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STUDY OF ANNOYANCE DUE TO URBAN AUTOMOBILE TRAFFIC
ANNEX 5 : SOCIOLOGICAL STUDY

D. Aubree, S. Auzou, and J. M. Rapin

Translation of "Etude de la gene due au trafic automobile urbain, Annex 5, Etude Sociologique", Centre Scientifique et Technique du Batiment, Paris, France, Report, June 1971 pp 415-499.

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16. Abstract

Aim, method, description and results of study of the influence of traffic noise on the annoyance of persons living near points of measurement. Includes facsimile of questionnaire used in the study.

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STUDY OF ANNOYANCE DUE TO URBAN AUTOMOBILE TRAFFIC
ANNEX 5 : SOCIOLOGICAL STUDY

D. Aubree, S. Auzou, and J. M. Rapin

5.1. Conduct of the Research /417*

5.1.1. Exploratory Survey

a) Its Aim

If the term and the notion of "annoyance" are familiar to us and used daily, it is advisable, in order to construct an index for it and measure it, to first analyse its dimensions or aspects. This analysis of the different dimensions of the notion of annoyance must permit isolation of the indices we will later seek to order or even to quantify. The scale that is constructed then permits evaluation of the annoyance and an answer to what appears to be a simple question, but which is fundamental: What is annoyance?

b) Method

A qualified interviewer was given the task of interviewing ten persons. He proceeded with open interviews. The proposed theme was rather wide and formulated in the survey in terms such as these: "Please speak to me about outside street noise, such as you hear in your apartment". The subject was therefore free to organize his reply as he wished and to touch on the ideas that seemed important to him. However, if the interviewee did not of himself approach certain themes that had appeared to be important in prior studies, the interviewee proposed them at the end of the interview.

These interviews were recorded on magnetic tape and then transcribed and typed for analysis. They form a compilation of 230 pages.

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* Numbers in the margin indicate pagination in the foreign text.

c) Results

A thematic analysis was done on the interviews. The essential themes are the following: /418

- The different dimensions of annoyance
- The means of defense against noise
- The criteria according to which the subjects describe the noises, as well as the image they have of it and its significance
- Attitudes regarding noise
- The functions of noises

We are now going to describe each of these themes.

- The Dimensions of Annoyance

At this level of analysis we may attribute two essential dimensions to the notion of noise: on the one hand a behavioral dimension. In order to accomplish certain behaviors the individual is disturbed by the noise. This annoyance is manifested by the fact that the individual is made unable to accomplish the behavior in question (reading, listening to the radio, speaking, sleeping) or has to perform a defensive act (close the window, speak more loudly, etc...). We therefore made the hypothesis that this annoyance can have very close relationships to the level of noise.

On the other hand, a "symbolic" dimension (which must no doubt be multiple).

In this dimension the sound level is undoubtedly no longer the principal factor although it may still have an influence. It is characterized by the intrusion of the noise inwardly; by the perceived impossibility of controlling the noise or escaping from it.

There is also annoyance when two needs are in conflict; for example, the need for coolness in summer (open the window) and the need /419 for quiet (close the window); the annoyance is therefore the necessity of making a choice.

- The Criteria for the Description of Noises

Those that are used most often by individuals are spatio-temporal criteria, where and when there is noise, but also "agent and mode" criteria: who makes the noise and how is it produced.

- The Image of Noise

To evaluate the annoyance or the subjective effects due to noise, we must know what representations it evokes for individuals and the manner in which they situate themselves in relation to these representations. The image that a person has of noise may be connected with the noise itself or even with its agents - mechanical or human - that produce it, or even with the entity considered responsible. Likewise, a noise may evoke a certain number of associated images for the one who perceives it.

It is thus that the noise may be life, the section of town, the activity, the modern world, technology, youth, etc. Noise is also charged with a certain number of social values: the need to work, but also "the price of silence", the latter being considered a luxury.

