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# ASSOCIATION BETWEEN NOISE ANNOYANCE AND INCIDENCE OF ISCHAEMIC HEART DISEASE IN THE CAERPHILLY AND SPEEDWELL STUDIES

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## ABSTRACT
In a cohort study, the association between annoyance and disturbances due to road traffic noise and the incidence of ischaemic heart disease (IHD) was studied in 3930 middle aged men. Dependent on the item used, non-significant odds ratios between 0.9 and 1.4 were found in highly noise annoyed/disturbed subjects as compared to less annoyed/disturbed during the 6y follow-up period. However, this relationship was found to be strongly modified by preexistent diseases. In subjects free of any chronic disease at the beginning of the follow-up, significant odds ratios between 1.7 and 3.0 were seen. In the subgroup with chronic diseases no such noise effects were seen. Regarding the objective noise level measurement the opposite was found. In this case noise and preexisting disease tended to act synergistic on the incidence of IHD.

## 1 - INTRODUCTION
The Caerphilly and Speedwell studies are two closely linked cohort studies in which the effects of a number of potential risk factors including road traffic noise on the incidence of ischaemic heart disease (IHD) were investigated. Cross-sectional and longitudinal results regarding exposure of the subjects to objective noise measures − namely the average A-weighted sound pressure level − were given earlier [1-4]. This paper is concerned with the subjective dimensions of the perception of sound − namely disturbances and annoyance − and its impact on cardiovascular risk. According to the noise-stress model, subjective noise measures may be closer connected to the health outcome than the objective sound level when considering the potential effect chain. This is: sound ⇒ disturbance/annoyance ⇒ stress indicators (stress hormones) ⇒ biological risk factors (e.g. blood pressure, blood lipids) ⇒ disease (e.g. myocardial infarction) [5].

## 2 - METHODS
Inasmuch as a detailed noise questionnaire was only administered during the second phase of the study, the follow-up analyses presented here refer to the observation period from phase 2 to phase 3. The reconstructed cohort of phase 2 of the Caerphilly sample consisted of 2398 men between 47-67 y of age. The Speedwell reconstructed cohort comprised 2055 men who were 48-66 y of age. The statistical noise analyses were carried out in a pooled sample of 3997 men aged 47-67 y who filled in the noise questionnaire. The average follow-up intervals for these men were 61 months (SD = 6) and 75 months (SD = 6), respectively (i.e., approximately 6 years). The incidence of ischemic heart disease was defined when a major IHD event occurred between the follow-up phases. These events could be IHD death (coded ICD 410-414 on death certificate), definite clinical non-fatal myocardial infarction (MI) meeting WHO criteria regarding clinical history, electrocardiogram (ECG) and enzyme changes (via written documentation in hospital or general practitioner records), or ECG defined MI that met WHO criteria [4], [6].

The investigators conducted noise measurements in every street where the subjects lived. The subjects were grouped into 5 dB(A)-categories of the A-weighted average sound pressure level outdoors from 6-22 h ($L_{eq,\ 6-22\ h}$). Due to the high correlation between day and night noise levels in the communities, this noise level is used as an indicator for the overall traffic noise exposure of the streets in the study [4]. Personal interviews assessed, on a 5-grade scale (i.e., never, seldom, sometimes, often, always), subjective measures of annoyance and disturbance of traffic noise at home. They measured annoyance (global item), disturbance of concentration, disturbance of conversation or listening to radio/TV, disturbance of relaxation, being nervous or tense, disturbance in going to sleep, and waking up at night [7].
All statistical analyses on the relationship between traffic noise and IHD incidence were controlled (model adjusted) for the potentially confounding factors age, social class, marital status, smoking, body mass index, family history of myocardial infarction, employment status, subjective noise sensitivity based on a single item, area (cohort), prevalence of IHD, and preexisting chronic diseases [3,4]. Diseases included heart attack or coronary thrombosis, stroke, yellow jaundice or liver disease, kidney disease, gout, thyroid problems, high blood pressure, blood clots or phlebitis, and diabetes. With regard to possible effect modification, the analyses were stratified with respect to the prevalence of any chronic disease. A new variable was created that was coded "1" if either the variable prevalence of any chronic disease was true (clinical interview) or prevalence of IHD was positive (clinical examination) as determined during the reference phase 2 of the follow-up investigation, and coded "0" if non of these was true. This new variable was named "preexisting disease". The multiple logistic regression technique was applied to calculate relative risk estimates (odds ratio) and 95%-confidence intervals (standard error), based on cumulative incidence numbers during the follow-up period. The statistical package SPSS was used for calculations.

