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ANNOYANCE DUE TO NOISE AND AIR POLLUTION TO THE RESIDENTS OF HEAVILY FREQUENTED STREETS

H. U. Wanner, Brigit Wehrli, J. Nemecek, V. Turrian

Translation of "Die Belaestigung der Anwohner verkehrsreicher Strassen durch Laerm und Luftverunreinigungen", Sozial - und Praeventivmedizin, Vol. 22, p. 108-122, 1977.

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| 16. Abstract The residents of different streets with varying traffic density and building density were questioned about annoyance due to traffic noise and air pollution. The results show that annoyance felt is dependent not only on the measured noise levels and/or air pollution concentrations, but that there do exist interactions between the residential quarters, and annoyance. These interactions should be considered while fixing the limits and standards. | | |
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THE ANNOYANCE DUE TO NOISE AND AIR POLLUTION TO THE RESIDENTS OF HEAVILY FREQUENTED STREETS

H. U. Wanner, Brigit Wehrli, J. Nemecek, and Verena Turrian*

HOW LARGE IS THE DEGREE AND THE FREQUENCY OF NOISE AND AIR POLLUTION ANNOYANCE UNDER INNER-CITY CONDITIONS? THE SUBJECTIVE RESPONSE TO THE ANNOYANCES THAT ARE USED TO DEFINE LIMITING VALUES WERE DETERMINED IN INQUIRIES IN THE CITY OF ZÜRICH.

1. INTRODUCTION AND DEFINITION OF THE PROBLEM

Environmental hygiene is nowadays not only concerned with /108** the identification of toxic effects by foreign substances in water and air, but more and more with environmental conditions that are not immediately the cause of illness. Such environmental conditions, for instance noise and air pollution, nevertheless may be the cause for physiological change processes (such as biochemical changes or reactions of the central nervous system) or they are felt subjectively as an annoyance.

Such annoyances through emissions into the environment whatever their type may reduce the physical and psychological health and, in this sense, they are an impairment of health according to the definition of the WHO. In order to assess the damage to health caused by the environment, it is necessary to develop criteria for the degree of annoyance. In this endeavor one encounters several problems of measurement technique in that simple physiological parameters or inquiries with respect to one particular annoyance factor are not sufficient. On the

* Institut für Hygiene und Arbeitsphysiologie
Eidgenössische Technische Hochschule, CH-8092 Zurich

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the contrary, it is necessary to compare statements with respect to different disturbance factors. In this respect of importance are data on direct reactions and behavioral changes, aside from the statements on the annoyance level, so that it becomes possible to estimate the degree to which an intended behavior has been impaired or prevented.

Additional factors of importance in influencing the degree and type of annoyance are habituation and sensitizing; in addition, there are the effects of generalization and transfer, that is the response to certain disturbances by its general social importance. As a consequence of this complexity, the annoyance by traffic noise, to quote an example, cannot be the same for all people. Young and old people, and inhabitants of various quarters will respond by different value scales and reactions. At this point, the question as to formation of representative groups appears, in particular, with respect to the definition of permissible levels and limiting values.

Previous investigations on annoyance by traffic noise were based on relationships between the number of annoyed persons and the measured level of noise. This type of "dose-effect relationship" is basic for an assessment of the degree of annoyance; however, whenever one wants to determine the level of permissible noise to be defined for a given group of persons, difficulties appear. This type of assessment requires the inclusion of additional boundary conditions, such as the influence of additional factors and the response to specific sources of disturbance. It would also be desirable to check the subjective annoyance against other, for instance, physiological studies.

The current work compares the annoyance due to two primary sources in city traffic, that is, noise and air pollution; the effect of the local situation is taken into account as much as possible. We have questioned the inhabitants of streets in four quarters with different traffic density and building density.

The program is part of a research project on air pollution on roads [8] supported by the "Schweizerische Nationalfonds."

2. DESCRIPTION OF THE QUARTERS

The streets of our study are in the older, relatively central section of the city of Zurich. In the case of three of the quarters, the streets have high traffic density and are immediately adjacent to the living quarters: Wehntalerstrasse, Winterthurerstrasse, and Langstrasse. The quarter "Oerlikon" with purely local traffic was chosen for comparison purposes.

OERLIKON (OE): Residential area with multi-family houses /109 and some small one-family houses on landscaped lots. The age of the buildings is between 20 and 40 years. On the whole, the building density is low with lots of greenery; the quarter is situated between two major traffic arteries.

WEHNTALERSTRASSE (WE): Residential quarter along a major artery; multi-family houses of similar construction, all about 40 years old. Relatively low building density with lots of greenery. Two groups may be distinguished in this quarter: houses situated directly along the road, and houses farther back, behind the first row. The first group will be called "up front" (WE_v), the second "behind" (WE_h).

WINTERTHURERSTRASSE (WI): Residential area with a few offices. Situated at a traffic artery with streetcars. Multi-family houses of similar construction, age about 50 - 60 years. High density, no gardens.

LANGSTRASSE (LA): Residential and commercial area, mixed offices, restaurants. Multi-family houses, mostly old and partly in bad repair. Very high density. No gardens.

