The Effects of a New Motorway on an Established Residential Area

Plate 1: The Bromford Bridge and Firs Estates.

It would seem to be a reasonable hypothesis that if a gross environmental change occurs in an established residential area then a correspondingly gross community reaction will be observed. It is this hypothesis that forms the departure point of this paper. The established residential area in this instance was the Bromford Bridge and Firs Estates of Birmingham Corporation; they number 2054 households of which 51% are flats in blocks ranging from eight to 19 storeys. The remaining 49% are two-storey houses of traditional form and construction. The 'gross environmental change' was brought about by the opening of the section of the M6 motorway, connecting the Gravelly Hill Interchange, to the north of the City of Birmingham, with the M1. This six-lane highway passes alongside the housing estates for a length of about 2.15km on an open viaduct some 8m above ground. The carriageways are flanked by concrete parapet walls 1m.
in bright. The estates average about 3.5m in depth and on an estimate about half the houses are within 1.5m of the motorway; one of the eight-storey flat blocks is only 3m from the nearest carriageway. The ground rises gradually in a direction away from the motorway.

At this point it is worth briefly considering the ways in which new motorways are suspected of causing annoyance, and their relevance to this particular situation. They are:

1. Reduction in property values
2. Visual degradation
3. Severance
4. Noise
5. Vibration
6. Lights
7. Atmospheric pollution

In these estates all but a few of the houses are rented from Birmingham Corporation and there has consequently been no significant loss of monetary value to the occupiers. The motorway is built above the existing watercourse of the River Tame and close alongside the main Birmingham to Derby railway line; thus no severance has occurred. A row of very large high tension power lines and pylons follows the course of the motorway, and the motorway viaduct partially obscures a large-scale industrial area; it is impossible to believe that any visual degradation has happened on the motorway side of the estates. Of the remaining factors listed noise remains as clearly the most likely cause of direct annoyance.

Social surveys and physical noise measurements were made both before and after the opening of the motorway, which took place in May 1972. Construction work generally had been finished some time before this, but the opening of this section was delayed while last-minute strengthening of box girder spans in the Gravelly Hill Interchange was done. The delay made it possible to make the first social survey in April 1972, some time after construction noise near the estates had ceased. Some noise measurements were made in July and August 1971, and a more elaborate programme in October and November 1972, after the Motorway had become firmly established both as a commuter and as a long-distance route. The second social survey was conducted in March 1973 some 10 months after the opening; by this time it seems reasonable to suppose that the initial shock reaction of the residents had subsided.

This adaptive process could be traced (albeit crudely) by observing the rate at which complaints about noise from this section of the motorway were received in the Public Health Inspectors’ Department. The first were received within three hours of the official opening, and remained at a high daily level for about three weeks. By this time it became clear that the authorities were beginning to think in terms of providing double-glazing, constructing noise barriers and so on. From then on the rate of complaints gradually diminished until at the time of our second survey they were running at less than one per week (Reynolds, 1973).

We have already suggested that the noise was likely to be the most annoying physical variable in this particular situation, and in order to examine its relationship to the psychological findings we had to find out its magnitude and other relevant characteristics. Our earliest measurements were little more than exploratory and were carried out at the urgent request of the Housing Committee. They involved measuring the noise levels at two flats before and after the opening of the motorway. Conventionally noise climate due to road traffic is measured in A-weighted decibels and, since the level is continuously varying in a more or less random way, it has to be expressed statistically. Griffiths and Langdon (1968) showed that the tenth percentile of the instantaneous noise levels, that is, the level exceeded for only 10% of the time, measured 1m outside dwellings over a given period, was fairly well correlated \( r = .68 \) with subjective reaction to the noise measured in a survey of 700 respondents living in suburbs in North London and affected by noise from free-flowing traffic routes. Scholes & Sargent (1969) have argued that, though it is possible to produce better physical correlates with subjective reaction, the tenth percentile, or \( L_{10} \) statistic, is easy to compute from reasonably simple data, is amenable to predictive techniques, shows at least a useful correlation with Griffiths & Langdon’s social survey data, and therefore ought, for the time being, to be used as the standard
measure for describing traffic noise. This proposal has since been adopted in this
country as official policy (Department of the Environment, 1972b); *L*_{eq} at any
point is defined as the mean of the hourly measured values for the 18 hours from
0600 until midnight; this circular also established a provisional criterion, that
no dwelling should, as an act of conscious policy, be exposed to an 18-hour *L*_{eq}
greater than 70 dBA without remedial or compensatory action. From September
this year, the criterion has been lowered to 68, for applying the provisions of
the Land Compensation Act.

