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The Effects of Impulse Noise on Sleep - a Behavioural Awakening Study

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1) INTRODUCTION

Considerable recent interest has been shown in the awakening effects of impulse noise (1)(2) and in particular sleep interference due to the sonic boom.

Furthermore a recent survey (3) has indicated that several important factors play differing roles and need to be considered when planning sleep experiments:- sleep variables (accumulated sleep time, sleep stages), stimulus variables (information content in the noise, habituative tendencies), intensity effects (physical characteristics of the noise), individual differences (age, sex, health state, population sub groups), psycho-physiological variables (behavioural effects, performance, synthesis and release of biochemicals), and subjective effects (relation of attitudes and rating scale values to laboratory and field situations).

Bearing these factors in mind a behavioural awakening study has just been completed in which 8 subjects (mean age 22.9 years) were each variously exposed to double event impulse noise simulations of a sonic boom over a period of seven consecutive nights.

2) ASSESSMENTS OF AWAKENING EFFECTS

2.1 Behavioural Awakening. The rationale for using a behavioural measure of awakening in this context has been discussed elsewhere (3). Briefly the reasons are based on the following:- A- the comparative y greater ease of relating behavioural awakening to any subsequent effects of sleep deprivation or interference. B- the impracticability of setting limits on night-time noise which induce EEG changes without behavioural awakening. C- the difficulty of assessing EEG records when mixtures of wakefulness and sleep are present. The behavioural response on awakening required the subject to press a weighted push-button. This action resulted in the time of awakening being recorded.

2.2 Subjective Tests. Questionnaires for assessing the subjective effects of sleep interference were given to subjects each morning after final awakening. These consisted of:- A.- A Subjective Stress Scale (4) B.- A Subjective Fatigue Scale - SFS (5) C.- The Clyde Mood Scale (6) D.- Sleep Questionnaire. Only the sleep questionnaire had not been previously tested in other situations, but it did include a simple scale of sleepiness (7).

2.3 Personality Tests. Since there is some evidence that personality factors influence both the quality of sleep and responsiveness to sounds, personality tests were completed by subjects before the experiment. Three separate tests were included in this preliminary study which covered extraversion and neuroticism (Eysenck Personality Inventory, Form A): sociability and adjustment (Heron Two-Part Personality Inventory) and anxiety (Taylor Manifest Anxiety Scale). Subjects were retested on the E.P.I. (Form B) and the Taylor

Manifest Anxiety Scale after the last experimental night.

3) STIMULUS

The stimulus used throughout was intended to represent a reasonable facsimile of an indoor sonic boom and was reproduced from a loudspeaker. The recording was obtained from a sonic boom simulator (8), which by altering conditions could produce a signature of an indoor boom which closely resembled those recorded inside buildings overflown supersonically. The loudness and other physical rating scale values of these indoor booms are shown in table 1.

Table 1. Physical Rating Scale Unit Values of Sonic Booms

	JRLL (11)(PHON)	JRLL (11)(PNdB)	ZEPLER (12)PHON	ZEPLER (13)METER	dB A*	dB D*	dB*
LOW	85.8	86.6	83.3	81.2	76.7	83.6	94.0
MEDIUM	88.9	90.0	86.8	86.1	79.7	88.0	99.8
HIGH	93.9	95.1	93.1	90.7	83.1	91.6	100.5

*Impulse SLM values for dB Fast subtract 5.4 dB
for dB Slow subtract 12.0 dB

4) EXPERIMENTAL DESIGN

8 subjects were divided into 4 groups of 2 and tested in pairs. Each group underwent 7 successive nights, the first 3 were "adaptation" nights, the remaining 4 nights constituted the main noise exposure or "experimental" nights. On each of three of the "experimental" nights 12 simulated sonic booms were presented to the sleepers, on the other night("control" night) no sounds were presented. During any one night, the intensity of the simulated booms remained constant but was changed between the three nights. The order of presentation of the three stimulus intensities and the control night was arranged by a latin square design. This procedure is thought preferable to successively increasing or decreasing the stimulus intensities over 3 nights since any habituative trends towards decreased awakening during the course of the experiment can be distinguished from the stimulus intensity-dependent effects.

Each night subjects were in bed, with lights out at 11.30 pm and were awakened by an alarm at 7.30 am. They were instructed to press their buttons once whenever they awoke for any reason during the night. On the final 4 nights, subjects were told that if they were already awake and subsequently heard a sonic boom they were to press their buttons twice. The criterion for an awakening in response to a simulated boom was that the button press had to occur within one minute of presentation of the boom. All times were automatically digitally recorded.

5) LOCATION

The bedroom used was the upstairs front room of a brick-built semi-detached house of a structure and design common in Britain for a dwelling constructed in about 1930. The room was therefore a normal bedroom rather than a laboratory. The associated equipment was located in an adjacent room.

6) ANCILLARY EQUIPMENT

The system was pre-programmed and designed to function automatically in the absence of the experimenter. The presentation of the stimuli at set times was achieved by a punched tape reader causing triggering pulses to be fed to the remote control unit of the tape recorder. A digital clock controlled the tape reader and allowed the presentation times (6 digits) to be recorded on a line printer, along with the subjects awakening responses each time his button was pressed.

