the corresponding objective and subjective measurements, which was 7·1 min. For the whole group of subjects, the overall mean objective latency after the first night in the laboratory was the same as the mean of the corresponding subjective latencies, 11·5 min.

The relationship between the objective latencies on the second and third nights in each subject ($r = 0{\cdot}61$; Table 2, *c–d*) gives a measure of the reliability of such measurements on a single night. By comparison, there was a closer relationship between the subjective and objective latencies for the same night ($r = 0{\cdot}72$; Table 2, *d–e*) than there was between the objective latencies on successive nights.

3.2. *Subjective Latencies at Home vs Laboratory*

The habitual subjective latencies when at home, reported either in the sleep questionnaire or derived from a series of daily reports, were not significantly different from, and also were highly correlated with, the mean subjective latencies after the first night in the laboratory (Table 2, *g–h*, *g–i*). This suggests that the majority of subjects adapted to the laboratory situation and then felt that they fell asleep as quickly as they would have at home.

Figure 3 shows the relationship between the habitual subjective latency at home, as reported in the sleep questionnaire, versus the mean subjective latency derived from a series of daily reports, also when at home but at a different time of the year ($r = 0{\cdot}80$). There was a very similar relationship between these two variables in the 37 additional subjects ($r = 0{\cdot}73$; $\ln(y) = 0{\cdot}96 \ln(x) - 0{\cdot}03$). In this case the regression coefficient

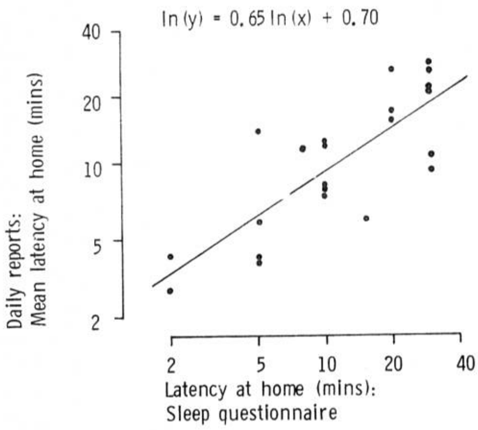

Figure 3. Relationship, in 22 subjects, between the mean of subjective sleep latencies reported daily at home and the usual latency at home reported in a general sleep questionnaire.

was not significantly different from 1·0, nor the intercept different from zero. Thus, both methods of measuring subjective latency (the sleep questionnaire and a series of daily reports) apparently give reasonably reliable estimates of a subject's usual sleep latency at home, and this does not change markedly over a period of several months in normal subjects.

3.3. *Subjective Latencies at Home vs Objective Latencies in the Laboratory*

The mean objective latency after the first night in the laboratory was correlated significantly, on the one hand, with the habitual subjective latency at home as reported in the sleep questionnaire ($r = 0{\cdot}73$; Table 2, *f–h*) and, on the other hand, with the mean subjective latency derived from the series of daily reports at home ($r = 0{\cdot}60$; Table 2, *f–i*). In addition, the mean differences between each of these subjective latencies and the objective latencies in the laboratory were only 3 or 4 min and were not statistically significant (Table 2, *f–h*, *f–i*). However, in each of these relationships (Figure 4) the regression coefficient was significantly less than 1·0 and the intercept was positive and statistically significant. The tendencies to underestimate subjectively

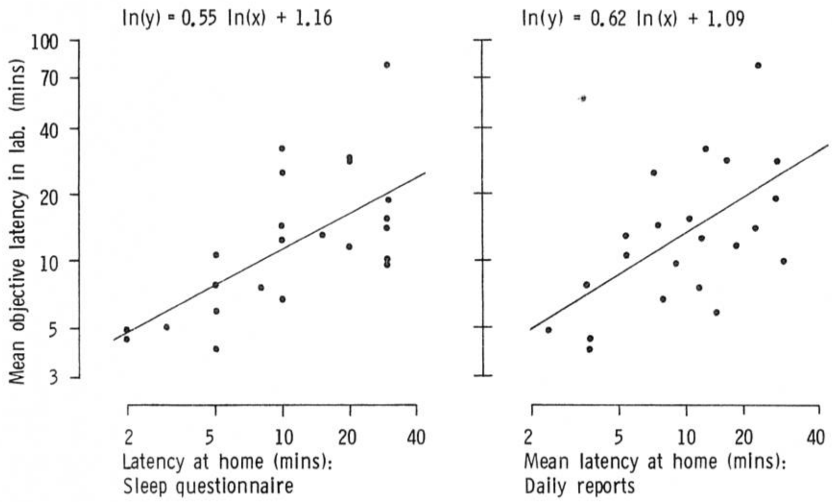

Figure 4. Relationships, in 23 and 22 subjects respectively, between the mean objective sleep latency in the laboratory after the first night and (left) the usual latency at home reported in a general sleep questionnaire, and (right) the mean subjective latency over a series of different nights at home.

the very short objective latencies and to overestimate the longer latencies were presumably present in these reports about sleep at home, as reported in section 3.1 about sleep in the laboratory.

Nevertheless, the results demonstrate that, within the limitation of accuracy, these subjects were able to give valid and reasonably reliable subjective estimates of how long it usually takes them to fall asleep at night.

4. Discussion

The results enable some conclusions to be arrived at about the measurement of sleep latencies, in normal subjects at least. Sleep latencies are log-normally distributed and so the geometric mean is a more appropriate measure for a group of observations than is the arithmetric mean which has been used in the past.

