

## Factor analysis of analogue scales measuring subjective feelings before and after sleep

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The measurement of subjective mood and feelings is becoming increasingly important; for example, in the study of psychiatric illness, or the effects of environmental changes or drugs (Lader & Wing, 1966; Thayer, 1967; Aitken & Zealley, 1970; Lader & Marks, 1971; Barton & Cattell, 1974).

At present, the two most commonly used methods involve the use of adjective check lists (ACLs) (e.g. Nowlis, 1960, 1965) or visual analogue rating scales (VASs). In the latter, the subject makes a mark across a horizontal line at a position which indicates how he feels at the time in relation to two words, such as 'alert' and 'drowsy', which define the extremes of a bipolar scale. VASs have been advocated particularly by Aitken and his colleagues (Aitken, Southwell & Wilmschurst, 1965; Zeally & Aitken, 1969; Aitken, 1970). Since each subject places himself appropriately along the dimensions, the problems of unequal category widths and failure to grasp nuances of feeling may be overcome, at least in part (Aitken, 1969).

A series of 16 VASs was devised by Norris (1971) and classified rather intuitively into four groups of feelings called 'mental sedation', 'physical sedation', 'tranquillization' and 'others'. However, factor analysis of scores from these 16 VASs by Bond & Lader (1974) produced only three factors, which overlapped but did not correspond exactly with Norris's grouping. Bond & Lader called their factors 'alertness', 'contentedness' and 'calmness', and they were able to demonstrate an effect of hypnosedative drugs on the scores for their second and third factors.

We have used a series of 18 VASs (including the 16 scales used by Norris) in four experiments concerned with measuring the quality of sleep. We report here the results of factor analysis of the scores on those VASs. Factor scores from this analysis were used to compare mood and feelings before and after a night's sleep, with or without purposeful disturbance of that sleep. Scores for the 'deactivation' part of Nowlis's ACL (Nowlis, 1960) were available for comparison with the other results in two of the experiments.

### METHODS

A total of 38 healthy volunteers, 35 male and 3 female, took part in 4 experiments as summarized in Table 1. Each subject marked the VASs 2 to 4 times per day for periods of 5-22 days. In Expt. I, the subjects filled in the forms before and after sleep regardless of whether this was in the laboratory (12 week-nights) or at home (mainly weekends). Subjects in Expts. II and III also completed Nowlis's ACL just before the VASs. A comprehensive report of mood changes as a function of disturbed sleep will be presented elsewhere in due course.

The VASs are shown in Table 2. Scales 1-16 were the same as Norris's, except that the word 'amicable' (Scale 14) was replaced by 'friendly', and 'gregarious' (Scale 16) by 'sociable'. Scales 17 and 18 were added on the basis of dimensions described in the factor analysis of Nowlis's ACL.

The horizontal line for each VAS was 100 mm long in Expts. II, III and IV but was (unintentionally) 116 mm long in Expt. I. Scores from the latter were scaled down so that all the results could be pooled. To

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Table 1. *Summary of conditions in the four experiments*

Experiment no.	No. Ss	Age range	No. nights per S	Environmental disturbance	VAS completed	Nowlis's ACL completed
I	4	24-55	16-22	None	Half hour before sleep, half hour after sleep	No
II	10	18-35	5	One night of noise	Immediately before and after sleep	Yes*
III	12	17-28	6	Two nights of heat	Immediately before and after sleep and at 09.50 and 14.50	Yes†
IV	12	17-23	6	Two nights of awakenings	Immediately before and after sleep and at 09.50 and 14.50	No

\* Subjects were instructed to respond initially to each adjective either positively (✓) or negatively (×) and then to indicate the magnitude of this response on a range from 1 to 3.

† Subjects responded in the conventional manner by circling one of 'vv, v, ?, no' to indicate a range from 'extremely' to 'does not apply'.