7) RESULTS

7.1 Behavioural Awakening. The number of awakenings over the seven nights are shown in Table 2 together with the awakenings in response to the booms. There were more awakenings during the 3 "adaptation" nights(79) than the "experimental" 4 nights(69). The frequency of awakenings over the 7 nights revealed a declining trend, which may be suggestive of a gradual adaptation to the sleeping and experimental conditions regardless of stimulus intensity. Applying the non-parametric Friedman two-way analysis of variance (9) to the "experimental" nights data, we find that the distribution of awakenings is a matter of chance ($X_r^2 = 2.81$, df = 3, $0.30 < p < 0.50$) in spite of the marginally fewer awakenings on "control" nights. Awakenings in response to noise stimuli showed that different intensities had no differential effect upon awakening ($X_r^2 = 0.25$, df = 2, p = 0.967). Overall subjects awoke to 14.28% (35/245) of the sonic booms, and were awake for approximately the same number of low, medium, and high, intensity sonic booms (14 or 15). Awakenings were more frequent in the second half of the night, 75.5% of total awakenings.

Table 2. Total number of awakenings (& awakenings in response to boom)

NIGHTS	SUBJECTS 1	2	3	4	5	6	7	8	TOTAL	*	**
Adapt 1	6	8	5	3	1	0	2	3	28	28	1
Adapt 2	2	3	1	6	3	1	4	6	26	26	2
Adapt 3	5	8	4	2	3	2	1	0	25	25	3
Control	3	1	2	2	2	1	1	1	13	17	4
Low	0(0/12)	5(2/12)	1(1/9)	3(3/10)	2(0/11)	2(0/11)	3(3/9)	4(4/8)	20	21	5
Medium	3(2/12)	4(1/12)	3(2/11)	3(3/9)	2(1/9)	1(0/12)	2(2/11)	1(1/6)	19	16	6
High	4(2/12)	3(0/12)	2(2/11)	1(1/10)	4(2/12)	0(0/12)	1(1/6)	2(2/6)	17	15	7

* Totals taking account of actual order of presentation according to Latin Square Design on days**.

7.2 Subjective Tests. (a) Subjective Fatigue Scale. Only slightly more fatigue resulted from boom exposure during the night than from the 3 "adaptation" nights, although the boom nights produced greater subjective fatigue than the "control" nights. The fatigue scores were dependent upon the conditions ("control" and "experimental") imposed ($X_r^2 = 10.61$, df = 3, $p < 0.02$), i.e. the distribution of subjective fatigue scores was not a matter of chance. (b) Subjective Stress Scale. Subjective stress was lowest following the "control" night. On mornings following boom exposure, subjective stress was approximately equal to that following "adaptation" nights. Unlike fatigue scores the stress scores were found to be independent of the conditions ($X_r^2 = 4.38$, df = 3, $0.20 < p < 0.30$). (c) Quality of sleep. Each morning subjects rated the quality of sleep, assessed the amount of disturbance, and rated themselves on a sleepiness scale. As with the subjective fatigue and stress scales, the least effect followed the "control" night - sleep was deeper, less disturbed, and subjects less sleepy in the morning. (d) Clyde Mood Scale. The Friendly, Aggressive and Sleepy factors on the Clyde Mood Scale were calculated for each individual for the first and last nights of the experiment. All factors decreased except for 2 individuals who showed increased sleepy scores. (e) Personality Tests and Anxiety Scale. The N scores for Forms A and B on the EPI differ only slightly from those of the normal population whilst the E scores were slightly above. There was therefore no change in trend for the E and N factors after the experiment.

The Taylor Manifest Anxiety Scores did not differ greatly from the normal score found by Taylor (10).

The Heron 2 part personality inventory was given only at the beginning of the experiment, since, unlike the EPI and TMAS, it is not suited to a test - retest situation. The results were not particularly definitive.

8) CORRELATIONS

Several correlation tests (using Spearmans Correlation Coefficient (9))were conducted with individual scores to determine factors contributing towards inter-individual differences in behavioural awakening. Of the individual behavioural and personality measures only the Eysenck neuroticism scale and the percentage of awakened responses to sonic booms were significantly correlated (rs = 0.712, N = 8, $p < 0.05$). Thus within the range of N scores used here, which were all within the limits for a normal population, individuals with higher N scores tended to awaken to a higher percentage of simulated booms.

The following were found between subjective tests and personality measures:- individual scores for subjective stress and TMAS (rs = 0.804, N = 8, $p < 0.05$) and with the Heron Part II Personality Inventory for sociability (rs = 0.839, N = 8, $p < 0.01$).

Only two correlations were found between behavioural measures and subjective tests. The subjective quality of sleep (over 7 nights) with the percentage of awakened responses to the boom (rs = 0.738, N = 8, $p < 0.05$), and with the number of occasions on which the subjects were already awake when the boom occurred (rs = 0.708, N = 8, p 0.05).

9) DISCUSSION

The following points emerge from this preliminary investigation (a) Decreased frequency of awakening over 7 nights suggests the possibility of habituation to sonic booms. This should be further investigated. (B) Subjects' awakenings were independant of the "adaptation" and "experimental" conditions, and of boom intensity on "experimental" nights. This applies within the range of intensities used here but may not with a more extreme range. "Adaptation" nights were more disturbed than "experimental" nights. (C) There were more frequent awakenings in the latter part of the night. (D) Subjective fatigue was significantly greater on "experimental" than "control" nights, whereas subjective stress and quality of sleep were not. On all subjective tests "adaptation" and "experimental" night scores were similar. All 3 factors used on the Clyde Mood Scale - Friendly, Aggressive and Sleepy - decreased at the end of the experiment. (E) No changes in personality scores were evident as a result of the experiment. (F) The correlation between higher N scores on the EPI and more frequent awakenings in response to the boom, and those between subjective stress and anxiety and unsociability scores, suggest certain personality characteristics influence awakening to simulated booms and the degree of subjective after effects.

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