

Factor analysis of subjectively reported sleep habits, and the nature of insomnia

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SYNOPSIS Factor analysis was performed on variables used to describe subjectively the sleep habits of three groups of subjects—male patients, female patients, and medical students. Similarities in the six factors from each analysis indicate the existence of dimensions of variation which are common to normal sleep habits and insomnia.

Insomnia is one of the most common disorders which doctors are asked to treat, yet surprisingly little is known about it. Treatment (which often means the prescription of hypnotic drugs) is usually instigated upon the basis of patients' complaints and descriptions of their sleep habits, not upon the results of objective study in the sleep laboratory. Thus, there is good reason to include subjective reports among the methods for studying sleep and insomnia—and this despite the inaccuracies which may be involved in some people's estimates, for example, of the time which they take to fall asleep or the duration of a period of wakefulness during the night (Lewis, 1969; Johns, 1971).

In an investigation which has been described previously (Johns *et al.*, 1970) a sleep questionnaire was used to study differences in the sleep habits of male medical and surgical patients, and to relate those differences to the age and symptoms of each patient. A comparable investigation among female patients yielded similar results (Goodyear *et al.*, 1971). The responses of healthy young adults to the same sleep questionnaire have also been described and product-moment correlation coefficients used to demonstrate relationships between 11 of the variables (Johns *et al.*, 1971a). Longer-than-average delays before

falling asleep were associated statistically with more time being spent awake during the night, with less sleep being obtained at night, and with a subjective feeling of having low quality sleep. These are all characteristics of so-called 'poor' sleep, which has been shown in young adults to be associated with increased adrenocortical activity during the day and night, with objective differences in their sleep measured in the laboratory, and with the presence of certain psychological disturbances (Monroe, 1967; Johns *et al.*, 1971b; Goodyear, 1973).

However, in the investigations cited above and others (Weiss *et al.*, 1962; McGhie, 1966; Ward, 1968; Baekeland and Hartmann, 1971), it has been clear that not all of these characteristics of 'poor' sleep or insomnia are equally prominent in different subjects. Some have difficulty in falling asleep initially, others have more difficulty in staying asleep, and a few wake up early in the morning and are unable to return to sleep. However, most subjects suffer from more than one type of disturbance and, notwithstanding some earlier teaching to the contrary, the type of insomnia is not closely related to particular psychiatric diagnoses (Hawkins and Mendels, 1966; Ward, 1968; Kupfer *et al.*, 1970). The aim of the present investigation was to elucidate further the interrelations between many of the variables which have been used to describe normal sleep habits and insomnia subjectively.

Factor analysis is a technique which is suited to this task because it enables a large number of variables, many of which are interrelated, to be

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reduced to a smaller number of mutually independent factors defined in terms of the original variables (Harman, 1967). Strictly, the factors apply only to the data used in the particular analysis. However, if similar factors are present in data from several different groups of subjects then, by inference, those factors probably apply to the general population. It seems that the only factor analysis of sleep habits reported previously was that of Detre (1966) who studied psychiatric patients.

In the present investigation, factor analysis of subjectively reported sleep habits was performed for three separate groups of subjects—104 medical students who were all about 23 years of age, 100 male patients and 119 female patients whose ages ranged from 15 to 80 years and who were seen in medical and surgical wards of a general hospital. Judging from the proportion of subjects who gave reports of difficulty in falling asleep, of waking up during the night, or of taking hypnotic drugs at least occasionally, approximately 30% of all the male patients, 40% of the female patients, and 10% of the medical students suffered from some form of insomnia (Johns *et al.*, 1970, 1971a; 1971c; Goodyear *et al.*, 1971). Similarities in the results of factor analysis from each of these groups enable some general comments to be made about sleep habits and insomnia.

