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TRAFFIC NOISE AND SLEEP

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There have been a number of experiments on the effects of noise upon sleep in the laboratory (see Lucas, 1975 for review of these), but only two corresponding studies in the more natural conditions of the home. One of the latter was concerned with aircraft noise (Friedmann et al, 1973) and the other with traffic (Vallet et al, 1976). Both suggested that "deep" sleep, as recorded by the electroencephalogram, was reduced by the noise.

The research to be reported here was also upon the effect of traffic noise upon sleep in the home. It was carried out in England in parallel with similar investigations in three other European countries, France, the Netherlands, and West Germany. The aim was that all these teams should implement identical experiments so that the results could be pooled to provide a large bank of data for common analysis. It is perhaps no surprise that this ambition proved over-optimistic. In the event the methodology of each team retained some individual features. Yet much remained in common: All teams recorded the electroencephalogram (EEG) and electrocardiogram (ECG) at night in the home while the level of traffic noise was measured continuously. All teams also administered the same questionnaire upon awakening and three teams gave the same performance test later in the morning. Also during part of each investigation the noise was attenuated, either by earplugs (the West German study) or by double glazing in the bedroom (the other three teams).

The rest of this report will be concerned solely with the investigation carried out in England. All the data have been collected but their analysis is far from complete. This report will therefore be mainly descriptive, with a few of the early results included at the end.

Measurements have been taken from 11 people living in London in places where the noise levels at night, due largely to traffic, exceeded either 60 dB(A) L_{eq} or 70 dB(A) L_1 as measured 1m. from the front wall of the house. Relatively few houses met these criteria. A typical example is a house on the North Circular Road about 100m. from the intersection of that road with the main A10 Cambridge to London one. Traffic was particularly noisy here as it decelerated into, or accelerated out of, the large roundabout at this intersection. Usually two people, a husband and wife, were recorded from one house.

To record the EEG and ECG, electrodes were placed on the head and on the chest in the late evening. A portable form of apparatus was used which allowed normal freedom in bed, and for getting up during the night. Discomfort due to the electrodes was minimal, and soon overcome by adaptation. Once the electrodes were attached those taking part were left to plug themselves into the recording system when they retired to bed. The next morning the experimenter returned to remove the electrodes, collect the night's records, and present the questionnaire and performance tests.

The Sunday and Monday night runs of the first week were regarded as trial ones for the sleepers to become used to the procedure of recording. The data were not used. Recording then continued in earnest for the remaining weekday nights of the first week. On Saturday double glazing was installed, producing about a 10 dB(A) attenuation of the noise level in the bedroom. The subjects were allowed a week to get used to this and then a further week's records were taken. At the end of this, the double glazing was removed, another week of adaptation allowed, and then on the fifth week, a further week's records were obtained. Thus, we have a basic Noise/Quiet/Noise design, the effect of the double-glazed Quiet week being compared with the average of the two Noise weeks in terms of the subjective, the behavioural, and the physiological measures.

Before describing some of the preliminary results an introduction to the EEG measures of sleep may be useful. As one descends into sleep the patterns of electrical activity seen by an electrode placed almost anywhere on the head (but typically at the vertex or top of the head) follow certain systematic changes. As one becomes drowsy the low amplitude high frequency record of alert wakefulness gives way to bursts of 10Hz. "alpha" waves. The first undoubted sign of sleep is the appearance of "spindles", short bursts of 14Hz. waves, waxing and waning quickly to give a characteristic spindle shape. After perhaps 35 min., slower, high amplitude waves will appear. These are the "delta" waves at about ½ to 2Hz. Still later this delta activity will dominate the record, swamping spindles. After spending some time in delta, say 20 min., and perhaps about 1hr. 10 min. into the night, the delta waves will cease, the patterns ascending quite rapidly towards the waking state, but usually not entering it. Instead the paradoxical state of Rapid Eye Movement sleep will take over. This is "paradoxical" because, while the general physiological picture, including the EEG, is one of waking, the person is still asleep in that he cannot be easily aroused, and will see nothing even if his eyes are opened. Bursts of rapid conjugate eye movements, which give this state its name, will occur from time to time, and if woken the sleeper will be much more likely to report a dream than when woken from any other stage of sleep. After about 10 to 15 min. in REM sleep the whole cycle will start again. Typically there will be 4 or 5 such cycles in a night's sleep, each having progressively less delta activity and more REM and spindle activity.