Table 1 shows the noise levels measured in the four quarters. The measurements were made on 2 days each in summer and

winter, each time during 24 hour periods. In 3 of the quarters additional measurements were made, 30 minutes each; this allows to determine the average level in a quarter. The three traffic arteries are typical for inner-city streets with high traffic density and noise levels. By contrast, Oerlikon is considered a relatively quiet inner-city residential area.

Table 2 shows the major measurements of air pollution. The gaseous components were measured in each quarter at 20 - 25 locations simultaneously in summer and winter. Suspended dust was measured during a year at a location in Oerlikon, one at Wehntalerstrasse, and one at Langstrasse. The measuring technique and the health implications of these measurements were already published elsewhere in detail [1, 6].

| | Quarter | | | |
|--|----------|------------------|---------------------|-------------|
| | OERLIKON | WEHNTALERSTRASSE | WINTERTHURERSTRASSE | LANGSTRASSE |
| Building type and location of the measuring location | | | | |
| Traffic density (vehicles per hour): | | | | |
| During the day (06-22 h) | 147 | 514 | 1668 | 990 |
| During the night (22-06 h) | 28 | 94 | 366 | 594 |
| Number of lanes | 1-7 | 4 | 2 plus streetcar | 2 |

Figure 1. Schematic representation of the four quarters.

Wehntalerstrasse: 2 groups

v = "up front" (houses next to the street) and

h = "behind" (houses in the back)

● = Noise (continuous measurements for 24 hours)

○ = Noise (30 minute measurements)

□ = gaseous component of air pollution (30 minute measurements)

■ = suspended dust (long-term measurement, one year)

3. METHODOLOGY OF QUESTIONING

The questioning was carried out in written form through questionnaires. In the case of the Langstrasse, Wehntalerstrasse, and Winter-

thurerstrasse all inhabitants along about 1 km were included; in the case of Langstrasse, the inhabitants of the first houses on streets branching off were also included. In the case of Oerlikon, the inhabitants of 10 streets in the quarter were included. In households with several adult members one particular person was addressed in order to obtain a homogeneous sample with respect to age and sex.

TABLE 1. NOISE LEVEL IN THE FOUR QUARTERS. AVERAGE VALUES OF 4 CONTINUOUS MEASUREMENTS EACH DURING 24 HOURS. IN PARENTHESSES THE RANGE OF THE 30 MINUTE SAMPLES AT ADDITIONAL LOCATIONS (SEE FIGURE 1).

| Noise level | Quarter | | | | |
|--------------------------|------------|-----------------|-----------------|----|----|
| | OE | WE _h | WE _v | W: | SA |
| During the day (06-22 h) | | | | | |
| L ₅₀ | 55 (53-61) | 56 (55-61) | 67 | 73 | 74 |
| L ₁ | 74 (67-82) | 71 (62-77) | 81 | 86 | 86 |
| L _{eq} | 62 (57-70) | 61 (56-67) | 70 | 77 | 77 |
| During the night (22-06) | | | | | |
| L ₅₀ | 42 | 42 | 48 | 58 | 67 |
| L ₁ | 67 | 61 | 73 | 80 | 83 |
| L _{eq} | 53 | 50 | 62 | 69 | 73 |

TABLE 2. AIR POLLUTION IN THE FOUR QUARTERS. AVERAGE VALUES OF THE GASEOUS COMPONENTS (30 MINUTE SAMPLES, MEASURING DAYS DURING THE SUMMER OF 1975 AND THE WINTER OF 1975/76. SUSPENDED DUST: WEEKLY SAMPLES BETWEEN OCTOBER 1975 AND SEPTEMBER 1976). FOR THE LOCATION OF THE MEASURING PLACES SEE FIGURE 1.

| Noise level | Quarter | | | | |
|---|---------|-----------------|-----------------|-----|------|
| | OE | WE _h | WE _v | W: | SA |
| Carbon monoxide (ppm) | 0.8 | 1.0 | 1.6 | 7.2 | 13.5 |
| Nitrogen monoxide (ppb) | 33 | 28 | 61 | - | 241 |
| Nitrogen dioxide (ppb) | 21 | 21 | 29 | - | 52 |
| Carbohydrates without methane (ppm) | 0.5 | 0.3 | 0.4 | - | 2.6 |
| Sulfur dioxide (ppb) | 11 | 10 | 13 | - | 54 |
| Formaldehyde (ppb) | 9 | 9 | 13 | - | 13 |
| Particulate matter (ug/m ³) | 68 | - | 72 | - | 36 |

A total of 1958 persons were addressed, 1297 replied; thus, the return percentage was 66%. By quarter the figures were 71% for Oerlikon, 67% for Wehntalerstrasse, 75% for Winterthurerstrasse, and 50% for Langstrasse.

4. COMPARABILITY OF THE QUARTERS WITH RESPECT TO THE SOCIAL SITUATION

The most important social structures in a quarter are age and social distribution of the inhabitants and the time during which they have lived in the quarter.