METHODS

Methods for the selection of subjects and their age distributions have been described previously for both the medical students and the male patients (Johns *et al.*, 1970; 1971a): those for the female patients were similar to the latter. The sleep questionnaire sought information about each subject's usual pattern of sleep and wakefulness during the preceding few weeks at home. Parameters such as the usual duration of sleep at night, the delay before falling asleep, and the total time spent in bed at night were calculated in hours per week rather than hours per day, thereby allowing for fairly consistent differences between weeknights and weekends. (Johns *et al.*, 1971a). The frequencies with which subjects had difficulty in falling asleep or had nightmares were reported as 'frequently', 'occasionally', or 'very seldom, never' in the questionnaire, but were scored as 3, 2, or 1 in the computer calculations necessary for factor analysis. Principal components analysis (a first step in factor analysis) was performed

on 18 variables used to describe the sleep habits and age of the male and female patients, as shown in the Table. However, the students' ages did not cover a sufficiently wide range, nor was their use of hypnotic drugs frequent enough to include these two variables in the third factor analysis, for which there were 16 variables (Table). The difficulty in and delay before falling asleep at night, the frequency and total duration of awakenings during the night, and the time between waking and getting out of bed in the morning were all treated as separate variables in this investigation, unlike the earlier one for the male patients (Johns *et al.*, 1970).

As is common practice, those factors were retained which corresponded to eigenvalues greater than 1.0 (Kaiser, 1960). Varimax rotation of the factor loadings facilitated their interpretation in terms of the original variables. Only those rotated factor loadings of 0.32 or higher were retained, according to the method for estimating their standard error suggested by Harman (1967). The computations were carried out on a CDC 3200 computer using the programme of Cooley and Lohnes (1962) modified by the present author.

RESULTS

The results are shown in the Table, in which the factor loadings of the 'significant' variables (after varimax rotation) are given for six factors derived from each of the three analyses. These factors accounted for a total of approximately 75% of the variance in the original data from each group of subjects. There were close similarities, on the one hand, between the results for male and female patients and, on the other hand, between those for female patients and medical students.

The first factor for both male and female patients (accounting for approximately one quarter of the original variance in both groups) was based on a combination of difficulty in falling asleep, of waking during the night and obtaining reduced amounts of sleep of low quality. This general factor of sleep disturbance was independent of the subject's age and was related to the use of hypnotic drugs by male but not by female patients. In the male patients there was an additional, small component of night awakenings which increased with age and was associated with increased amounts of sleep during the day. In the female patients there was a second component of difficulty in falling asleep which was related to their age and use of hypnotic drugs.

TABLE

VARIMAX ROTATED FACTOR LOADINGS AND PROPORTION OF DATA VARIANCE ASSOCIATED WITH EACH OF SIX FACTORS FOR MALE PATIENTS, FEMALE PATIENTS, AND MEDICAL STUDENTS*

Variable	Factors																	
	Male patients						Female patients						Medical students					
	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
Time of going to bed on weeknights			-.92						-.89						-.76	-.47		
on weekends			-.81						-.85						-.43	-.37	-.53	
Delay before falling asleep	.83					.51					.58							.89
Frequency of difficulty in falling asleep	.88					.33					.71							.81
No. of nights with awakenings per week	.59				.43	.72							.92					
No. of awakenings per night	.51				.48	.83							.87					
Total duration of night awakenings	.67			.32		.88							.82					
Time of finally waking on weekdays		-.90							-.85						-.79			
on weekends		-.82							-.87						-.80			
Time between waking and getting up on weekdays				.81						.89							.75	
on weekends				.86						.90							.80	
Total amount of time spent in bed at night		-.72	.48	.36			.77	-.49	.35				.89					
Total duration of sleep at night	-.46	-.78					-.63	.56	-.33				.92					
during day					.87							.83	-.40					
Quality of sleep	-.46					-.50	.47				-.57						-.63	-.47
Frequency of disturbing dreams or nightmares						-.87	.33					.43						.89
Use of hypnotic drugs	.75										.79		—	—	—	—	—	—
Age		.45			.60		.32	.55	.52				—	—	—	—	—	—
Percentage of data variance associated with each factor	29.1	14.9	11.2	9.7	5.9	5.7	24.5	16.8	14.2	7.2	6.7	6.3	22.8	16.0	11.5	9.9	8.2	6.6

* Only those factor loadings greater than 0.32 are shown.

In the more homogeneous group of medical students, difficulty in falling asleep and night awakenings formed the bases of separate factors. Thus, there is evidence that 'good-poor' sleep, when defined in terms of the variables used here, has more than one component; and this is

supported by the finding that reports of the subjective quality of sleep had more than one component in all groups of subjects.

