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FACTORS AFFECTING THE ANNOYANCE OF COMBINATIONS OF NOISE SOURCES

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INTRODUCTION

The modelling of annoyance due to combinations of noises, such as aircraft or impulse in a traffic background, has been discussed in an earlier paper [1] where it was concluded that an 'energy summation' model, based on the total L_{Aeq} of all sources, does not account for annoyance reactions. The 'dominant source' model, where total annoyance is governed by the subjectively dominant source, was suggested as having more potential application but was in need of further verification. This paper explores the possibility in the light of newly acquired laboratory and field data.

ANNOYANCE RESPONSES

Models for the prediction of annoyance due to combinations of noises should make allowance for both 'source specific' and 'total' annoyance reactions. However, as yet, there appears to be no satisfactory way of obtaining such information, partly because the problem is confounded by the way in which the information is obtained and partly because there is no way of exactly knowing how respondents interpret the questions they are asked.

Field Data

Without doubt social survey data is the most confusing, where it has frequently been observed, as is shown in Figure 1, that the 'source specific' annoyance responses are greater than 'total' annoyance responses [2-5]. The reason is not clear, and three possible explanations may be hypothesised:

(a) The 'total' annoyance question is usually the first of the noise questions to be asked, and takes a form similar to Q1 in the Appendix. It has been postulated that an early 'total' annoyance question does not sufficiently alert respondents to all of the components in their noise environment. This explanation may be discounted. Figure 2 shows that, even when repeated later in the questionnaire, and asked as part of a composite question where there is little doubt that respondents should have been alerted to its intended meaning, the same result is obtained (see Q2 and Q3 in the Appendix).

(b) A variant of the above is when respondents appear to have been alerted, but still do not spontaneously include all sources in their response. When questionned more closely and encouraged or prompted to take account of all noise sources, they sometimes reply, "Oh, the aircraft (or the gunfire), they are over there!". This means that more distant noise sources can be specifically excluded, and the annoyance response is driven by the more immediately present traffic or background noise. Although plausible, this explanation does not seem to be that robust.

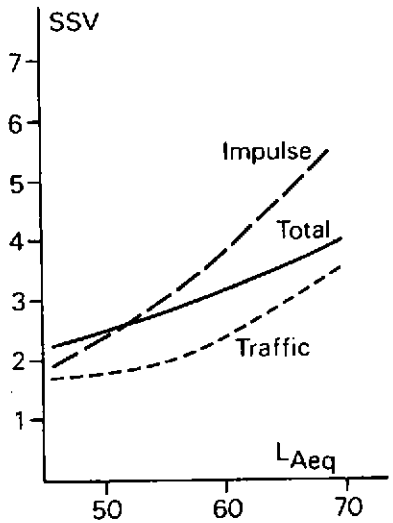


Figure 1: Source specific and total annoyance responses for combinations of impulse and road traffic noise. Field data from (4)

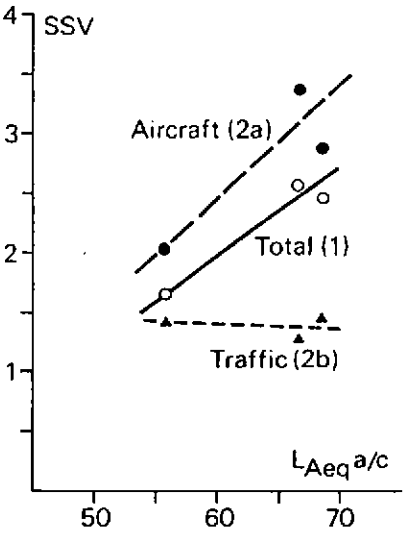
(c) The period over which respondents integrate their annoyance responses probably holds the key to the problem. The 'source specific' response may be designated the heightened or 'worse mode' annoyance actually felt whilst the offending noise is heard. The 'total' response is the integrated or 'average mode' annoyance formulated over a long time period and reflecting to some extent the acceptance/tolerance of the combined situation.