There are significant differences in the age structure of the quarters in that the quarters with the oldest buildings, that is Winterthurerstrasse and Langstrasse, also have a greater age of the inhabitants. As a result, the percentage of 60-year old persons is different in the quarters: /110

| | |
|-----------------------|-----|
| - Oerlikon | 28% |
| - Wehntalerstrasse | 21% |
| - Winterthurerstrasse | 40% |
| - Langstrasse | 42% |

The comparison figure of the percentage of 60-year old persons among the adults of the entire city of Zurich is 30% [2].

The social structure of the inhabitants in the quarters is slightly, but not significantly different. The professional structure and the income distribution are essentially comparable. Most of the inhabitants belong to the lower middle class (workers and white-collar workers with an average income of about 3000 sfr).

However, there are some educational differences. The majority of the male inhabitants had finished Sekundarschule with subsequent job training. The inhabitants of Langstrasse have

a somewhat lower educational level (23% of the males did only attend Volksschule), whereas the inhabitants of Winterthurerstrasse have a somewhat higher level (34% attended a Mittelschule).

The percentage of non-employed persons (housewives, social security recipients) among the persons questioned is also comparable; this may be of importance for the annoyance problem. There is a higher percentage of social security recipients in Langstrasse and Winterthurerstrasse, but it is compensated by a higher percentage of housewives in Oerlikon and Wehntalerstrasse.

TABLE 3. FREQUENCY OF ANNOYANCE DUE TO TRAFFIC NOISE, RELATED TO THE TIME OF DAY WITH THE MAXIMUM DISTURBANCE:

| Quarter | N | Seldom or never annoyed | Often annoyed | Time of day with the largest annoyance in the case of persons who were often disturbed (100% = total of often disturbed persons). | | | |
|-----------------|-----|-------------------------|---------------|---|-------|-------|-------|
| | | | | 06-09 | 09-19 | 19-22 | 22-05 |
| OE | 375 | 42 | 16 | 16 | 19 | 25 | 40 |
| WE _h | 91 | 18 | 45 | 2 | 27 | 27 | 44 |
| WE _v | 248 | 6 | 67 | 8 | 26 | 28 | 39 |
| WI | 228 | 5 | 71 | 18 | 35 | 19 | 29 |
| LA | 191 | 6 | 72 | 3 | 10 | 15 | 72 |

The number of years during which the inhabitants had lived in the quarters was essentially the same. Since all quarters are established since a long time, more than half of the inhabitants lived in their quarters more than 10 years, about 25% lived there for 4-10 years, and 25% lived in their quarters for less than 3 years.

In summary we conclude that the social structure of the four quarters is not significantly different with the result that the social boundary conditions should not influence the response to noise and air pollution.

5. SUBJECTIVE RESPONSE TO NOISE AND AIR POLLUTION

Table 3 summarizes the data on the frequency of disturbances by traffic noise, in relation to the time of day with most of the annoyance. The questionnaire requested a time of maximum annoyance; only a number answer was possible.

TABLE 4. DEGREE OF ANNOYANCE DUE TO TRAFFIC NOISE, IN RELATION TO THE TIME OF DAY WITH MAXIMUM ANNOYANCE. CLASSIFICATION OF THE DEGREE ACCORDING TO THE "NOISE THERMOMETER": 0-3 WEAK, 4-7 MEDIUM, 8-10 STRONG.

| Quarter | Maximum annoyance during the day | | | | Maximum annoyance during the night | | | |
|-----------------|----------------------------------|---|----|----|------------------------------------|---|----|----|
| | Total N | Degree of annoyance Weak Medium Strong | | | Total N | Degree of annoyance Weak Medium Strong | | |
| OE | 228 | 63 | 30 | 7 | 148 | 69 | 24 | 7 |
| WE _h | 60 | 28 | 52 | 20 | 31 | 31 | 38 | 31 |
| WE _v | 156 | 12 | 52 | 36 | 92 | 3 | 39 | 58 |
| WI | 162 | 4 | 39 | 57 | 66 | 9 | 39 | 52 |
| LA | 67 | 12 | 49 | 39 | 124 | 6 | 39 | 55 |

We have found that with the exception of Oerlikon a large percentage of the people, in the case of houses directly on heavy-traffic streets even the majority, felt annoyed frequently. However, the time of day with maximum annoyance differs. As a whole, the largest percentage of people was annoyed during the night, except in the case of Winterthurerstrasse; however, the figures are only significant at the houses in the back of ("behind") ~~Wehntalerstrasse~~ and on Langstrasse.

We have in addition to the frequency of annoyance, obtained data on the intensity. The degree of subjectively felt annoyance was measured by asking the respondents to classify their

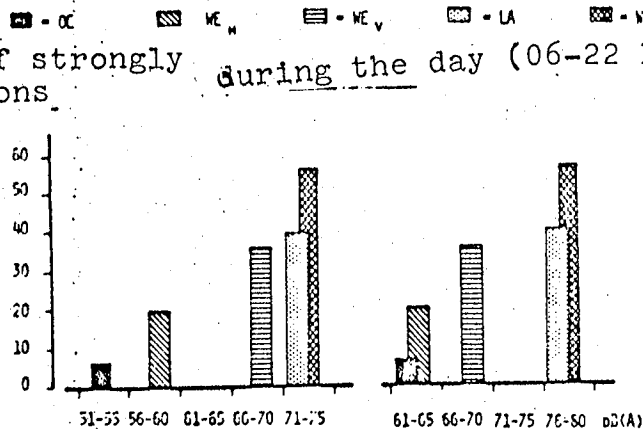
response on a "noise thermometer" which had been previously tested [9]; the scale ranges from 0 to 10. Level 0 means no noise disturbance, level 10 that the annoyance is unbearable.