- Attitudes Regarding Noise

These may be situated on bipolar scales whose ends would be:
Exasperation - Tolerance
Compromise - Intransigence

The attitudes of individuals in regard to noise depends no doubt more on the significance than on the sound level. But the significance accorded noise depends on the image one has of it (that is, what interindividual variations can be recorded), as well as the physical characteristics of the noise and of the context. /420

- Function of Noise

The function of which it is a question here is that which is attributed to the noise by the subjects. It appears clearly in the interviews that this function is a social, or more precisely as psycho-social, one. In fact, noise is a "means", a "medium" through which the individual is conscious of his relationships with the society, since noise is one of the multiple manners by which the society manifests itself to the individual. Likewise, it is a "means" by which the individual situates himself in relation to others, since noise is used as a means of expression and of affirmation of self.

- The Fight Against Noise

Within this general theme we can distinguish three parts:

- 1) means
- 2) credibility
- 3) significance

1) Means

It is a question here of all the means envisaged by the subjects, individually and collectively. Individually, all of the intermediate situations between the ear plugs and complete sound proofing of the apartment are envisaged. Collectively, the responsibility is put on "the authorities", who are vague and anonymous, to regulate either the source of the noise (quieter motors, more or less categorical regulation of traffic); that is to say, town planning.

Many envisage technical solutions: the electric motor, which /42 according to them has the double advantage of being quieter and of not polluting the air. This classification into individual and collective means is not the only one that appears in the analysis. We can in fact rank them on a scale that would take more account of the personalities of the subjects. In fact, if certain subjects actively defend themselves against noise, seeking to suppress it for themselves (ear plugs, double windows) or for the community (petitions, demonstrations), others are content to deny it annoying effect, or to escape it as soon as they can (moving, weekends in the country).

2) Credibility

That is, which one accords to the efficacy of the fight. Its greater or lesser intensity is explained by the same personality traits as those that underlie the means used (active or passive). We will characterize it by three attitudes:

- the fight is possible and may presently be effective.
- it would have been possible before (by regulating it).
- it is utopian

3) Significance

Noise, and even traffic noise, is not a stimulus, a neutral signal; it is a carrier of meaning; we have a certain image of it. The result is that any action taken against noise also has a meaning and even a positive or negative value. For certain people, silence is a benefit and the fight against noise therefore takes on the value of an improvement of the conditions of life. For others, noise is progress, life, health, and to defend oneself against it is therefore to regress. To want silence is to choose old age, death. Finally, /422 an artifical silence through isolation cuts off the outside world; it makes this world incoherent, hostile, strange and even schizoid.

The analysis that we have just made of these interviews is clearly a rapid and therefore summary one. It shows, however, that if the annoyance depends on the intensity of the sound that is experienced, we must also take into account in our evaluation, meanings that are attached to it. The annoyance, if we take the detour of these meanings, is found to increase or diminish according to the image we have of the noise.

5.1.2. Wording and Testing of the Questionnaire

a) Wording

The questionnaire that we used was inspired, for the purpose of comparison, by the studies already made in France and abroad. The 7-point scale, for example, used several times is taken directly from the study of I. D. Griffiths and F. J. Langdon of the B.R.S. In our questionnaire we did not retain all of the dimensions of annoyance. That would have weighed it down excessively.

Besides the behavioral dimension already present in the prior studies, we tried to evaluate the symbolic dimension by the bias of the opinions and of the representations. In fact, we retained only certain aspects (specified below) of this multiple dimension. The annoyance that we seek to evaluate in this questionnaire is limited to that experienced at home. For part of the population it is therefore a question of the annoyance felt during a period of leisure and relaxation; for another part, mainly the women who do not engage in professional activity, it is necessary to add the annoyance felt during the performance of housework. Certain hypotheses determined the development of the questionnaire: the annoyance evaluated with our scale could be biased by the fact that interacting variables /423 maximuze it by interfereing with the specific effect of the noise. We therefore introduced in the questionnaires a certain number of questions aimed aimed at controlling the effects of these variables. The different behaviors retained could not be disturbed in the same way by the noise; we therefore expected to introduce questions that would allow us to calculate a weighting coefficient. In this study we sought to evaluate:

- an overall annoyance, using the 7-point scales.
- a behavioral annoyance for daytime activities: reading - listening to the radio - television - meals with family or guests
- a behavioral annoyance for night time activities: bedtime - nocturnal sleep - awakening in the morning.