The times of going to bed at night, both on weekdays and on weekends, and the total amount of time spent in bed at night formed the basis of

a factor which was similar for all three groups of subjects. This is consistent with an earlier finding that people who go to bed relatively late on weekdays do so at weekends too, despite a considerable difference in the actual times involved (Johns *et al.*, 1970a). The times of waking up in the morning were independent, to some extent, of the times of going to bed at night. However, among the medical students, there was a second component of the variation in their usual times of going to bed which was related to their times of waking up next morning. Thus, of the students who went to bed early at night, some, who thereby spent longer than average in bed and asleep, could be called 'long' sleepers. Others, who woke up early next morning, could be called 'early' sleepers.

Although the total amount of sleep obtained at night was influenced to some extent by sleep disturbance, other factors were more important, especially among the students. Thus, the amount of sleep obtained, within the limits observed here, was not by itself a useful measure of sleep disturbance.

The usual delay between waking and getting out of bed in the mornings (both on weekdays and weekends) formed the basis of a factor which was similar in all three groups of subjects. Estimation of this delay was intended to provide an indication of early morning awakening—that is, of one aspect of sleep disturbance. However, it is uncertain to what extent the variations observed between subjects were caused by insomnia.

The frequency with which hypnotic drugs were taken by male patients was related to their general factor of sleep disturbance. By contrast, the use of hypnotic drugs by female patients was related to that component of difficulty in falling asleep which increased with age. Nightmares formed the basis of a separate factor in each group of subjects.

DISCUSSION

It is difficult to compare the results of factor analysis in different populations. Nevertheless, the finding of similar factors within the sleep habits of three separate groups of subjects whose ages varied widely, who had different occupations as well as varying degrees and types of

physical and psychological disorder, suggests that such factors or dimensions may be applicable generally to the measurement both of normal variations in sleep habits and of different degrees of insomnia—the difference between these may be mainly quantitative rather than qualitative.

This idea is supported by comparison of the present results with those of an earlier factor analysis of sleep habits reported in terms of 11 variables by psychiatric patients of different ages, both sexes, and various diagnostic categories (Detre, 1966).

Among the male and female patients of the present investigation and the psychiatric patients of Detre there was good evidence for the existence of a general dimension of 'poor' sleep which included difficulty in falling asleep, awakenings during the night, and a feeling of having poor quality sleep.

A possible explanation for the occurrence of this 'poor' sleep is provided by the concept of hyperactivation of the arousal-promoting neuronal systems in the central nervous system (particularly the ascending reticular activating system and the limbic system) which oppose the effects of sleep-promoting systems (Jouvet, 1967). There is evidence that this hyperactivation is commonly associated with, and perhaps caused by, emotional involvement in daily life and particularly in mental conflicts, whether or not they reach consciousness (Monroe, 1967; Rechtschaffen and Monroe, 1969; Johns *et al.*, 1971b).

Nevertheless, we must explain the finding in the present investigation of secondary components of the difficulty in falling asleep and of awakening during the night which were not simply related to the main factor of 'poor' sleep. Among both the male and the female patients these additional components were related to the subject's age.

Ischaemic heart disease and prostatomegaly causing nocturia, all of which increase with age, may be contributory causes of this secondary component of 'poor' sleep, mediated presumably by an increase in the frequency of afferent impulses to the reticular formation from stretch receptors in the bladder wall and from the pulmonary vasculature at various times during the night (Johns *et al.*, 1970). However, the secondary component of 'poor' sleep could also

be caused by degenerative changes within the central nervous system which continue gradually throughout adult life and accelerate in old age, reducing the capacity of sleep-promoting neuronal systems to sustain sleep actively for many hours at a time. Feinberg and Carlson (1968) described a relationship between the rate of cerebral oxygen uptake and changes in sleep at various ages which is consistent with this explanation.