Table 4 shows a summary of the degree of annoyance during day and night hours. We find, as we did with respect to frequency, that with the exception of the Winterthurerstrasse the percentage of annoyed people is larger during the night.

Figure 2 shows these statements as a function of the corresponding noise levels. The relationship between the measured noise levels (average noise level L_{50} and equivalent continuous noise level L_{eq}) and the amount of annoyance is more pronounced during the day than during the night. Nevertheless, neither L_{50} nor L_{eq} show a clear correlation with the percentage of strongly annoyed individuals. The following points are of interest:

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percentage of strongly annoyed persons during the day (06-22 h)



Percentage of strongly annoyed persons during the night (22-06 h)

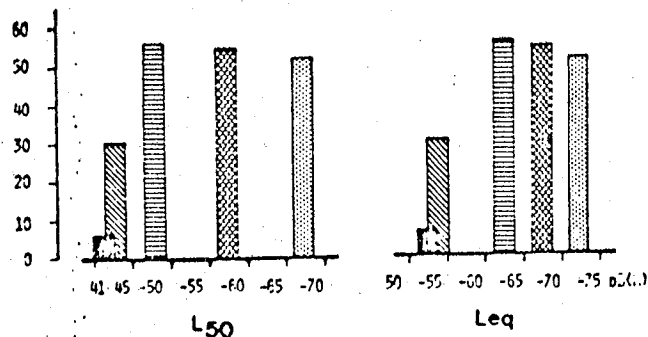


Figure 2. Noise pollution and subjective annoyance: during the day and during the night.

- Given the same noise level (both L_{50} and L_{eq}) the percentage of strongly annoyed persons during the day is 39% at Langstrasse, but 57% at Winterthurerstrasse. In the same range of L_{eq} values 7% in Oerlikon were strongly annoyed; the corresponding value at the houses in the back of Wehntalerstrasse was 20%. The discrepancies are even more obvious during the night: Oerlikon 7% and 31% at the rear end of Wehntalerstrasse, with the L_{50} and L_{eq} values about the same.

- The percentage of strongly annoyed persons during the night is about the same as the front end of Wehntalerstrasse, on Langstrasse, and Winterthurerstrasse, although the noise levels were quite different. Even with L_{eq} values in the range of 61-65 dB(A) more than 50% of the inhabitants are strongly disturbed; however, the percentages do not increase with increasing noise levels.

- Particularly high are the percentages of strongly disturbed persons during the night in the cases where the houses are directly on traffic arteries. Taking the group which responded by the thermometer value of 10 (unbearable), we quote the persons on Langstrasse: 75% quoted maximum disturbances during the night.

The sensitivity during the night is equally obvious in Figure 3. Although the L_{eq} values are lower during the night (this is particularly pronounced in the case of WE_h), the percentage of strongly annoyed persons is significantly increased in the case of Wehntalerstrasse and Langstrasse.

Figure 4 shows the dependence of the number of strongly annoyed persons on the traffic frequency. The correlation is fairly good during the day. Thus, it is conceivable that the difference between the percentages of strongly annoyed persons between the Winterthurerstrasse and Langstrasse has to do with traffic frequency. There is the complication that

TABLE 5. FREQUENCY AND DEGREE OF ANNOYANCE DUE TO AIR POLLUTION. PERCENTAGES OF "OFTEN" DISTURBED PERSONS AND OF "STRONGLY" DISTURBED PERSONS (SCALE RANGE 8-10).

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| Quarter | N | Often annoyed persons (%) | Strongly annoyed persons (%) |
|-----------------|-----|---------------------------|------------------------------|
| CE | 480 | 13 | 7 |
| WE _h | 97 | 25 | 12 |
| WE _v | 263 | 45 | 26 |
| WI | 248 | 73 | 50 |
| LA | 209 | 64 | 47 |

As we did in the case of traffic noise, the frequency and intensity of the subjective annoyance was researched in the case of air pollution: Again, the intensity was determined by the interrogated persons themselves on a "thermometer."

Table 5 summarizes the degree and the frequency of annoyance due to air pollution. The correlation of the subjective annoyance and of the level of actual pollution is not very good; the amount of pollution is clearly largest on Langstrasse. This is due to two factors: on the one hand, the gaseous pollutants (with the CO and NO₂ components) are difficult to observe by the victims, while there is a strong correlation between the annoyance by noise and by pollution so that we may assume that the inhabitants of a street with a high noise level automatically assume that the degree of pollution, too, is very high.

In summary, we find the following correlations among the annoyance measures:

- Frequency of annoyance due to air pollution and frequency of annoyance due to noise $\gamma = 0.78$
- Intensity of disturbance due to air pollution and intensity of disturbance due to noise: $\gamma = 0.72$.