## 3 - RESULTS

The 6 y cumulative incidence of major IHD was 161 (of 2398) and 191 (of 2055) subjects in the Caerphilly and Speedwell cohorts, respectively. A total of 3997 men filled in the noise questionnaire. Due to missing values, adjusted analyses in the study refer to the pooled sample of 3950 men who completed information on the noise questionnaire and for whom control variables were available. The average age of men was 57.3 y (SD = 4.5). The average annual incidence rate was 1.38 %. The odds ratios of the relationship between control variables and IHD incidence are shown in Table 1. The following factors were associated significantly with a higher IHD risk: Smoking, family history of IHD, age, body mass index, unemployment, area, IHD prevalence, and preexisting disease. The odds ratios are given for the total sample and the subsamples of subjects with and without prevalence of any chronic disease including IHD prevalence. The effect estimates are reasonably stable across the strata, particularly in factors which are virtually independent of the prevalence of diseases.

| Pooled sample, 6 y-follow-up | Odds ratio (95% confidence interval) | | |
|---|---|---|---|
| | Total sample | No preexisting disease | Preexisting disease |
| Control variable | N = 3950 | N = 2431 | N = 1519 |
| Social class (manual vs. partly skilled or unskilled) | 1.1 (0.7 - 1.4) | 1.0 (0.6 - 1.6) | 1.0 (0.6 - 1.6) |
| Social class (non-manual vs. partly skilled or unskilled) | 1.2 (0.8 - 1.7) | 0.9 (0.5 - 1.6) | 1.4 (0.8 - 2.3) |
| Social class (professional or intermediate vs. partly skilled or unskilled) | 1.1 (0.8 - 1.4) | 1.0 (0.7 - 1.8) | 0.9 (0.6 - 1.5) |
| Employment status (employed vs. unemployed) | 0.7 (0.5 - 0.9) | 0.6 (0.4 - 0.8) | 0.8 (0.5 - 1.1) |
| Smoking (ex-smoker vs. non-smoker) | 1.4 (1.0 - 2.2) | 1.5 (0.8 - 2.8) | 1.5 (0.9 - 2.6) |
| Smoking (current smoker vs. non-smoker) | 2.1 (1.5 - 3.3) | 2.7 (1.4 - 4.9) | 1.8 (1.1 - 3.2) |
| Family history of IHD | 1.5 (1.1 - 2.0) | 1.5 (1.0 - 2.3) | 1.5 (1.0 - 2.2) |
| Prevalence of IHD or any other preexisting disease | 2.0 (1.6 - 2.6) | – | – |
| - IHD prevalence | 2.1 (1.6 - 2.6) | – | – |
| - Prevalence of preexisting chronic diseases | 1.7 (1.3 - 2.1) | – | – |
| Area (Speedwell vs. Caerphilly) | 1.6 (1.3 - 2.2) | 1.5 (1.0 - 2.2) | 1.9 (1.3 - 2.7) |
| Age (per year) | 1.05 (1.02 - 1.08) | 1.06 (1.01 - 1.11) | 1.04 (1.00 - 1.09) |
| Body mass index (per kg/m$^2$) | 1.06 (1.02 - 1.09) | 1.05 (1.00 - 1.10) | 1.07 (1.02 - 1.11) |
| Subjective noise sensitivity | 0.9 (0.6 - 1.3) | 1.1 (0.6 - 1.9) | 0.8 (0.5 - 1.3) |
| (much or very much vs. not at all, a little or moderate) | | | |

**Table 1:** Association between control variables and IHD incidence.

Table 2 gives the number of men (percentages) for each disturbance/annoyance category. Dependent on the item, ca. 3-4 % of men were highly (categories 4 + 5 = often + always) and ca. 13-24 % considerably (categories 3 + 4 + 5 = sometimes + often + always) annoyed/disturbed by traffic noise.