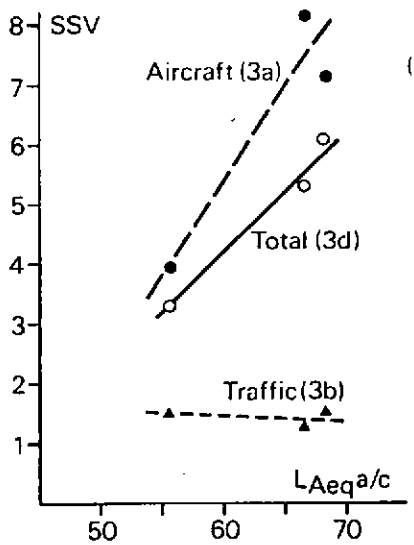
Laboratory Data

There is evidence from laboratory studies [1,4,6] that the 'dominant source' model appears to predict annoyance due to combinations of noises. Figure 3 illustrates this, where it may be seen that 'total' annoyance judgements are driven by whichever of the two 'source specific' responses dominates the particular situation. Subjects' responses were obtained using a variant of Q4 in the Appendix. In this case there is no need to consider the 'total' annoyance responses which become redundant.

However, Figure 4 shows that this result is not always obtained. Here it may be seen that 'source specific' responses are greater than 'total' responses, and this result is not unique. In repeated measures experiments, where each subject hears every noise combination, the result is variously obtained in low road traffic background conditions [1,4] or when 'experienced' [7], as opposed to 'naive' subjects, are used to make the judgements. In this context 'naive' means subjects who have been selected at random, usually from a student population, and 'experienced' refers to those subjects deliberately chosen on the basis of having been previously exposed to the noises in their home environments. Again, the reason for these different effects is again not clear, and two possible explanations may be hypothesised:

(a) Four point scale — Appendix Qns. 1 and 2



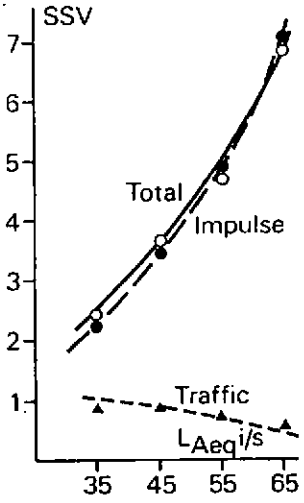


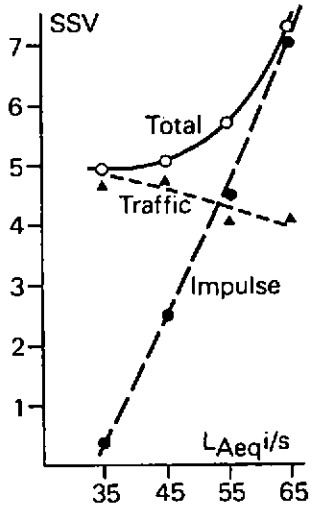
(b) Ten point scale – Appendix Qn. 3

Figure 2: Source specific and total annoyance responses for combinations of aircraft and low road traffic noise. Field data after (5).

FACTORS AFFECTING THE ANNOYANCE OF COMBINATIONS OF NOISE SOURCES

(a) Low road traffic – 35 L_{Aeq}





(b) High road traffic – 55 L_{Aeq}

Figure 3: Source specific and total annoyance responses for combinations of impulse and road traffic noise. Repeated measures laboratory data from (6)

(a) The evidence in support of the 'dominant source' model obtained on 'naive' subjects could be explained on the basis that the noises are only heard for a short period of time (e.g., 10 minutes), and this is not long enough to experience the periods of relief which inevitably occur in the real life situation [4,6]. Hence subjects do not learn to integrate their responses over long periods which contain intermittencies in the noise exposure. In fact they answer the questions specifically asked and in effect subjectively add their responses to form a 'total' response which closely follows the model.

(b) 'Experienced' subjects with field exposure to the noises being studied in the laboratory are understandably better able to project (as in Q4 in Appendix) to the home environment [7]. This projection apparently includes an element of long term integration notably absent with 'naive' subjects.