This relationship is represented in fig. 5. We see that in the case of Wehntalerstrasse the number of people disturbed by air pollution is 2 to 3 times as high as in Oerlikon, although the emission concentration is fairly low in Wehntalerstrasse. The number of people complaining about air pollution is about as high in Winterthurerstrasse as in Langstrasse, although in the latter location the concentration of gaseous as well as suspended pollutants is about twice as high. The fact that we obtain everywhere high correlations between the subjective annoyance by noise and by air pollution probably means that the annoyance felt by air pollution depends on the intensity of annoyance due to noise.

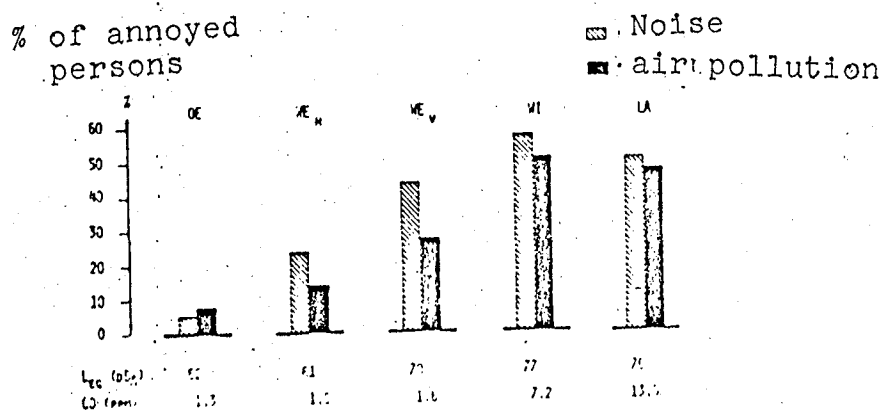


Figure 5. Comparison of the subjective annoyance due to noise and due to air pollution.

TABLE 6. INTENSITY OF ANNOYANCE DUE TO NOISE AND AIR POLLUTION AS A FUNCTION OF AGE, BASED ON THE "THERMOMETER" WITH THE SCALE RANGE 8-10 = STRONGLY ANNOYED.

| Age group (years) | N | Percentage of strongly annoyed persons by noise (%) | Percentage of strongly annoyed persons by air pollution (%) |
|-------------------|-----|---|---|
| < 30 | 241 | 16 | 22 |
| 30 - 50 | 410 | 23 | 32 |
| > 50 | 634 | 34 | 37 |

6. SOCIAL INFLUENCES AND THE INFLUENCE OF THE LOCATION OF THE LIVING QUARTERS

The strongest influence with respect to the subjective annoyance is presented by age both in case of noise and air pollution (see Table 6).

The stronger reaction by older people is also seen in the difference of the individual reactions. Older people are more often scared by a noise event, and they take more frequently sleeping pills because of the noise (see Section 7).

We have not found an influence of the duration of habitation with respect to noise annoyance which would lead to some getting use to the noise, or conversely, a successive sensibilization.

The location of the living quarters were generally of little importance for the degree of annoyance due to noise. There was a weak correlation with the height above ground: The inhabitants of the ground floor and the first level up were a little less frequently disturbed to a large degree than the inhabitants of floors higher up.

There is a certain influence of the location of the rooms with respect to noise annoyance: The percentage of persons who feel "strongly disturbed" by noise is significantly higher, if the living or bedroom faces the street. This difference is only noticeable, if the house is directly on the street. The degree of annoyance due to air pollution does not depend on the location of the rooms.

7. CONSEQUENCES AND REACTIONS

The most important health impairments due to noise have to do with sleeplessness. Table 7 shows that 35 to 40% of the

inhabitants of quarters with a high noise level complain about disturbances of the recreative functions (sleep and recreation). About a third of the inhabitants of these quarters also complain about disturbances of communicative functions. This type of disturbance is a little less pronounced on Langstrasse than on Wehntalerstrasse and Winterthurerstrasse, although the noise levels are about the same. This situation is similar to the one already noted with respect to the intensity of disturbances; note, in particular, the day-time situation on Lanstrasse and Winterthurerstrasse (see Table 4).

TABLE 7. DISTURBANCES OF LIVING FUNCTIONS DUE TO NOISE.

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| Living function | Percentage of frequent disturbances | | | | |
|---|-------------------------------------|-----------------|-----------------|----|----|
| | OE | WE _h | WE _v | WI | LA |
| Recreative functions (sleep, recreation) | 7 | 21 | 39 | 35 | 40 |
| Communicative functions (Radio, TV, telephone) | 5 | 20 | 30 | 30 | 22 |
| Productive functions (work) | 1 | 4 | 12 | 19 | 15 |

TABLE 8. REACTIONS TO NOISE ANNOYANCE

| Reactions | Percentage of frequent reactions | | | | |
|---|----------------------------------|-----------------|-----------------|----|----|
| | OE | WE _h | WE _v | WI | LA |
| Consumption of sleeping pills and tranquilizers | 10 | 27 | 28 | 23 | 33 |
| Use of ear plugs | 7 | 13 | 17 | 21 | 30 |
| Closing the windows (during the day) | 11 | 21 | 60 | 69 | 57 |
| Improving the insulation of the living quarters. | 2 | 11 | 13 | 29 | 24 |