| Item | Category | | | | |
|---|---|---|---|---|---|
| (noise effect) | 1 (never) | 2 (seldom) | 3 (sometimes) | 4 (often) | 5 (always) |
| "Annoyance" | 51.9 % | 24.7 % | 19.5 % | 2.7 % | 1.2 % |
| "Disturbed concentration" | 46.7 % | 29.1 % | 19.8 % | 2.9 % | 1.5 % |
| "Disturbed conversation, radio, TV" | 58.2 % | 23.2 % | 14.8 % | 2.8 % | 1.0 % |
| "Disturbed relaxation" | 59.1 % | 24.0 % | 13.6 % | 2.3 % | 1.0 % |
| "Feeling nervous or tense" | 68.4 % | 18.8 % | 10.2 % | 1.9 % | 0.7 % |
| "Difficulty in falling asleep" | 66.9 % | 18.3 % | 11.6 % | 2.3 % | 0.9 % |
| "Waking up at night" | 51.5 % | 24.8 % | 19.7 % | 2.9 % | 1.1 % |

**Table 2:** Distribution of subjective responses to traffic noise using the questionnaire categories.

Table 3 gives the percentages of highly annoyed/disturbed subjects in each traffic noise level category for the total sample and the 2 strata of subjects with and without preexisting chronic diseases.

| Item | Traffic noise level [dB(A)] | | | | $Chi^2$-Test | |
|---|---|---|---|---|---|---|
| (Categories: often + always) | 51-55 | 56-60 | 61-65 | 66-70 | Group | Trend |
| "Annoyance" | 2.1 % | 6.1 % | 6.1 % | 10.3 % | 0.000 | 0.000 |
| no preexisting disease | 1.7 % | 4.6 % | 5.3 % | 10.1 % | 0.000 | 0.000 |
| preexisting disease | 2.8 % | 8.6 % | 13.9 % | 10.5 % | 0.000 | 0.000 |
| | | | | | | |
| "Concentration" | 4.2 % | 4.2 % | 5.3 % | 5.0 % | 0.694 | 0.290 |
| no preexisting disease | 3.0 % | 3.8 % | 3.8 % | 32 % | 0.880 | 0.611 |
| preexisting disease | 6.0 % | 5.0 % | 7.5 % | 7.9 % | 0.688 | 0.356 |
| | | | | | | |
| "Conversation, Radio, TV" | 3.3 % | 3.7 % | 7.1 % | 5.0 % | 0.001 | 0.001 |
| no preexisting disease | 2.8 % | 3.4 % | 5.7 % | 3.7 % | 0.092 | 0.052 |
| preexisting disease | 4.1 % | 4.3 % | 9.1 % | 7.0 % | 0.021 | 0.008 |
| | | | | | | |
| "Relaxation" | 3.0 % | 2.6 % | 3.5 % | 6.0 % | 0.045 | 0.023 |
| no preexisting disease | 2.6 % | 1.7 % | 2.6 % | 2.1 % | 0.819 | 0.645 |
| preexisting disease | 3.6 % | 4.3 % | 4.8 % | 12.3 % | 0.000 | 0.000 |
| | | | | | | |
| "Nervous or tense" | 2.4 % | 2.6 % | 2.9 % | 3.6 % | 0.640 | 0.217 |
| no preexisting disease | 1.8 % | 2.1 % | 2.6 % | 1.6 % | 0.818 | 0.731 |
| preexisting disease | 3.4 % | 3.6 % | 3.2 % | 7.0 % | 0.274 | 0.186 |
| | | | | | | |
| "Falling asleep" | 2.9 % | 2.6 % | 4.4 % | 4.6 % | 0.134 | 0.032 |
| no preexisting disease | 2.6 % | 1.7 % | 3.4 % | 2.7 % | 0.690 | 0.743 |
| preexisting disease | 3.3 % | 4.3 % | 5.9 % | 7.9 % | 0.063 | 0.007 |
| | | | | | | |
| "Waking up" | 3.4 % | 4.5 % | 5.1 % | 6.3 % | 0.044 | 0.005 |
| no preexisting disease | 3.3 % | 2.5 % | 5.3 % | 3.7 % | 0.323 | 0.301 |
| preexisting disease | 3.7 % | 7.9 % | 4.8 % | 10.5 % | 0.003 | 0.002 |