We also introduced questions aimed at studying the attitudes regarding noise. These attitudes were evaluated by the bias of the opinions of the subjects on the possibilities of defending themselves against the noise and on the supposed effects of noise on their health.

The definitive questionnaire includes 61 questions (counting page 495*, which does not have a numbered question), of which:

5 are on overall annoyance.
18 are on behavioral annoyance.
4 are on attitudes.
2 are for weighting.
22 are for correction.
10 other questions are descriptive questions, filter questions or special controles (e. g., on the time of rising and of going to bed).

The questions aiming at evaluating possible biases bear on: /424

- the rate of exposure of the dwelling (No. of rooms overlooking street) / ~~(Total no. of rooms)~~ (EXPO)

- the rate of occupancy $\frac{\text{(No. of persons)}}{\text{(No. of rooms)}}$

- satisfaction with the section of town (S.Q.)

- the time spent in the dwelling - daytime
  - night

- the place where radio and TV are listened to

- the location of the room, on the street side or in back

- the length of time living in the present dwelling

- the subjective evaluation of the noise in the previous dwelling (BLP) in comparison with the present noise

- sex

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* Page 12 bis of the original questionnaire.

- age (see FIG. 63)

- profession

- the possession and frequency of use of an automobile.

b) Testing

The questionnaire was tested on twenty persons in order to verify that the form and content of the questions were clear and easily understood by the interviewees and that they did not result in refusals to respond.

The questionnaire was then twice to 700 persons.

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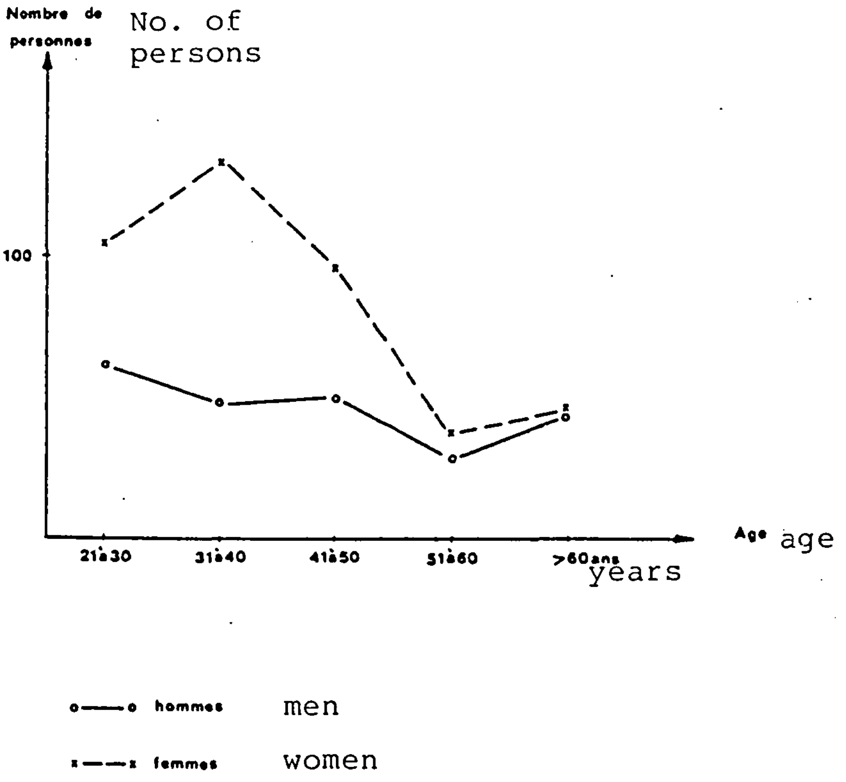