There are basically two types of reactions: Reactions that are aimed at an improved adaptation, and the solution of moving

out. Table 8 shows a summary of this type of "adaptation reactions." Aside from the pervasive reaction of closing the windows the sleeping-pill consumption and the use of ear plugs are most frequent. The statements are closely correlated with the percentage of "strongly annoyed" persons in the respective quarters. Considering people older than 50 years, responsible for a larger percentage of "strongly annoyed" persons, we find an increase of individuals taking sleeping pills because of the noise problem to 28% by comparison with the group of 30-50 year old people (21%) and the group below 30(9%).

TABLE 9. INTENT TO MOVE OUT DUE TO NOISE AND AIR-POLLUTION PROBLEMS (MULTIPLE STATEMENTS POSSIBLE)

| Quarter | N | Percentage of inhabitants with moving intentions | |
|-----------------|-----|--|----------------------|
| | | Due to noise | Due to air pollution |
| OE | 451 | 7 | 6 |
| WE _n | 97 | 17 | 3 |
| WE _v | 263 | 32 | 14 |
| WI | 248 | 35 | 27 |
| LA | 209 | 38 | 21 |

A clear difference among the quarters is shown by moving intentions (Table 9). If one considers the age of the respondents it is clear that younger people are more ready to move out. The reasons for the moving intentions may be different; in any case, younger people do not consider the living situation as definitive. The older people have, presumably, a closer relationship with their quarters; this may be the reason for their more "individually defensive" reaction against disturbances, such as taking sleeping pills and using ear plugs against noise. The largest differences are found on Winterthurerstrasse: Here, 57% of the people below 30 would like to move out, but only 26% of the people older than 50.

8. CONCLUSIONS

We find the following general conclusions: Among the inhabitants of quarters with traffic arteries of high vehicle frequencies about two thirds are frequently disturbed by noise and air pollution, half are "strongly" disturbed; the percentage of people who are "occasionally", "weakly", or "never" disturbed is less than 10%. By comparison, in the case of the Oerlikon quarter with its local traffic the percentage of the "strongly" disturbed people is only 7%, whereas about two thirds of the people claim to be "mildly" disturbed, 40% "seldom" or "never." In general, the annoyance is more pronounced at night, in particular by older people. The same behavior is evidenced by the different reactions to the noise annoyance: About a third of the inhabitants of quarters next to traffic arteries complain about sleeplessness, about the same number of people use sleeping pills or tranquilizers, about 25% experience disturbances of their communicative functions, and a third has plans to move out either because of noise or air-pollution annoyance. By comparison, in the case of the Oerlikon quarter, the values are between 5 and 10%.

If one compares the frequency and the intensity of the subjective annoyance with the measured noise levels or the concentrations of dust or gaseous pollutants, the four quarters we have investigated do not present a clear picture. For instance, the percentage of people who are "strongly" disturbed in the off-street houses on Wehntalerstrasse, both during the day and during the night, is significantly higher than in Oerlikon; this is in spite of the essentially similar levels of noise and air pollution. The location next to traffic artery probably influences the reactions, even if the row of houses between the specific location and the artery significantly reduces the noise level and the air pollution. Additional problems, related to the high /114

traffic volume, such as the increased accident risk, the difficulty to cross the street, the separation of a formerly unified quarter by the artery, may influence on the subjective annoyance by noise and air pollution. The inhabitants of Oerlikon, by contrast (some of them being the owners of one-family houses with gardens), have a more positive reaction to their living area. As a result, the percentage of "strongly" annoyed people by noise (at a relatively high level, in fact) remains below 10%.

An "influence of the quarter" of another type is probably responsible for some of the responses from Langstrasse: Here, the percentage of "strongly" annoyed people is noticeably smaller than in the case of the otherwise similar Winterthurerstrasse quarter (including the smaller amount of disturbances of the communicative functions); this may have to do with the fact that Langstrasse with its many offices, businesses and restaurants has intrinsically a higher noise level which is accepted, in particular, since quite a few of the inhabitants are related to these business enterprises. In summary we conclude that the noise level alone does not allow conclusions as to the percentage of annoyed individuals. One must take the specific details of a quarter into account.

TABLE 10. Noise levels and the quality of living areas [10]

| L_{50} in dB(A) During the day | Percentage of annoyed persons | Evaluation of the quality living area |
|-------------------------------------|----------------------------------|---|
| Up to 50 | 3 -5 | Quiet living area |
| 51-60 | 5 -12 | Living area with average noise disturbances |
| 61-65 | 20-25 | High noise level; measures ought to be taken. |
| above 65 | above 50 | Very high noise level; drastic changes required. |

A relatively good correlation was found between the percentage of "strongly" disturbed persons during the day and the traffic frequency. By contrast during the night, about 50% of the people thought to be "strongly" annoyed at an average level of 100 vehicles per hour, and this number did not increase even at the level of 600 vehicles/hour. Additional indications to the effect that the traffic frequency is an important parameter in evaluating the intensity of disturbances are found in Swedish investigations [5]. The best correlation here was found with the frequency of truck traffic. Further studies have to show that these tentative conclusions have a general validity.