In the preliminary measurements we could not get a realistic value for the
18-hour *L*_{eq} because of untypical construction noise during the daytime. Evening
measurements taken every hour, however, indicated an increase of up to 15 dBA
in the ambient noise level after the opening (Fig. 1). An increase of 15 dBA
represents approximately a threefold increase in the perceived loudness.

Once the motorway was opened and the traffic pattern established we could
define the *L*_{eq} with greater precision. For this purpose the Director of Housing
made available to us an empty flat on the 18th floor of a tower block, facing the
motorway, 40m above ground and 85m distant horizontally from the nearest
carriageway. With this facility we were able to carry out a number of physical
investigations, including a continuous series of hourly *L*_{eq} measurements for 10
days and nights. An examination of the considerable volume of data which this
operation produced indicated that the hourly variations in noise output from the
motorway repeated themselves daily with remarkable constancy. For a normal
weekday the standard deviation of all the recordings at any given hour was
typically 0.8 dBA. We felt it was safe, therefore, to average each hourly reading
for all normal weekdays to produce a standard statement of the most probable
value of *L*_{eq} at any hour at our measuring-station. Fig. 2 shows this statement in
graphical form. Identification of these 'circadian rhythms' enabled us to use a
simple procedure for determining the 18-hour *L*_{eq} at any point in the estate
without the need for a round-the-clock measurement. A measurement at any
point, taking perhaps 15 minutes to carry out, and giving the *L*_{eq} at that
particular time could be immediately converted into a close estimate of the
average 18-hour value by reference to this basic graph.

We conceivd that the final product of research of this kind, if successful,
ought to be a system by which human reaction to a motorway could be predicted
at the early planning stages from the main design parameters of that motorway.
Techniques already exist for predicting the 18-hour *L*_{eq} at any point near a
motorway, by methods involving distance from the motorway, intervening
barriers, traffic flow rate, percentage of heavy vehicles in the traffic stream, and
mean vehicle speed (for example, Delany, 1972 and Building Research
Establishment 1973). Incidentally, a subsidiary part of our research has been to
test these predictive techniques for accuracy and ease of use against actually
measured values at a number of points in the estate; this is being reported
elsewhere (Walters & Cottee). We can say, therefore, that it is already possible to
start with the design parameters of a new motorway and get as far as *L*_{eq} at any
point in space near to it with fair confidence; but from *L*_{eq} to human reaction is
a journey through terrain which is not so well charted, though many explorers
have travelled the route and left us some sketch maps.

When setting up our psychological measuring procedures to explore this part
of the route further, we took as our starting point the premise that a subject's
response to noise is likely to be a function of at least three sets of variables: the
physical characteristics of the noise, the context in which it is heard and the
personality of the subject himself. Planners and designers of the built environment
are much exercised by the interplay of the noise and its context, but they have to
accept the variability produced by individual differences. We feel that the
context of environmental noise is most important in determining the degree of
annoyance caused, and for that reason a questionnaire-based field survey, with
all its imperfections, was preferred to any kind of laboratory study. The two
surveys, undertaken before and after the opening of the motorway, had sample
sizes of 189 and 173 completed interviews respectively; this represents a sampling
rate of about 9% on each occasion. The two samples were drawn from the list
of all addresses on the estates by means of Random Number Tables, and did
not overlap.