FIG. 63 - Histograms of age - 646 subjects

5.1.3. Preliminary Survey with 200 Persons /426

a) Aim

A first sample of 200 persons allowed us to make certain controls (such as the time of rising and of going to bed) and to begin the study of the influence of the correction variables for the purpose of systematically controlling them in the extensive survey. It also permitted us to try to develop a system for the composition of different annoyances and to choose the noise variables to be related to annoyance.

b) Choice of the Sample of Sites

In this study, the sampling of the subjects is strictly dependent on the location of the acoustic measuring points. In fact, it was a question of evaluating the annoyance due to traffic noise in the homes of persons living near a measuring point. We therefore in fact did a sampling of sites. In each of the sample sites the interviewers spoke to about twenty persons.

For the preliminary survey on these 200 subjects, we still did not have the results of the acoustic measurements, so we based the choice of sites on the division of the streets into categories.

In Paris there are one-way and two-way streets of different width and service roads.

In the suburbs there are main roads, delivery roads and service roads.

Since there was a total of 100 measuring points, with 60 in the suburbs and 40 in Paris, we chose 5 points in Paris, of which 1 was half-width one-way, 2 were very wide two-way and 2 were service. /427

We retained 6 points in the suburbs, of which 2 were main, 3 delivery and 1 service.

The criterion chosen, the size of the street, seemed to us to be, in the absence of other information, the best for giving us a correct sampling of the different noise levels.

This hypothesis was also confirmed later by the results of the factorial analysis. In FIG. 67 and FIG. 68 the preliminary survey points have been underlined; they are distributed over the entire range of noise.

c) Results

For the preliminary survey, as for the extensive survey, the responses were precoded for transcription on perforated cards and processing with a computer.

For each item of the questionnaire, we did the histogram of the responses with the population of the class, the corresponding percentage and the cumulative percentage. These histograms, by giving an idea of the form of the distribution, allowed an overall view of the results item by item in the questionnaire.

Control of time of rising and of going to bed.

At the time of preparation of this study, we arbitrarily cut the 24 hour day into 4 partially overlapping periods. This division was made in order to obtain acoustic measurements corresponding to the periods of bedtime - sleep - awakening - daytime.

The limits were: for bedtime : 2230 - 0030 hours /428
for night : 2230 - 0730 hours
for awakening : 0530 - 0730 hours
for daytime : 0730 - 2230 hours

The cumulative percentage curves of the responses to the questions on the hours of rising and of going to bed very clearly differentiated two populations (cf. FIG. 64 and FIG. 65). In effect, at the 50% level we ascertain a displacement of about one hour between the hours of rising and of going to bed in the suburbs and in Paris; the suburbanites evidently rise earlier and also go to bed earlier.

These results have lead us to modify the division of the 24 hours as follows:

for bedtime : 2130 - 0030 hours
for night : 2230 - 0730 hours
for awakening : 0530 - 0830 hours
for daytime : 0730 - 2230

The periods of rising and of going to bed were extended by two to three hours, this period being the one during which about 95% of the total population goes to bed and gets up.

- Weighting

It was our hope to assign to each behavior a coefficient which would have translated its greater or lesser susceptibility to noise. The method used is that of comparaison by pairs.