Although it is difficult to arouse a person from REM sleep, it is during delta activity that he is most dead to the world. Furthermore, if sleep is lost for one night, then on the next night it will be delta sleep which increases most. These are two strong reasons for thinking that delta sleep may be the deepest and most important kind of sleep.

Clearly, then, the response of delta sleep to a reduction in traffic noise was of major interest in the present study. In the event it was the only pattern of sleep to be affected significantly: In 10 out of our 11 volunteers the median score of delta activity was increased when the level of traffic noise was reduced by double glazing. This effect suggests that under the prevailing conditions of traffic noise the people we studied were not sleeping as well as they could have done in quieter localities.

The next step in the analysis is to look at individual peaks of noise at various levels and from various kinds of vehicle. The frequency pattern of the EEG, and particularly delta of course, will be examined before and after the peak to see if any change occurs. Ultimately these data will be presented as averaged pre- and post-peak profiles for different levels and kinds of peak.

Turning to the second physiological measure, the ECG, heart rate was higher in Quiet than in Noise. This increase in heart rate with double glazing was small but very consistent and reliable. Any simple claim that noise impairs health by making the heart "work harder" is clearly unjustified if straightforward heart rate is the criterion. Nor did noise reduction have any reliable effect upon the variability of heart rate during the night.

To obtain a subjective impression of the quality of sleep the volunteers were asked to complete a questionnaire every morning in which they rated the quality of the previous night's sleep by ticking a 10cm. line at an appropriate point between the extremes of "Worst I can remember" and "Best I can remember", thus :

Worst I can remember |——————|——————| Best I can remember

only 6 out of 11 people reported better sleep during the week of double glazing than under the normal conditions of noise. This suggests that, even though the EEG indicated an improvement of sleep with noise reduction, the sleepers themselves were clearly not aware of any difference the next morning.

With subjective impression failing to support the physiological findings it was clearly important to know how performance on the following day responded to a reduction of nighttime noise. Usually the husband had to leave for work in the morning, and sometimes the wife also, so the three performance tests given each morning had to be short ones. All were limited to 10 min. duration. One, short-term memory, showed no effect of noise reduction. This test involved writing down strings of 8 digits immediately after auditory presentation. Another test, choice serial reaction time, required the subject repeatedly to press one of four buttons to the onset of one of four lights. Each response brought on the next light in random order; so the subject carried on, responding as quickly as possible, consistent with accuracy, in matching the button to the light. This test appeared to be done better during the week of noise reduction, but the result could possibly have been due to a nonlinear improvement with practice through the five weeks. The third test was one of unprepared simple reaction time to a single light source which came on unpredictably at intervals of from 3 to 13 seconds. Here again performance was reliably faster during the middle week of noise reduction at night, and in this case we can be more confident about the result as this test shows little change with practice. Thus the results from the performance tests in this study, which have been reported in more detail elsewhere (Wilkinson et al, 1980), support the physiological data of the EEG in suggesting that the quality of sleep was improved by attenuating traffic noise, and implying therefore that the prevailing levels of noise were preventing people from sleeping as well as they should.

In summary, physiological and behavioural, though not subjective, assessments have indicated that levels of traffic noise in the areas we have studied are sufficient to reduce the quality of sleep and daytime performance in people residing close to the urban arterial roads. It is hoped that some indication of acceptable peak levels may be derived from further analysis of the present data, although the collection of further records from a wider range of settings would seem desirable both for a clearer definition of acceptable thresholds and for some indication of the kind of vehicle whose nocturnal passage causes most distress.

References

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