**Table 3:** Percentages of highly annoyed/disturbed subjects in each noise level category.

Table 4 gives the prevalence of preexisting disease compared with the traffic noise exposure of the study subjects. Regarding objective noise measurements no associations between the outdoor traffic noise level and disease prevalence could be seen. However, regarding annoyance/disturbance ratings, significant trends towards higher prevalences in higher annoyed/disturbed subjects was found.

| Exposure variable | Exposure category | | | | $Chi^2$-Test | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | Group | Trend |
| (Traffic noise level [dB(A)]) | (51-55) | (56-60) | (61-65) | (66-70) | | |
| (Annoyance / Disturbance) | (never) | (seldom) | (sometimes) | (often+always) | | |
| Traffic noise level | 38.3 % | 37.0 % | 41.4 % | 41.4 % | 0.561 | 0.622 |
| Traffic noise level * | 38.7 % | 37.3 % | 38.2 % | 36.4 % | 0.905 | 0.518 |
| * adjusted for room orientation and window opening habits [5] | | | | | | |
| "Annoyance" | 37.3 % | 37.1 % | 40.5 % | 52.3 % | 0.001 | 0.003 |
| "Concentration" | 37.5 % | 35.5 % | 41.5 % | 54.9 % | 0.000 | 0.000 |
| "Conversation" | 37.0 % | 37.6 % | 42.6 % | 49.0 % | 0.003 | 0.001 |
| "Relaxation" | 37.0 % | 37.4 % | 43.4 % | 52.7 % | 0.000 | 0.000 |
| "Nervous or tense" | 36.4 % | 43.0 % | 40.0 % | 54.4 % | 0.000 | 0.000 |
| "Falling asleep" | 37.3 % | 37.2 % | 44.1 % | 49.6 % | 0.002 | 0.001 |
| "Waking up" | 37.0 % | 35.8 % | 44.1 % | 46.2 % | 0.000 | 0.000 |

**Table 4:** Prevalence of preexisting chronic diseases in different traffic noise exposed subjects.

Table 5 gives model-adjusted odds ratios of IHD incidence in different objectively and subjectively traffic noise exposed groups of subjects for the total sample, and the two subsamples of subjects with and without preexisting chronic disease (separate models). In the total sample, the association between IHD incidence and subjective measures of exposure (annoyance/disturbance) with non-significant relative risks, ranging between 0.9 and 1.4 in the highest exposure category of each item, does not tend to be any closer than with objective measures of exposure (traffic noise level) where non-significant relative risks range between 1.1 and 1.3 in the highest noise category. However, from the stratified analyses the presence effect modification (interaction) becomes obvious. In subjects with preexisting diseases no association between annoyance/disturbance due to traffic noise and IHD incidence was found. In fact, subjects in the highest exposure category (often or always = highly annoyed/disturbed) showed lower relative risks ranging between 0.4 and 1.0 depending on the item used than those in the lowest category (never annoyed/disturbed), which are not significant. On the other hand, in subjects with no preexisting disease those highly disturbed/annoyed showed higher relative risks of IHD incidence than those never annoyed/disturbed with relative risks ranging between 1.7 and 3.0, which is significant for some items. Regarding the traffic noise level, an opposite non-significant tendency of effect modification is found. While there was no higher IHD risk in noise exposed subjects without preexisting chronic diseases, a borderline effect was found in subjects with prevalent chronic diseases in the highest noise category (RR = 1.8, $p < 0.10$) when the outdoor noise level was adjusted for room orientation and window opening habits [4].