We had three daytime activities:
A : reading - B : radio, TV - C : meals

Three night time activities :
D : going to sleep - E : sleep - F : awakening

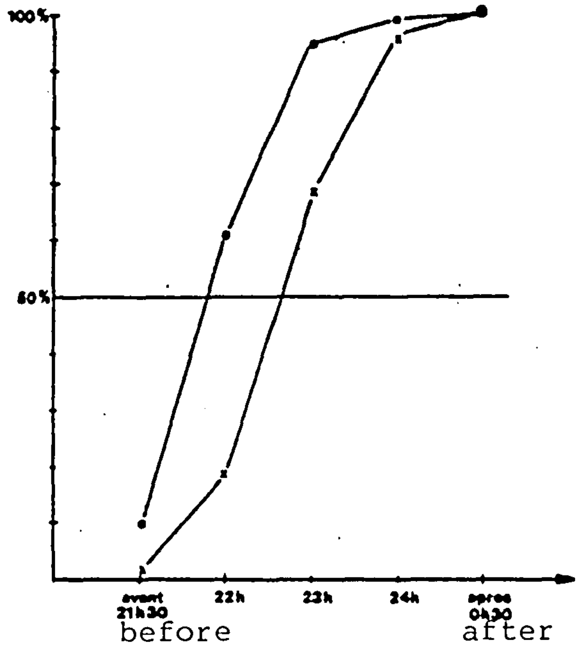


Fig. 64 - Horaire du coucher
FIG. 64 - Bedtime schedule

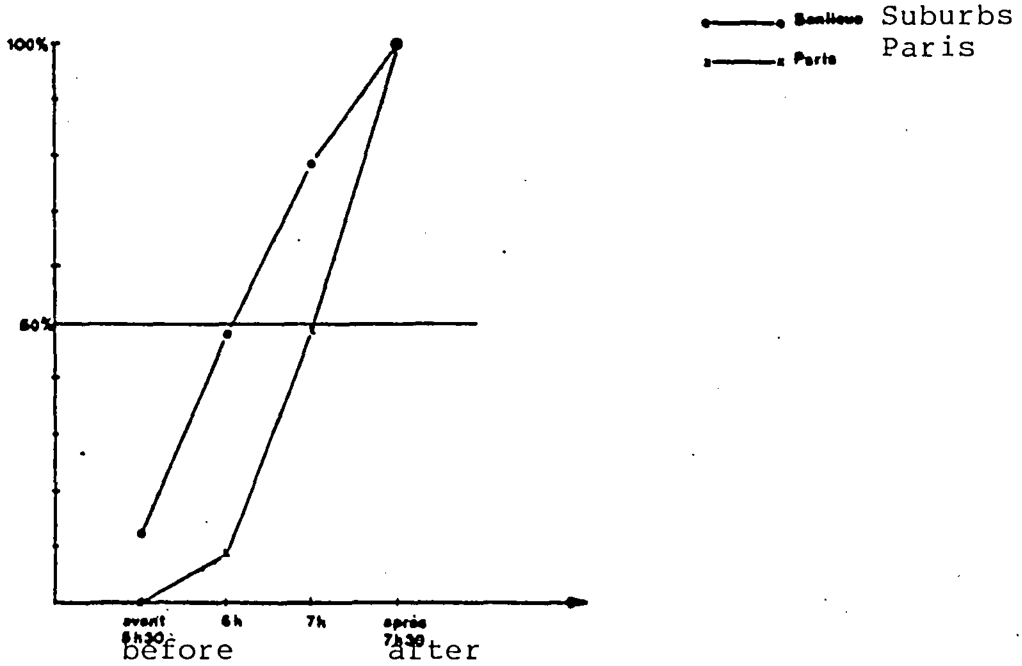


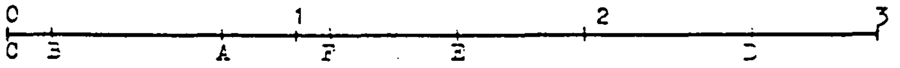
Fig. 65 - Horaire du lever
FIG. 65 - Rising schedule

We have presented (cf. page 495*) 15 pairs to 200 subjects of the preliminary study. /430

We ascertained that the daytime activities (A-B-C) were clearly set apart and less disturbed by noise than the night time activities (D-E-F); going to sleep being the most disturbed of all, and mealtime the least (see graph below, 1st sample). Verification on another sample of 200 subjects taken from among the 500 of the extensive survey yielded another result (2nd sample).

1st sample

2nd sample



We see that if the order is strictly the same, the distances are totally different. This difference is also highly significant in the X^2 test.

With 15 degrees of freedom, $X^2_{15} = 188.19$ and the probability is much lower than 0.001. The scale obtained with the first sample of 200 subjects is therefore not completely suitable for describing the second and we have rejected this system of weighting.