Of particular importance for the establishment of limiting values are the often highly significant differences in the subjective annoyances between day and night. We find that during the night the percentage of people who are "strongly" disturbed is larger than during the day; this is in contradiction to a study made in Vienna, where it was found that during the day more people are disturbed by noise than during the night [4]. Aside from this discrepancy, the Vienna study has also shown a very good correlation between annoyance by noise and by air pollution, with the noise being the crucial factor.

If we compare our results on the four inner-city quarters with those of the study "Wohnen im Neubau" [living in new housing areas], [9], and the "Flugarmstudie" [Aircraft noise study], [3], which contain the results of questionnaires on traffic noise, we see that in these studies, during the day, the L_{50} levels were around 56-60 dB(A) and resulted in about 10% of "strongly" disturbed persons, that is about the same number we found in Oerlikon. On the 66-70 dB(A) level, these studies had about 50% or just a little more than we found on the front portion of Wehntalerstrasse at corresponding noise levels. The disturbances of communicative functions and reactions at

comparable noise levels were of the same order of magnitude." A study in Paris [2] obtained a relation between the subjective noise annoyance and the general satisfaction with the living area; this study regarded the satisfaction with the living room as an input variable for the intensity of the noise annoyance.

Table 10 shows a noise-level classification on the basis of the two studies in Switzerland [9]. On this basis, the noise disturbance on Wehntalerstrasse, Winterthurerstrasse, and Langstrasse (L_{50} values between 67 and 74 dB(A) during the day and between 48 and 67 dB(A) during the night) is very high; this is in agreement with more than 50% of the people being "strongly" annoyed by noise. It is obvious that in these quarters the critical limit for noise annoyance beyond which health-impairing events due to noise disturbance occur in increasing numbers has been exceeded. Drastic changes, either by architectural or traffic means, must be undertaken. Similar measures should be contemplated in the case of the rear end of Wehntalerstrasse with its 20 - 25% "strongly" annoyed persons.

Questionable are still the evaluation criteria for permissible noise levels during the night; it is clear, however, that a situation in which more than 50% of the inhabitants are "strongly" disturbed by noise, as is the case with the above streets, is not within permissible limits.

If plans are made with respect to nominal and limiting values or if improvements are mapped out, the evaluations of the type studied in this work on noise and air-pollution annoyance should be taken into account. The specifics of inner-city quarters must clearly be considered. Not answered is the question as to additional parameters: aside from the noise level /115 the amount of air pollution, the traffic frequency and the type of traffic, the architectural structure and the location of the quarters should be included.

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QUESTIONNAIRE USED TO CONDUCT STUDY
ON "ANNOYANCE DUE TO NOISE AND AIR
POLLUTION TO THE RESIDENTS OF HEAVILY
FREQUENTED STREETS"

H.U. Wanner, B. Wehrli, et al.

Eidgenossische Technische Hochschule
Zurich; Institut fuer Hygiene und
Arbeitsphysiologie, 1977, 6 p.

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| 16. Abstract A questionnaire is presented which is used by the Federal Technical Academy, Zurich. It asks questions such as impressions of the environment, the degree of annoyance from traffic noise, and the annoyance of air pollution. <u>The document, Annoyance Due to Noise and Air Pollution to Residents of Heavily Frequented Streets, was published as NASA TM-75496.</u> | | | |
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Federal Technical Academy Zurich
Institute for Hygiene and Work Physiology

CH-8006 Zurich
Clausiusstrasse 25
Telephone (01)
32 62 11

QUESTIONNAIRE

Please fill out as completely as possible and return
within 8 days in the enclosed envelope (unstamped).

Your replies will be kept strictly confidential.

Thank you.

2. Do you have the window open in your bedroom at night?

- frequently
- occasionally
- seldom
- never

If "seldom" or "never" do you have a special reason?

- noise
- bad smell
- other

3. You know that many people today are disturbed by traffic noise. How is your situation, are you bothered at home by traffic noise?

- frequently
- occasionally
- seldom
- never

If "frequently", "occasionally" or "seldom", at what time does traffic noise disturb you the most? (only one entry, please)

- in the morning (6-9).....
- during the day (9-19)
- evenings (19-22)
- nights(22-6).....

4. Does it happen that the traffic noise

frequently occasionally seldom never

- startles you
- disturbs your sleep
- bothers you while listening
to the radio or watching TV.....
- disturbs you during conversation
or when telephoning
- is harmful to your peace and
relaxation
- disturbs you at work

5. Has the traffic noise led you or a member of your family for example

- | | yes | no |
|---|--------------------------------|--------------------------|
| - to use cotton (Ohropax) or similar means at night | <input type="checkbox"/> | <input type="checkbox"/> |
| - to take sleeping pills or tranquilizers ... | <input type="checkbox"/> | <input type="checkbox"/> |
| - to keep the window closed during the day .. | <input type="checkbox"/> | <input type="checkbox"/> |
| - to have your home better insulated against noise | <input type="checkbox"/> | <input type="checkbox"/> |
| - to have discussed with a doctor possible damages to your health | <input type="checkbox"/> | <input type="checkbox"/> |

6. Do you have a balcony facing the street?

yes no

If yes, do you use the balcony

- frequently
- occasionally
- seldom
- never

If "seldom" or "never" do you have a specific reason?