| Exposure variable | Exposure category | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| (Traffic noise level [dB(A)]) | (51-55) | (56-60) | (56-60) | (66-70) |
| (Annoyance / Disturbance) | (never) | (seldom) | (sometimes) | (often+always) |
| Traffic noise level | 1.00 | 0.71 (0.46-1.11) | 0.68 (0.44-1.03) | 1.07 (0.70-1.65) |
| no preexisting disease | 1.00 | 0.78 (0.42-1.47) | 0.97 (0.55-1.72) | 1.03 (0.55-1.94) |
| preexisting disease | 1.00 | 0.65 (0.35-1.23) | 0.44 (0.23-0.84) | 1.08 (0.60-1.95) |
| | | | | |
| Traffic noise level * | 1.00 | 0.69 (0.42-1.12) | 0.64 (0.37-1.09) | 1.31 (0.78-2.21) |
| no preexisting disease | 1.00 | 0.71 (0.35-1.43) | 0.89 (0.44-1.80) | 0.84 (0.36-1.99) |
| preexisting disease | 1.00 | 0.70 (0.35-1.38) | 0.43 (0.18-1.00) | 1.82 (0.92-3.58) |
| * adjusted for room orientation and window opening habits [5] | | | | |
| | | | | |
| "Annoyance" | 1.00 | 0.79 (0.58-1.08) | 0.93 (0.68-1.27) | 0.95 (0.52-1.75) |
| no preexisting disease | 1.00 | 0.70 (0.44-1.12) | 1.05 (0.67-1.65) | 2.45 (1.13-5.31) |
| preexisting disease | 1.00 | 0.85 (0.56-1.28) | 0.80 (0.52-1.23) | 0.43 (0.16-1.13) |
| | | | | |
| "Concentration" | 1.00 | 1.03 (0.77-1.36) | 0.86 (0.62-1.20) | 0.94 (0.50-1.74) |
| no preexisting disease | 1.00 | 1.21 (0.81-1.81) | 0.95 (0.57-1.56) | 1.91 (0.77-4.74) |
| preexisting disease | 1.00 | 0.86 (0.58-1.29) | 0.78 (0.50-1.22) | 0.62 (0.23-1.44) |
| | | | | |
| "Conversation, Radio, TV" | 1.00 | 0.96 (0.72-1.29) | 0.91 (0.64-1.29) | 1.23 (0.69-2.18) |
| no preexisting disease | 1.00 | 1.23 (0.82-1.86) | 0.78 (0.44-1.38) | 2.17 (1.00-4.70) |
| preexisting disease | 1.00 | 0.75 (0.49-1.15) | 0.97 (0.62-1.51) | 0.75 (0.32-1.75) |
| | | | | |
| "Relaxation" | 1.00 | 0.86 (0.64-1.16) | 0.89 (0.62-1.27) | 1.39 (0.76-2.54) |
| no preexisting disease | 1.00 | 0.94 (0.62-1.44) | 0.75 (0.41-1.36) | 2.61 (1.14-6.01) |
| preexisting disease | 1.00 | 0.77 (0.51-1.18) | 1.00 (0.63-1.59) | 0.86 (0.36-2.04) |
| | | | | |
| "Nervous or tense" | 1.00 | 1.19 (0.88-1.60) | 0.92 (0.60-1.40) | 1.28 (0.63-2.62) |
| no preexisting disease | 1.00 | 1.01 (0.63-1.61) | 0.98 (0.53-1.82) | 3.00 (1.12-8.02) |
| preexisting disease | 1.00 | 1.29 (0.87-1.91) | 0.86 (0.48-1.54) | 0.77 (0.28-2.14) |
| | | | | |
| "Falling asleep" | 1.00 | 1.07 (0.42-1.76) | 1.09 (0.76-1.57) | 0.86 (0.42-1.76) |
| no preexisting disease | 1.00 | 1.02 (0.65-1.60) | 0.76 (0.40-1.42) | 1.70 (0.70-4.17) |
| preexisting disease | 1.00 | 1.11 (0.72-1.71) | 1.34 (0.85-2.11) | 0.44 (0.13-1.45) |

| Exposure variable | Exposure category | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| "Waking up" | 1.00 | 1.10 (0.82-1.47 | 1.01 (0.74-1.39) | 1.38 (0.79-2.40) |
| no preexisting disease | 1.00 | 1.42 (0.94-2.15) | 1.15 (0.71-1.86) | 2.06 (0.93-4.56) |
| preexisting disease | 1.00 | 0.83 (0.54-1.27) | 0.92 (0.60-1.40) | 1.05 (0.49-2.24) |

**Table 5:** Model-adjusted odds ratios of IHD incidence for different traffic noise exposed subjects (odds ratio, 95%-confidence intervals) of the total sample (N=3950) and the subsamples of subject with no preexisting chronic disease (N=2431) and with preexisting disease (N=1519).