In the questionnaire, the evaluation of the behavioral annoyance is generally made by means of two questions. The first verifies the presence or absence of disturbance by noise for the behavior in question in the most unfavorable situation; that is, with the window open. It is a yes or no question about reading, TV, radio, and mealtimes. /430
If in this case the noise is judged not disturbing, there is no need to ask the next question, the object of which is to evaluate the disturbance in the most favorable situation, with the window closed.

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* Page 12 bis of original questionnaire.

We used a computer to prepare tables of the numbers corresponding to each behavior.

Here are the results that we obtained.

1. Radio

			Annoyance, window closed		
			don't know	no	yes
			1	2	3
listening possible, window open	don't know	1	0	4	1
	no	2	1	83	32
	yes	3	0	58	1

The constructing of a hierarchy being possible only if the subjects responded to the two questions, we eliminated the subjects who ansered "don't know" to one of the questions. The above table shows that the loss of subjects is very low (6).

Moreover, of 174 subjects answering both questions, one subject answered aberrantly* in regard to the hierarchy:

" - not annoyed, window open or closed,
- annoyed, window open but not annoyed with window closed,
- annoyed, window open and closed",

a very small proportion.

It is therefore possible to construct a hierarchical scale for for the two questions, which will be coded 1, 2, 3, according to an increasing degree of annoyance. The code 0 is for the eliminated subjects. We obtain the following coding table used for combining the two questions. (It is generally admitted that the proportion of errors, in order to conclude that a scale is ordered (of the Guttman type) must not exceed 10%) /432

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* During the preliminary survey, the interviewer systmatically asked all of the interviewees the questions.

		Annoyance, window closed		
		don't know	no	yes
	don't know	0	0	0
listening possible, window open	no	0	2	3
	yes	0	1	0

2. TV

			Annoyance, window closed		
			don't know	no	yes
			1	2	3
listening possible, window open	don't know	1	0	3	0
	no	2	4	78	30
	yes	3	0	53	2

The proportion of error in relation to a hierarchical scale is 2/163. It is again very low and allows construction of an ordered /433 scale according to the following coding table:

		Annoyance, window closed		
		don't know	no	yes
listening possible, window open	don't know	0	0	0
	no	0	2	3
	yes	0	1	0

3. Radio and TV

These two results were then combined. Using the computer, we prepared the table of subjects ordered for radio and TV at the same time. We obtained the following table, in which the indices in the margins are the orders obtained for radio and TV respectively.

		TV		
		1	2	3
Radio	1	23	10	1
	2	7	32	8
	3	3	10	8

We must specify that the 102 subjects in this table listen to radio and TV under tha same conditions, that is, either on the street side, or in back.

The above table shows that there is a relationship between the annoyance felt for the radio and that for the TV. The greates numbers are in fact, in the diagonal. On the other hand, we note that there /434 is no difference at all (sign test) between the rank attributed to the annoyance for the radio and that for TV, the table being symmetrical.

We therefore constructed a 5-point scale according to the coding seen in the following table:

		TV		
		1	2	3
Radio	1	1	2	3
	2	2	3	4
	3	3	4	5

4. For reading, the law of combination is simpler and adheres to the basic model. The difference resides simply in the fact that the second question is not dichotomic, but evaluates the frequency of the disturbances, window closed, never (J), rarely (R), often (S), very often (TS); S.R. indicates "no response".

			Annoyance, window closed				
			S.R. 1	J 2	R 3	S 4	T.S. 5
reading possible, window open	don't know	1	2	3	1	0	0
	no	2	0	33	46	25	10
	yes	3	1	50	15	3	0

The response "rarely" being in fact very close to the response "never", we considered aberrant the only subjects who said they were often or very often annoyed with the window closed, while they were not disturbed with the window open, or 3/182.