Table 2. *The series of Visual Analogue Scales (not to scale)*

Scale no.		
1	Alert	Drowsy
2	Calm	Excited
3	Strong	Feeble
4	Muzzy	Clear-headed
5	Well-coordinated	Clumsy
6	Lethargic	Energetic
7	Contented	Discontented
8	Troubled	Tranquil
9	Mentally slow	Quick-witted
10	Tense	Relaxed
11	Attentive	Dreamy
12	Incompetent	Proficient
13	Happy	Sad
14	Antagonistic	Friendly
15	Interested	Bored
16	Withdrawn	Sociable
17	Depressed	Elated
18	Self-centred	Outward-going

prevent response stereotypy, the VASs administered at mid-morning and mid-afternoon had the scales in a different order, and some were reversed from left to right. These were converted to the standard format for further analysis. The raw scores on each scale were derived from the distance (mm) between the subject's mark and the left-hand end of the scale. As with Bond & Lader's (1974) experiment, preliminary analysis of these scores showed that some of the frequency distributions were skewed to the left, some to the right. To overcome this and to ensure that valid comparisons could be drawn with Bond & Lader's results, Scales



Table 3. Mean scores and standard deviations (after  $\log_e$  transformation) for each scale, and the rotated factor matrix

Scale	Mean score	Standard deviation	Rotated factor matrix		Communalities
			Factor 1	Factor 2	
1 Alert/Drowsy	3.675	0.797	0.865	0.232	0.802
2 Calm/Excited	3.055	0.876	0.099	0.798	0.646
3 Strong/Feeble	3.537	0.745	0.793	0.362	0.760
4 Clear-headed/Muzzy	3.519	0.903	0.775	0.392	0.755
5 Well-coordinated/Clumsy	3.457	0.811	0.759	0.442	0.771
6 Energetic/Lethargic	3.749	0.710	0.856	0.221	0.781
7 Contented/Discontented	3.149	0.887	0.398	0.785	0.775
8 Tranquil/Troubled	3.191	0.915	0.260	0.823	0.745
9 Quick-witted/Mentally slow	3.607	0.807	0.878	0.276	0.846
10 Relaxed/Tense	3.130	0.934	0.312	0.782	0.708
11 Attentive/Dreamy	3.671	0.803	0.864	0.284	0.826
12 Proficient/Incompetent	3.518	0.770	0.826	0.360	0.812
13 Happy/Sad	3.127	0.919	0.444	0.744	0.751
14 Friendly/Antagonistic	2.900	1.058	0.331	0.701	0.600
15 Interested/Bored	3.439	0.886	0.539	0.463	0.504
16 Sociable/Withdrawn	3.034	1.077	0.474	0.648	0.644
17 Elated/Depressed	3.571	0.742	0.592	0.543	0.645
18 Outward-going/Self-centred	3.469	0.826	0.591	0.489	0.589

4, 6, 8, 9, 10, 12, 14, 16, 17 and 18 were reversed by subtracting the scores from 100. A few scores of zero were converted to unity and then a  $\log_e$  transformation was performed on all scores.

Principal-components analysis was performed on the VAS scores for 732 cases for all 38 subjects. Separate analyses were also performed on data from each subject in Expt. I (32-45 cases each). As is commonly done, those factors were retained for which eigenvalues were greater than 1.0, and Varimax rotation was carried out in order to simplify the structure of factors (Harmon, 1967). Each factor was defined by including in it the highest factor loading for each scale. Factor scores were calculated for each case. The statistical significance of differences in these scores was tested by the *t* test for paired observations (Winer, 1962).

#### RESULTS

The mean scores and standard deviations for each scale, after  $\log_e$  transformation, are shown in Table 3. The results for Scales 1-16 were similar to those reported by Bond & Lader (1974).

#### Factor analysis

Factor analysis of scores for all 732 cases yielded two factors which accounted for 62 and 10 per cent of the data variance respectively (Tables 3 and 4). Separate analysis, using raw data rather than that which had been  $\log_e$  transformed, produced the same factors. Factor 1 was based mainly on scales related to psychomotor performance (e.g. quick-witted, proficient, attentive, strong) and to a lesser extent on some aspects of subjects' mood at the time (e.g. outward-going, interested).

Factor 2 was based mainly on descriptions of affect (e.g. calm, relaxed, friendly, happy). This factor is a combination of Bond & Lader's second and third factors which they called 'contentedness' and 'calmness' respectively.