- too small
- too little sun
- noise
- dust
- bad smell
- other

7. Does it happen that you close your window at home because of dust or exhaust fumes?

- frequently
- occasionally
- seldom
- never

If "frequently" or "occasionally", mostly at what time of the year?

Winter

Summer

The whole year

8. If you are in front of your house, are you bothered by car exhaust fumes?

frequently

occasionally

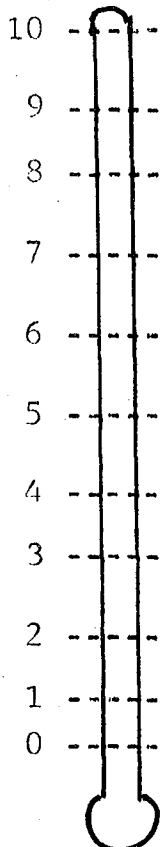
seldom

never

9. Assume this is a thermometer with which you could measure how much traffic noise and air pollution bothers you at home.

The 10 mark means that traffic noise and air pollution in your home are almost unbearable; the 0 mark that they don't bother you at all. Where would you personally grade traffic noise and air pollution on this thermometer? (Please mark the scale)

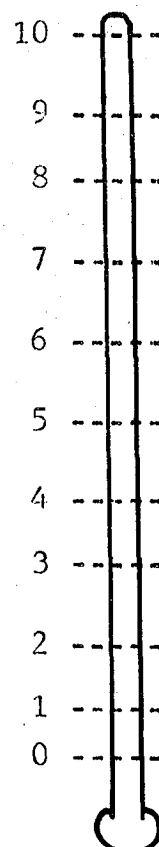
Traffic Noise



unbearable bother

no bother at all

Air Pollution



Finally, we do have several statistical questions; would you please check the applicable boxes:

Age:

| | | |
|----------|-------|--------------------------|
| under 20 | | <input type="checkbox"/> |
| 21 - 30 | | <input type="checkbox"/> |
| 31 - 40 | | <input type="checkbox"/> |
| 41 - 50 | | <input type="checkbox"/> |
| 51 - 60 | | <input type="checkbox"/> |
| over 60 | | <input type="checkbox"/> |

Sex:

| | | |
|--------|-------|--------------------------|
| female | | <input type="checkbox"/> |
| male | | <input type="checkbox"/> |

Present occupation:

| | self | spouse |
|--|--------------------------|--------------------------|
| Worker, skilled worker, foreman | <input type="checkbox"/> | <input type="checkbox"/> |
| business and technical employee, official | <input type="checkbox"/> | <input type="checkbox"/> |
| managing employee or official, self-employed | <input type="checkbox"/> | <input type="checkbox"/> |
| Retired | <input type="checkbox"/> | <input type="checkbox"/> |
| not employed, i.e. housewife, student | <input type="checkbox"/> | <input type="checkbox"/> |

Income (Francs per month)

| | self | spouse |
|-----------------|--------------------------|--------------------------|
| less than 2,000 | <input type="checkbox"/> | <input type="checkbox"/> |
| 2,000 - 3,000 | <input type="checkbox"/> | <input type="checkbox"/> |
| 3,000 - 4,000 | <input type="checkbox"/> | <input type="checkbox"/> |
| over 4,000 | <input type="checkbox"/> | <input type="checkbox"/> |
| none | <input type="checkbox"/> | <input type="checkbox"/> |

Education:

| | self | spouse |
|--------------------------------|--------------------------|--------------------------|
| elementary school | <input type="checkbox"/> | <input type="checkbox"/> |
| secondary school, trade school | <input type="checkbox"/> | <input type="checkbox"/> |
| high school, university | <input type="checkbox"/> | <input type="checkbox"/> |

How long have you lived in your present dwelling?

| | | | |
|------------------|-------|--------------------------|--------------------------|
| Less than 1 year | | <input type="checkbox"/> | <input type="checkbox"/> |
| 1 - 3 years | | <input type="checkbox"/> | <input type="checkbox"/> |
| 4 - 10 years | | <input type="checkbox"/> | <input type="checkbox"/> |
| over 10 years | | <input type="checkbox"/> | <input type="checkbox"/> |

On which floor do you live?

- Ground floor
- 1st floor
- 2nd floor
- 3rd floor
- 4th floor and up

Which rooms of your dwelling are facing the street?

(main thoroughfare)

- Living room
- bedroom
- Children's room
- kitchen, bath, toilet
- other room

How do you rate the rent for your dwelling?

- cheap
- appropriate
- too high

Have you occasionally thought of moving out?

- yes
- no

If yes, for what reason?

- Change of work or residence
- space reasons
- noise
- air pollution
- other

Do you smoke?

- never
- occasionally
- regularly

Does anyone else smoke in your dwelling?

- never
- occasionally
- regularly