The subjective latency reported after a particular night's sleep in the laboratory may differ considerably from the objective latency measured by means of the EEG but the two measurements are significantly correlated with each other over a series of nights. Similar findings have been reported previously (Lewis 1969, Baekeland and Hoy 1971, Thornby *et al.* 1974). The tendency for normal subjects who have relatively long sleep latencies (of the order of 30 min) to report slightly longer subjective latencies would be consistent with reports that insomniacs usually overestimate their sleep latency in the laboratory (Monroe 1967, Bixler *et al.* 1973). The subjective latency depends on the subject's ability to estimate time intervals, and this is known to be influenced by several factors, including personality (Orme 1962). However, it appears that not all discrepancies between objective and subjective latencies are due to the inaccuracy of subjective time estimation. As reported previously (Johns 1975 b), the subjective latency sometimes includes brief periods of sleep of which the subject is not aware. Agnew and Webb (1972) have also described the inability of some subjects to discriminate brief periods of sleep from wakefulness. This may explain in part why insomniacs often report much longer sleep latencies than are measured objectively. Perhaps objective measurements of sleep latency should also disregard brief periods of sleep which precede the onset of a more prolonged period of uninterrupted sleep.

If it is assumed that objective measurements of sleep latency as made in this investigation are accurate, then subjective reports are relatively inaccurate and are frequently in error by 50% or more for a particular night or for an individual subject. Nevertheless, for a group of normal subjects, the overall mean subjective latency is the same as the mean objective latency over a series of nights, which suggests that the subjective reports are both valid and accurate for group data as well as being relatively easy to collect.

The sleep latency of normal subjects varies to some extent from night to night so that even the 'accurate' measurements based on the EEG are not highly reliable as predictors of the latency on another night (Agnew and Webb 1971, Moses *et al.* 1972, Clausen *et al.* 1974). Hence the need to record for several nights when measuring habitual sleep latency. Such measurements may be less reliable again in insomniacs whose sleep tends to be more variable than that of normal subjects (Karacan *et al.* 1973). By contrast, the present results are consistent with previous reports of high reliability (r approx 0·8) with answers to a question about sleep latency in a questionnaire given to normal subjects under test–retest conditions over a period of several weeks or months (Webb and Stone 1963, Haynes *et al.* 1974). The results add weight to investigations which have indicated that differences in subjective sleep latency were related to age and to personality in normal subjects (Johns *et al.* 1970, 1974).

The results also demonstrate that both subjective methods of estimating habitual sleep latency (a sleep questionnaire and a series of daily reports) are about equally valid and accurate. Furthermore, it is reassuring of sleep-laboratory studies, at least with normal subjects, that their sleep latencies in the laboratory, after the first night or two to adapt to the recording situation, are very similar to their latencies when sleeping at home. It must not be implied, however, that subjective reports about other aspects of sleep habits, particularly the fragmentation of sleep by awakenings during the night, are as reliable, as accurate or valid as are reports of sleep latency; nor that sleep in the laboratory is fragmented no more than that at home. Indeed, there is evidence to the contrary (White 1975, Johns and Doré 1976).

The choice of methods for investigating sleep habits should be made with the realisation that all available methods have limitations but that the subjects' own reports may have an important role to play, especially since they enable large groups to be studied relatively easily.

La validité des jugements subjectifs des délais d'endormissement a été éprouvée chez 28 sujets normaux agés entre 20 et 55 ans. Ceux-ci devaient répondre à un questionnaire portant sur leurs habitudes de sommeil et leurs délais d'endormissement dans les conditions normales de vie. Ces sujets dormaient également au laboratoire pendant 3 à 12 nuits au cours desquelles on objectivait leurs délais d'endormissement au moyen de l'enregistrement de l'EEG. La moyenne géométrique des latences d'endormissement distribuées selon une loi log-normale pour les 118 nuits enregistrées en laboratoire était de 12,7 mn, alors que l'évaluation subjective fournissait une moyenne de 13,3 mn. Après l'adaptation au laboratoire, la latence moyenne subjective pour chaque sujet était fortement corrélée avec la moyenne objective (r = 0,6 à 0,8) relevée au laboratoire ou estimée in situ. Les différences entre ces moyennes n'étaient pas non plus significatives. Ces résultats montrent que les estimations subjectives concernant les délais d'endormissement sont valides, fidèles et précises pour des groupes de sujets normaux, mais ne sont pas très précises pour des sujets pris individuellement.

Es wurde die Validität von sujektiven Berichten der Schlaf-Latenzen (Verzögerungszeiten vor dem Einschlafen) bei 28 'normalen' Versuchspersonen im Alter von 20 bis 55 Jahren gemessen. Sie beantworteten einen Fragebogen über ihre Schlafgewohnheiten, dann beschrieben sie ihren Schlaf zuhause in Tagesberichten, darauf schliefen sie dann im Laboratorium für 3 bis 12 Nächte, um objektive Meßdaten über ihre Schlaf-Latenzzeiten zu erhalten. Die Daten wurden mit dem Elektroencephalogramm (EEG) gemessen. Das geometrische Mittel der Meßdaten, die sich für die Schalflatenzen für alle 118 Nächte im

Laboratorium normal verteilten, war 12, 7 min bei Messung im EEG und 13,3 min bei subjektiven Berichten. Nachdem sich die Vpn im Laboratorium adaptiert hatten, korrelierte die mittlere subjektive Latenz für jede Vp hoch ($r = 0{\cdot}6$–$0{\cdot}8$) und war nicht signifikant verschieden, weder von der mittleren objektiven Latenz im Laboratorium, noch von der subjektiven Latenz zuhause. Die Ergebnisse zeigen, daß subjektive Berichte von gewöhnlichen Schlaf-Latenzzeiten valide sind und auch einigermaßen reliabel und genau für Gruppen normaler Vpn, aber nicht sehr genau für besondere Vpn.

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