The questionaires were administered by second-year students from the
Birmingham School of Architecture who received some instruction in interviewing techniques as part of their course; they did not make their purpose known to the interviewees until after the data had been gathered. The questionnaire (substantially the same for both surveys) began with questions concerning the size and make-up of the household, and the length of residence of the family on this estate. The respondent was then asked a series of questions about his or her attitude to the residential area in general and his home in particular. Within these series were unobtrusive questions on the noisiness of the area and the sound insulation of the house. The respondent was then asked how annoying he found a number of noise sources, including noise from traffic. The list of noises was compiled from an observation of the area and from the findings of previous workers. (McKennell & Hunt 1966, Lamoure & Radelon 1967, Griffiths & Langdon 1968, Walters 1968, Bottom & Croome 1969.)

Respondent attitudes to their area and home changed remarkably little between the two surveys. There was a slight tendency for more people to complain of the noisiness of the area in 1973, though the difference was certainly not significant. Even in 1973 the lack of local shopping and public transport gave rise to more dissatisfaction than general environmental noise. However, when we turn to the questions related specifically to noise sources, road noise is shown to cause significantly more annoyance in 1973 than in 1972, while there is no significant change in the annoyance caused by other sources of noise. In spite of this, indirect questions about noisiness and sound insulation did not show any significant shift, as might have been expected if the noise problem was a serious one. As we have already indicated noise levels in some parts of the area are not only high but continuously so over a large part of the 24 hours. So we must
look for intervening variables.

The most obvious variable likely to affect the annoyance response is the distance of the home from the motorway; there is a highly significant negative correlation of 0.38 between noise annoyance scores and minimum distance from the carriageways (Fig. 3). A chi-squared test also shows a significant increase \((p<0.01)\) in complaints when the motorway is actually visible from the living room or bedroom windows, thus affording a direct sound path to the most used spaces of the house.

Fig. 3: Noise annoyance scores against distance from motorway (1973 survey).

Another likely variable to influence a respondent's reaction to noise is the pattern of time spent in the house. The results were tested to see if housewives, daytime workers and night-time workers felt differently about the motorway: they did not. In fact all groups showed the same characteristic bi-modal distribution; that is to say, road noise was most frequently found either not at all annoying or very annoying. Fig. 3 shows this tendency clearly. There was a similar bi-modal response to aircraft noise in both surveys. These bi-modal responses have been found by Anderson (1971) and very recently by Bryan & Tempent (1973). Such results confirm earlier findings (e.g. McKennell & Hunt, 1966) that two identifiable groups exist in the population: those who do and those who do not find noise an annoying phenomenon.

To test this, a statistic of general noise annoyance was computed for every respondent in the 1973 sample, by simply summing their responses to the questions on various noise sources. Road noise was omitted from the sum and correlated with this noise annoyance score. A correlation of 0.39 was obtained \((p<0.001)\). In other words, people who complain about road noise also tend to complain about noise from other sources.

A second statistic of complaints about environmental inconvenience was computed from the responses to the series of questions on the area and the home. This was then correlated with an overall noise annoyance score including road noise. A correlation of 0.35 was obtained, which is also highly significant. Checks were made to see whether any personal circumstances could be responsible for this co-variation. Sex, age, type of employment, type of dwelling and size of household all proved to be uncorrelated with the rate of complaints either about the environment generally or about noise. This finding agrees with that of McKennell (1965). Thus it seems that there is a noise-sensitive section of the population, who are annoyed by background noise, even at very modest levels. Yet another section, the noise-tolerant group appear not to be worried by even quite high and intrusive levels of persistent noise.

Extended open-ended interviews carried out after the second survey add evidence to this argument. Those who had complained of being annoyed by
road noise frequently expressed a sense of increasing frustration and growing
doubts as to how long they could put up with their ordeal. Thus they were
suffering not just from physical noise but also from the psychological stress caused
by the build-up of frustration and doubt. By contrast other people appeared to
have habituated to the noise and some, often old and possibly lonely people, even
felt the motorway to be a positive friend, interesting to watch and a defence
against loneliness.