The proportion is still very low and we may consider that there is a hierarchy. /435

			Annoyance, window closed				
			S.R. 1	J 2	R 3	S 4	T.S. 5
reading possible,	don't know	1	0	0	0	0	0
window open	no	2	0	2	3	4	5
	yes	3	0	1	1	0	0

5. In regard to mealtimes, the method of combination is as follows: (S.R. means "no response").

			Annoyance, family mealtime		
			SR 1	NO 2	YES 3
Annoyance,	SR	1	4	5	0
mealtime with guests	NO	2	0	76	3
	YES	3	1	12	92

For each of the two situations, family mealtime and mealtime with guests, we asked only one question, "Do you have to close the window because of noise from the street?", in each of these situations. The combination of the two serves to evaluate annoyance for conversation at table.

In the above table, if the difference between the two situations is tested, we see that it is clearly significant: $X^2_1 = 4.27$, or a probability of occurrence such that : $0.02 < p < 0.05$.

The noise is thus clearly judges more disturbing for meals with guests than for family mealtime. This difference is confirmed on the overall sample, where $X_1^2 = 12.01$, or a probability of occurrence of $p \leq 0.001$. /43

Thus it appears that, in regard to the median terms "annoyed in one of the two situations", the hierarchy favors entertaining, for which the noise is judged to be more disturbing. Consequently, a subject who will be disturbed for family mealtime will be necessarily when entertaining guests.

We asceratain in our table that there is a very low proportion of aberrant cases, 3/183. Contrary to the other behaviors, we retained these subjects and regrouped them as indicated in the coding table below.

		Annoyance, family mealtime		
		SR	NO	YES
Annoyance, mealtime with guests	SR	0	0	0
	NO	0	1	1
	YES	0	2	3

The other combinations were also verified on the overall sample and their results were confirmed.

Other studies were begun on the sample of the preliminary survey. Since they were taken up again or completed on the total sample of 700 persons, we will give the results in the chapter on the data of the extensive survey.

Note: Parallel to the different studies done on the data of the preliminary study, we studied the different variables proposed by the acousticians. A factorial analysis, the results of which are given in Chapter 5.5, allowed us to select the variables that were the most representative of all of them. /437