The four separate, within-subject factor analyses of VAS scores (Expt. I) yielded 3-5 factors

Table 4. *Extracted factors with loadings after Varimax rotation*

Scales	Rotated factor loadings
<i>Factor 1 (Alertness)</i>	
Quick-witted/Mentally slow	0.878
Alert/Drowsy	0.865
Attentive/Dreamy	0.864
Energetic/Lethargic	0.856
Proficient/Incompetent	0.826
Strong/Feeble	0.793
Clear-headed/Muzzy	0.775
Well-coordinated/Clumsy	0.759
Elated/Depressed	0.592
Outward-going/Self-centred	0.591
Interested/Bored	0.539
<i>Factor 2 (Tranquillity)</i>	
Tranquil/Troubled	0.823
Calm/Excited	0.798
Contented/Discontented	0.785
Relaxed/Tense	0.782
Happy/Sad	0.744
Friendly/Antagonistic	0.701
Sociable/Withdrawn	0.648

in each subject. In all of them, the first factor was the same as Factor 1 described above. In three of the four subjects, the second factor was the same as Factor 2 above. It was only in the fourth subject that Scales 2 and 8 ('calmness' and 'tranquility') formed the bases of two separate factors. The additional, minor factors in these subjects involved various combinations of loadings for Scales 13-18.

#### *Factor scores*

The mean evening and morning scores on Factor 1 in each study appear in Fig. 1. In Expts. II, III and IV there was a statistically significant overnight increase in these scores, indicating lower levels of alertness within a few minutes of awakening in the morning compared with just before 'lights out' the previous night ( $P < 0.01$  in each case). Scores on the 'deactivation' part of the Nowlis's ACL (Expts. 2 and 3) showed a similar change ( $P = 0.02$ , Wilcoxon's test; Siegel, 1956).

In Expt. I, when the subjects slept in the laboratory, there was also a small overnight decrease in alertness, but this was not statistically significant. By contrast, when sleeping at home these subjects reported a significant overnight increase in alertness ( $P < 0.02$ ). The level of alertness in the mornings after sleeping at home was not reliably different from that in the laboratory. However, when sleeping at home, they felt significantly more drowsy than they did when in the laboratory ( $P < 0.01$ ).

Since subjects may go to bed later at weekends (Johns, Egan, Gay & Masterton, 1970) and therefore feel drowsier when completing pre-sleep mood questionnaires, we compared the reported times of going to sleep at home and in the laboratory. They were not significantly different.

It should also be noted that, in the laboratory, the subjects of Expt. I reported lower levels