To sum up, then: the initial hypothesis of a gross community reaction to a
gross environmental assault cannot be fully sustained on this evidence. No doubt
it would have seemed true if the second survey had been made within a few
weeks of the motorway’s opening, when the whole area appeared to be seething
and boiling with a sense of outrage. But after a year has gone by people seem,
on the surface at least, to have settled down again. The unobtrusive noise
questions elicited no significantly changed response in the second survey. It is
only when people are directly questioned about the motorway that a change in
the hypothesised direction can be observed. It is almost as though people have
pushed the motorway and its din to the back of their consciousness and only
complain about it when specifically reminded. Resigned acceptance is one’s first
impression when looking at the data as a whole; yet when examining individual
cases one frequently encounters considerable annoyance. The area studied is a
wholly working-class one, and it is instructive to compare the appearance of
somewhat inarticulate stoicism recorded here with the reactions of the highly
articulate (mainly middle-class) objectors at the Public Inquiry into the proposed
route of the M42, or at the Third London Airport Inquiry. One cannot help
wondering whether, because of this difference, we are in danger of relegating all
our urban motorway routes to working-class areas, as we did with the railways
130 years ago.

Two important points, we think, emerge which might be worth further
consideration. As we have already mentioned we found, as other workers have
done, that the population appears to contain identifiable sub-populations
of complainers and non-complainers, a phenomenon which must be related to
personal rather than situational differences. Now this bi-modality may possibly
be an artefact, created by the way in which questions about annoyance are
usually put. To ask people to place their sense of annoyance into one of four or
five ordinal ratings may well be an impossible task for most people. Perhaps for
normal people annoyance is really a binomial thing: you either feel annoyed
about something or you don’t. If this is so, the appearance of the bi-modal
distribution begins to make sense. Fig. 4 helps to show what happens. These are
the histograms of responses to all the noise annoyance questions in both surveys,
arranged in order from least annoying to most annoying. As we move along the
diagram towards the more annoying noise sources, the mode does not simply
move across the histogram as one might expect, but instead a second mode begins
to grow at the ‘very annoying’ end as the mode at the ‘not at all annoying’ end
drops, rather like liquid in a U-cube. The moderate responses in the middle
remain at a generally low level throughout, because in a bi-modal situation
moderate responses would have no real meaning. We do not doubt that this
bimodality would be maintained even if stimuli of greater annoyance potential
were introduced into the situation, to give histograms which would form a mirror
image of Fig. 4.

Our final point relates to the proper level at which the contentious criterion
defining the level at which remedies at the public expense should be available.
As already mentioned, at present this criterion is set at 68 dBA. Of the 90
houses in the 1973 survey only 10 appear to be exposed to a level greater than
68 dBA. It can be seen from Fig. 5 that there is a considerable majority of ‘very
annoyed’ responses in the region of 66 dBA and upwards. Now it is no business
of researchers to dictate where a criterion such as this ought to be set. The
decision involves economic, political and social questions, such as ‘What is the
cost to the nation, in money terms, of lowering the “compensation or remedy”
level by 2 dBA?’; ‘What percentage of the population can we afford to protect?’;
‘What percentage are we willing to leave in a state of annoyance?’; But at least
we can suggest what different levels mean in terms of these percentages. As far
as the results from the present survey show, and 18-hour average value for t40
of 66 dBA represents the 50th percentile of annoyance—the level at which an equal
Fig. 4: Histograms of responses to noise annoyance questions (1972 and 1973 surveys) arranged in order of the mean annoyance scores of each.

Fig. 5: Noise annoyance scores against distance and estimated $L_{10}$ for houses in 1973 survey.

The number of people are likely to be annoyed as not annoyed. In other words, 66 dBA, not 68, is where you put the criterion if you are willing to accept the probability of annoying half the exposed population. Because the dB scale is logarithmic and not a linear function, the difference of 2 dB between 66 and 68 is not so insignificant as it might seem. At 68 dB it is probable that well over half of the people exposed to the noise will be suffering annoyance in some degree or other. From the purely human standpoint 68 dBA is still too high.

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