Discussion

A different representation of the effectiveness of the 'dominant source' model may be seen in Figure 5. When traffic noise is the dominant source (left hand side of the figure), 'total' annoyance closely follows traffic annoyance, whereas when the more intermittent 'impulse source' is dominant (right hand side of the figure) the difference between total and impulse noise annoyance is generally negative, with 'total' annoyance being lower than the more dominant

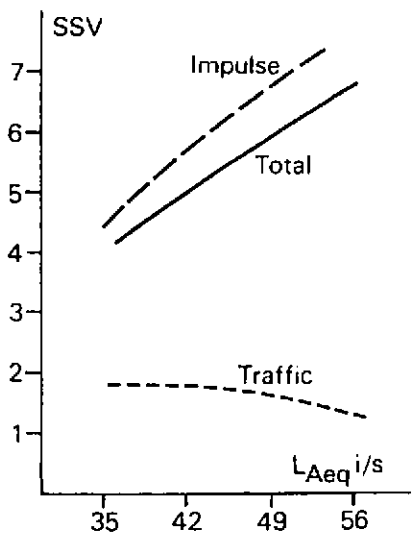


Figure 4: Source specific and total annoyance responses for combinations of impulse and road traffic noise. Repeated measures laboratory data from (4)

FACTORS AFFECTING THE ANNOYANCE OF COMBINATIONS OF NOISE SOURCES

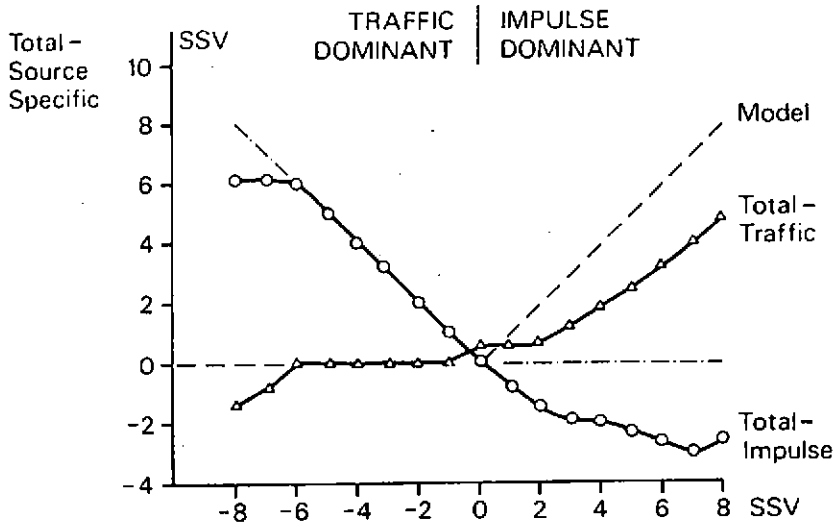


Figure 5 : Dominance model : Field data from (3)

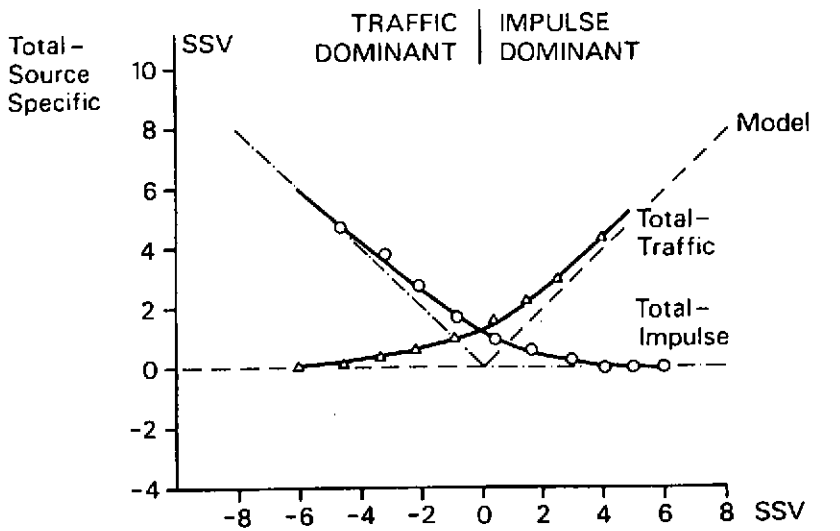


Figure 6 : Dominance model : Laboratory data after (6)

impulse noise [3]. The traffic noise also seems to influence the 'total' annoyance responses to some extent when the impulse noise is dominant, as is evidenced by the depression from the 'dominant source' model of the total minus traffic annoyance values. The close adherence to the 'dominant source' model for the 'naive' laboratory data [6] is shown in Figure 6.