Neither degenerative changes in the central nervous system nor other physical illnesses were present in the medical students of this investigation to explain why their difficulty in falling asleep and awakenings during the night formed the bases of two separate factors of sleep habits rather than one general factor of 'poor' sleep. Perhaps this is one of the vicissitudes inherent in factor analysis. However, another possible explanation may be derived from a recent study of psychological correlates of differences in the sleep habits reported by this same group of medical students (Johns *et al.*, 1974). Long delays before falling asleep were significantly correlated with a tendency to worry excessively and to be pessimistic and self-doubting, as determined from scores on various scales of the Minnesota Multiphasic Personality Inventory. By contrast, awakenings during the night were correlated both with the denial of having difficulties or emotional distress in daily life and with complaints of bodily symptoms such as feeling weak and having dizzy spells.

It has been suggested (Johns *et al.*, 1974) that some people who have psychological disturbances are usually able to control, albeit unconsciously, the level of their emotional involvement in those disturbances. When such people go to bed they are able to inhibit mental activity, thereby falling asleep quickly. However, the mental activity which goes on in various forms during the night (not only during dreams) may be less well controlled, or at least controlled differently, from that of wakefulness (Rechtschaffen and Monroe, 1969). I suggest that the emotional concomitants of this mental activity may activate the arousal-promoting systems of the central nervous system and hence produce periods of wakefulness during the night. Whether a particular person has difficulty in falling asleep or in staying asleep or both may depend not only on the existence of mental

conflicts but also on the efficiency with which most mental activity tends to be controlled by psychological defence mechanisms during wakefulness as well as during sleep. The mental conflicts of which nightmares are thought to be a manifestation (Hersen, 1971; Johns *et al.*, 1974) are presumably under control for much of the time because they do not necessarily produce either difficulty in falling asleep or much loss of sleep because of frequent night awakenings.

CONCLUSIONS

With the proviso that to demonstrate an association, for example, between psychological disorders and 'poor' sleep is not to prove the existence of a cause and effect relationship between them, some tentative conclusions may be drawn about several independent dimensions along which variations both in normal sleep habits and degrees of insomnia can be measured. Other dimensions may be apparent if additional variables were to be used to describe sleep habits, especially the relative proportions of the various stages of sleep measured in the laboratory.

Within a group of adult subjects there are differences of sleep habits along a dimension which could be called 'the time of sleeping'—that is, the usual times of the night when sleep is obtained—rather than its duration. These variations are most prominent among young adults, such as medical students of the present investigation in whom 'early' and 'late' sleepers have been shown to have different personality characteristics, relating probably to extraversion (Johns *et al.*, 1974). The time of sleeping may also influence and in turn be influenced by circadian rhythms such as that of body temperature (Östberg, 1973).

Other differences in sleep habits occur along a dimension of 'sleep duration'—how much sleep is usually obtained. These differences are influenced to some extent by delays before falling asleep and by awakening during the night but, more importantly, by the total amount of time spent in bed. What determines whether a subject shall be a 'long' or a 'short' sleeper is uncertain. Some psychological differences have been described (Hartmann *et al.*, 1972) but have not been confirmed in other studies (Webb and Friel, 1971; Johns *et al.*, 1974).

There are probably three dimensions of the 'quality' of sleep, the first of which seems to reflect long-term differences in the level of activation of the central nervous system. This major dimension includes difficulty both in falling asleep and in staying asleep, the varying proportions of which may reflect differences in the extent to which the emotional concomitants of mental activity are usually experienced or controlled during wakefulness and sleep. A second dimension of sleep 'quality' may be caused by stimulation of pain and stretch receptors as a result of chronic physical disorders. In addition, this second dimension of sleep 'quality' may be a manifestation of degenerative changes in the central nervous system which cause a reduction in the capacity of sleep-promoting neuronal systems to initiate and sustain sleep with increasing age. A third dimension of sleep quality is based on the frequency of nightmares and disturbing dreams.

Differences in the amount of time spent lying in bed after waking in the morning form yet another dimension of sleep habits which is probably related to the symptom of early morning awakening, but the relationship of the latter to 'poor' sleep remains uncertain. Sleep during the day is mainly a compensation for staying up late and having reduced amounts of sleep at night, but other influences may also be present, especially in the elderly.

Factor analysis in other populations will be necessary before the present findings and tentative explanations about sleep habits and insomnia can be applied more widely with confidence.

Sleep questionnaires were distributed to the male patients by Dr. P. Egan and to the female patients by Dr. M. D. E. Goodyear.

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