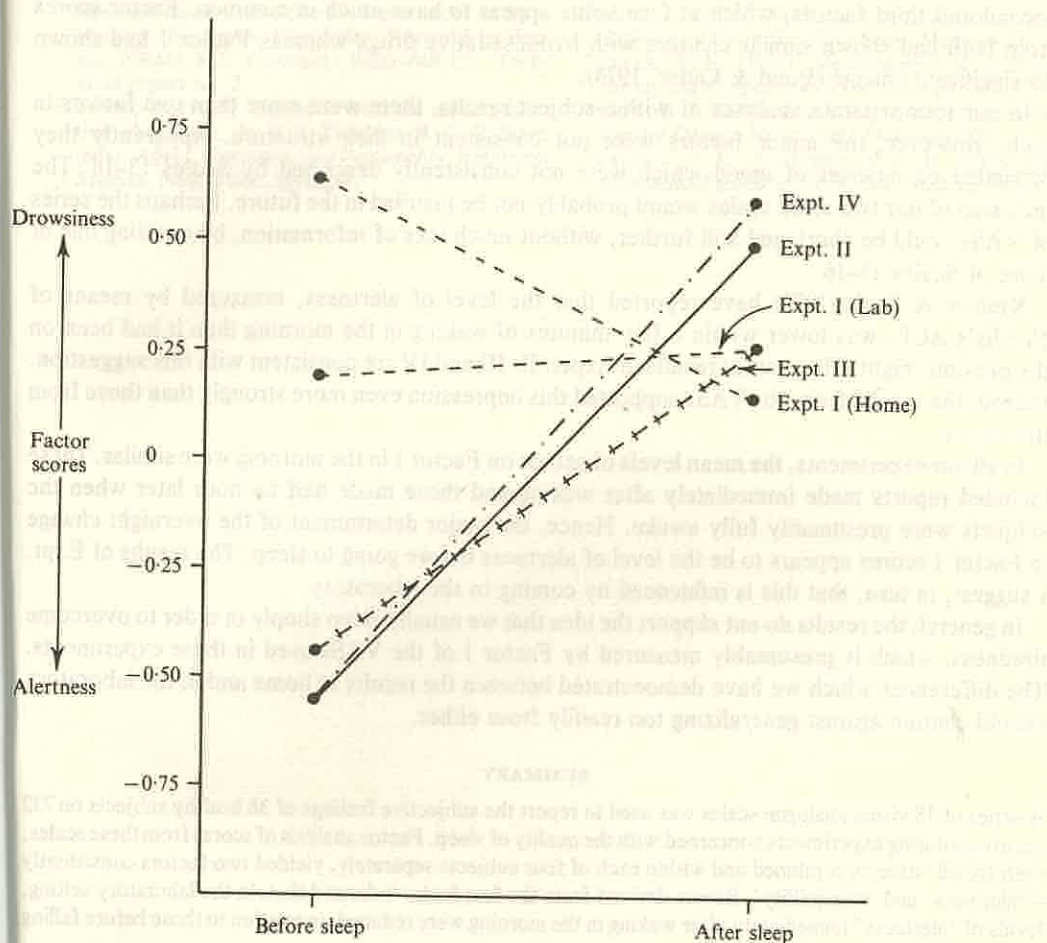


Fig. 1. Mean scores on Factor 1 before and after sleep in the four experiments. (Scores for the home and laboratory conditions in Expt. I are shown separately.)

of alertness before sleep than did the subjects in the other experiments. This difference between the pre-sleep levels of alertness may be due to the time at which the VASs were filled in. In the first study, unlike the others, the VASs were marked half an hour before going to bed. Three of the four subjects in Expt. I were older than the oldest subject in the other studies. Nevertheless, the mean levels of alertness on laboratory nights were not significantly correlated with age ( $r_s = -0.027$ ).

#### DISCUSSION

The results confirm to some extent the earlier findings of Bond & Lader (1974) who used a similar series of VASs. Factor 1, which we would also term 'alertness', was virtually the same as that of Bond & Lader except that the additional scales (17 and 18) are included with relatively low factor loadings. Minor changes in the adjectives of Scales 14 and 16 and the presence of two additional scales did not affect the results significantly.

It is in Factor 2 that an important difference appears between the present results and those of Bond & Lader. Their third factor, based on Scales 2 and 10 ('calm' and 'relaxed'), is evidently not generally applicable to VAS scores, either from groups of subjects or from the same subject. Our Factor 2, which we would call 'tranquillity', was formed by a combination of Bond & Lader's

second and third factors, which at face value appear to have much in common. Factor scores from both had shown similar changes with hypnosedative drugs whereas Factor 1 had shown no significant change (Bond & Lader, 1974).

In our four separate analyses of within-subject results, there were more than two factors in each. However, the minor factors were not consistent in their structure. Apparently they depended on nuances of mood which were not consistently described by Scales 13-18. The inclusion of our two extra scales would probably not be justified in the future. Perhaps the series of VASs could be shortened still further, without much loss of information, by omitting one or more of Scales 13-16.

Kramer & Roth (1973) have reported that the level of alertness, measured by means of Nowlis's ACL, was lower within a few minutes of waking in the morning than it had been on the previous night. The present results in Expts. II, III and IV are consistent with this suggestion. Indeed, the results from our VASs supported this impression even more strongly than those from the ACLs.

In all our experiments, the mean levels of scores on Factor 1 in the morning were similar. These included reports made immediately after waking and those made half an hour later when the subjects were presumably fully awake. Hence, the major determinant of the overnight change in Factor 1 scores appears to be the level of alertness before going to sleep. The results of Expt. I suggest, in turn, that this is influenced by coming to the laboratory.

In general, the results do not support the idea that we usually sleep simply in order to overcome tiredness, which is presumably measured by Factor 1 of the VASs used in these experiments. The differences which we have demonstrated between the results at home and in the laboratory should caution against generalizing too readily from either.

#### SUMMARY

A series of 18 visual analogue scales was used to report the subjective feelings of 38 healthy subjects on 73 occasions during experiments concerned with the quality of sleep. Factor analysis of scores from these scales both for all subjects combined and within each of four subjects separately, yielded two factors consistent - 'alertness' and 'tranquillity'. Scores derived from the first factor indicated that, in the laboratory setting levels of 'alertness' immediately after waking in the morning were reduced, in relation to those before falling asleep on the previous night.

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