The overall conclusion drawn from these findings would seem to be that on balance the 'total' annoyance response as reflected by the field data seems to be preferred to the 'dominant source' model, particularly as the laboratory results projected by 'experienced subjects' also tend to refute the findings of Figures 3 and 6.

IMPLICATIONS

The choice of either 'source specific (dominant source)' or 'total' annoyance dose-response relationships for use as planning criteria has quite profound economic effects, the former carrying by far the larger penalty for the noise maker. Figure 1 shows that the penalty for impulse noise compared to traffic noise is about 5-10 dB when 'source specific' responses are used. This can be increased by up to 20 dB if 24 h L_{Aeq} measures are used for the measurement of the noise exposure, rather than the actual operation times of the plant. 'Total' annoyance responses reduce the size of the penalty.

Predictive modelling combinations of noises is therefore dependent not only on whether 'source specific' or 'total' annoyance dose-response relationships are used, but also on the integration periods over which the noise measurements and annoyance judgements are made. If, as this paper suggests, the 'total' responses are used, then radical rethinking of planning criteria will be needed.

REFERENCES

1. C.G. RICE, K. IZUMI 1984 *Proc. IOA* Spring Conference, 287-294. Annoyance due to combinations of noises.
2. P.J. COOPER, I.D. DIAMOND, C.G. RICE, J.G. WALKER 1984 *Proc. IOA* Spring Conference, 301-308. The modelling of source specific and total noise annoyance using source specific noise measurements.
3. Y. GROENEVELD, R.G. DE JONG 1985 *NIPG TNO Delft Publication* 85008. CEC Joint Research Project - Effects of impulse noise on human beings: The field survey.
4. C.G. RICE 1985 *University of Southampton ISVR Memorandum* No. 659. CEC Joint Research on Annoyance due to Impulse Noise: Comparison of field and laboratory studies.
5. I.D. DIAMOND, J.G. WALKER, J.B. CRITCHLEY, G.C. RICHMOND 1986 *Directorate of Research Report* DR 8601. The influence of residual noise on disturbance from aircraft noise. Civil Aviation Authority, London.
6. C.G. RICE 1985 *Proc. Internoise 85*, II, 913-916. CEC Joint Project on Impulse Noise: Effect of road traffic noise level on judged annoyance.
7. E. BUCHTA 1986 Institut fur Larmschutz, Dusseldorf. Personal communication.

FACTORS AFFECTING THE ANNOYANCE OF COMBINATIONS OF NOISE SOURCES

APPENDIX

Question 1: *from Reference [5]*

10. 'Taking all things into account, how much would you say the noise around here bothers or annoys you?'

Very much	4
Moderately	3
A little	2
Not at all	1

Question 2: *from Reference [5]*

19a 'Taking all things into acount, how much would you say the noise from aircraft around here bothers or annoys you?'

Very much	4
Moderately	3
A little	2
Not at all	1

19b 'And how much would you say the noise from traffic around here bothers or annoys you?'

Very much	4
Moderately	3
A little	2
Not at all	1

Question 3: *from Reference [5]*

24. 'Just to make sure I have it all straight, how do you feel overall about:'

(a) the noise from aircraft?
(b) the noise from traffic?
(d) the overall level of noise around here?

Not annoyed 0 1 2 3 4 5 6 7 8 9 Extremely annoyed

Question 4: *from Reference [4]*

C3.1-3 'How annoying would you find the (total/impulse/traffic) noise you have just heard, if you heard it all the time in your own living room in the evening?'

Not annoying at all 0 1 2 3 4 5 6 7 8 9 Extremely annoying

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