## 4 - CONCLUSION

The results of this prospective cohort study of the association between road traffic noise and incidence of IHD give some support to the hypothesis that subjects with health problems − not to say sick people − may be a risk group for adverse health effects of environmental noise when the objective noise level is considered. The simple explanation may be that these peoples' organisms may have less resources to cope with the noise stress. Or, the noise may further increase the level of psycho-physiological arousal which may be already higher in people with health problems [8]. In noise level regulations sick people are often considered as a potential risk group of higher susceptibility towards noise stress. However, regarding cardiovascular health this was not proven before in a prospective epidemiological traffic noise study.

As far as ratings of annoyance/disturbance are concerned, subjects with preexisting diseases were not at higher risk for IHD incidence when more annoyed/disturbed by traffic noise. Recall bias can be an explanation of the interaction phenomena [9]. The noise interview was made after the clinical interviews. This means that diagnostic bias and overreporting of disease history was not a problem in the study. However, due to the presence of a chronic disease overreporting of exposure (annoyance/disturbance) may have occurred. Diseased subjects are more likely to give "wrong" (exaggerated) answers about their annoyance/disturbance by traffic noise in the interview although not virtually being stressed by the noise (e.g., because they may tend to blame their environment for their health difficulties). This source of differential exposure misclassification could have lead to an underestimation of the true effect of the disturbance/annoyance by traffic noise on IHD incidence in the total sample. Consequently, in the subsample free of preexisting diseases where this source of exposure misclassification was not present, the subjects highly annoyed/disturbed by traffic noise had a markedly and in some cases significantly higher risk of IHD incidence. These associations were stronger than those with the traffic noise level, which is in accordance with the effect chain of the noise hypothesis.

In conclusion, prevalence of a disease is an important effect modifier on the relationship between noise and cardiovascular health outcome. Subjective responses to the noise in epidemiological studies and social surveys must be viewed with caution − not only in cross-sectional studies. They may be strongly influenced by the prevalence of diseases. Due to recall bias (overreporting) the true effect of interest may be diluted if the analysis does not account for this kind of interaction.

## REFERENCES

1. **Babisch W, Ising H, Gallacher JEJ, Elwood PC**, Traffic noise and cardiovascular risk: the Caerphilly study, first phase. Outdoor noise levels and risk factors, *Arch Environ Health*, Vol. 43, pp. 407-414, 1988

2. **Babisch W, Ising H, Gallacher JEJ, Sharp DS, Baker IA**, Traffic noise and cardiovascular risk: the Speedwell study, first phase. Outdoor noise levels and risk factors, *Arch Environ Health* , Vol. 48, pp. 401-405, 1993

3. **Babisch W, Ising H, Elwood PC, Sharp DS, Bainton D**, Traffic noise and cardiovascular risk: the Caerphilly and Speedwell studies, second phase. Risk estimation, prevalence, and incidence of ischemic heart disease, *Arch Environ Health*, Vol. 48, pp. 407-413, 1993

4. **Babisch W, Ising H, Gallacher JEJ, Sweetnam PM, Elwood PC**, Traffic noise and cardiovascular risk: The Caerphilly and Speedwell studies, third phase - 10 years follow-up, *Archives of Environmental Health*, Vol. 54, pp. 210-216, 1999

5. **Babisch W**, *Epidemiological studies on cardiovascular effects of traffic noise, Advances in noise research, Volume 1: Biological effects of noise*, Prasher D, Luxon L, eds., London: Whurr Publishers Ltd., pp. 312-327, 1998

6. **MRC Epidemiology Unit**, *Epidemiological studies of cardiovascular diseases. Progress report VII*, ISBN 0 9508951 3 X. Cardiff: MRC Epidemiology Unit, 1991

7. **MRC Epidemiology Unit Cardiff**, *The Caerphilly Collaborative heart Disease Studies. Project description and manual of operations*, ISBN 0 9508951 1 3. Cardiff: MRC Epidemiology Unit, 1985

8. **Jansen G**, Effects of traffic noise on critical groups, *Zeitschrift für Lärmbekämpfung*, Vol. 34, pp. 152-156, 1987

9. **Hennekens CH, Buring JE**, *Epidemiology in medicine*, Boston/Toronto: Little, Brown and Company, 1987