5.1.4. Extensive Survey on 500 Persons

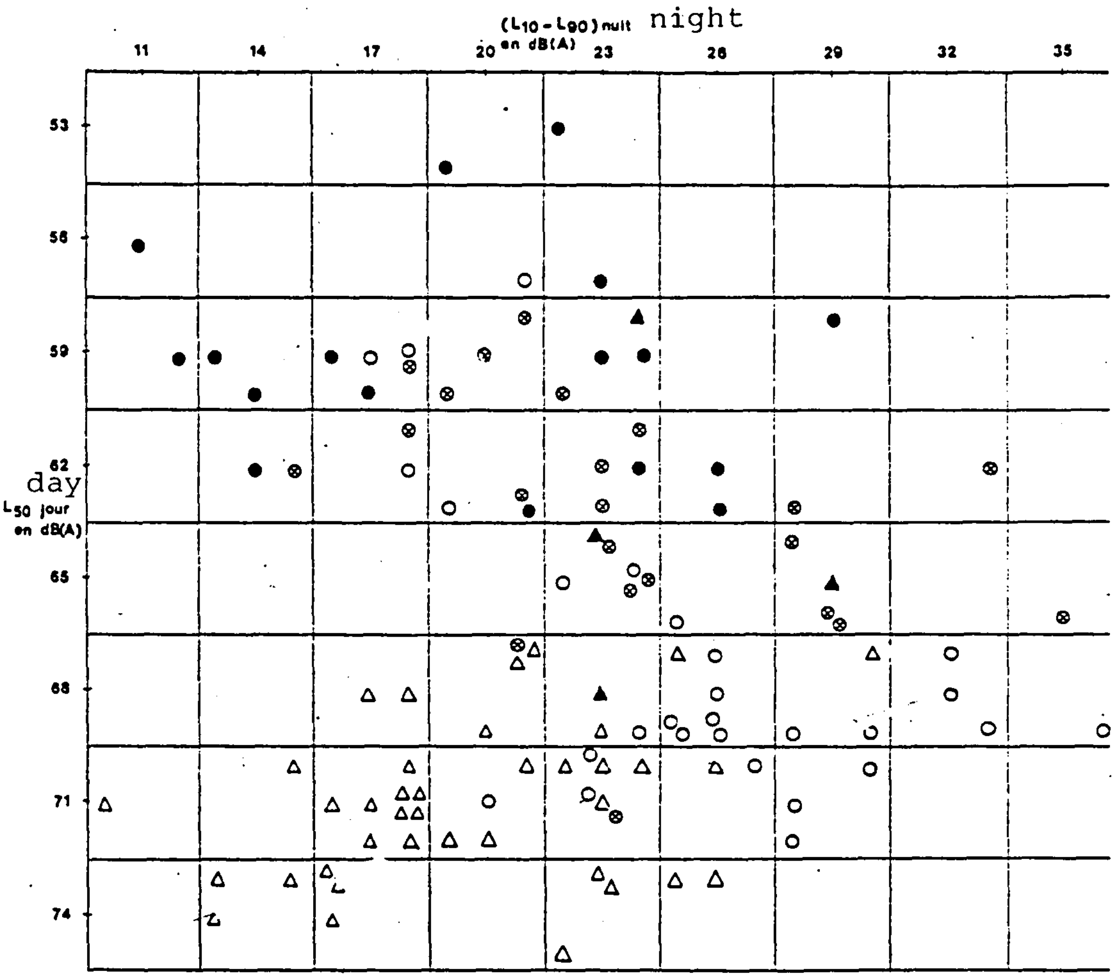
Selection of Sites

For the extensive survey, we availed ourselves of the acoustic data for the 110 measuring points in Paris and the suburbs. The factorial analysis provided us with the necessary information on the acoustic variables that were most representative. It was therefore possible for us to construct our sample in relation to the physical data and the tasks we wanted to perform.

FIG. 66 shows all of the sites classified according to the most representative variables of the acoustic data. This schema, pointing to the right as it soes, is characteristic. We can distinguish two types of streets immediately. In one, the main streets of Paris and the suburbs, the difference between the background noise and the peaks increases when the average level decreases. In the other, mainly the service and delivery roads, the difference increases at the same time as the average level.

In this assembly we have chosen the sites for the survey so that, for an average difference (23 dB), there are points at all of the L_{50} levels. We also took sites so that, for a given average level, there is a variation in the differences. The lacunas in FIG. 66 led us to choose two bands, at 59 dB and at 68-71 dB.

Finally, in order to have a rather large population whose members are subject to similar noise, in view of standardization of the annoyance statements, we took all of the "average" sites having an L_{50} of 65 dB and an $(L_{10} - L_{90})$ of 23 dB.



1. △ Paris, voies artérielles
2. ▲ Paris, voies de desserte
3. ○ Banlieue, voies artérielles
4. ⊗ Banlieue, voies de distribution
5. ● Banlieue, voies de desserte

KEY

(See p. 22)

FIG. 66 - Sets of Sites

The sites chosen are indicated in FIG. 67, in relation to the /43 two acoustic variables already mentioned, and in FIG. 68, in relation to the third representative variable indicated by the factorial analysis (L_{10} - L_{90}) Rising and (L_{10} - L_{90}) Night already used in the preceding table. This third variable was abandoned in the rest of the study as not having any influence on annoyance.

5.1.5. Selection of Acoustic Variables : Factorial Analysis into Principal Components

a) Brief Presentation of the Method*

In order to describe the noise, we availed ourselves of seven different variables (L_1, L_{10}, L_{50}, L_{90}, (L_{10} - L_{50}), (L_{10} - L_{90}), L_{eq}), for each of the following periods: rising, daytime, retiring, night, 24 hours, for a total of 35 different variables.

It is not so easy to analyse and to synthesize the results of a series of intercorrelations among such a large number of variables; it becomes entirely impossible if to them are added the variables describing annoyance. Facorial analysis permits a simplification of the data by reducing the number of variables, which then allows a coherent interpretation of the set of results. For technical reasons (capacity of IBM 1130) we had to made two factorial analyses.

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* See in 5.2 a more detailed presentation of the method used here.

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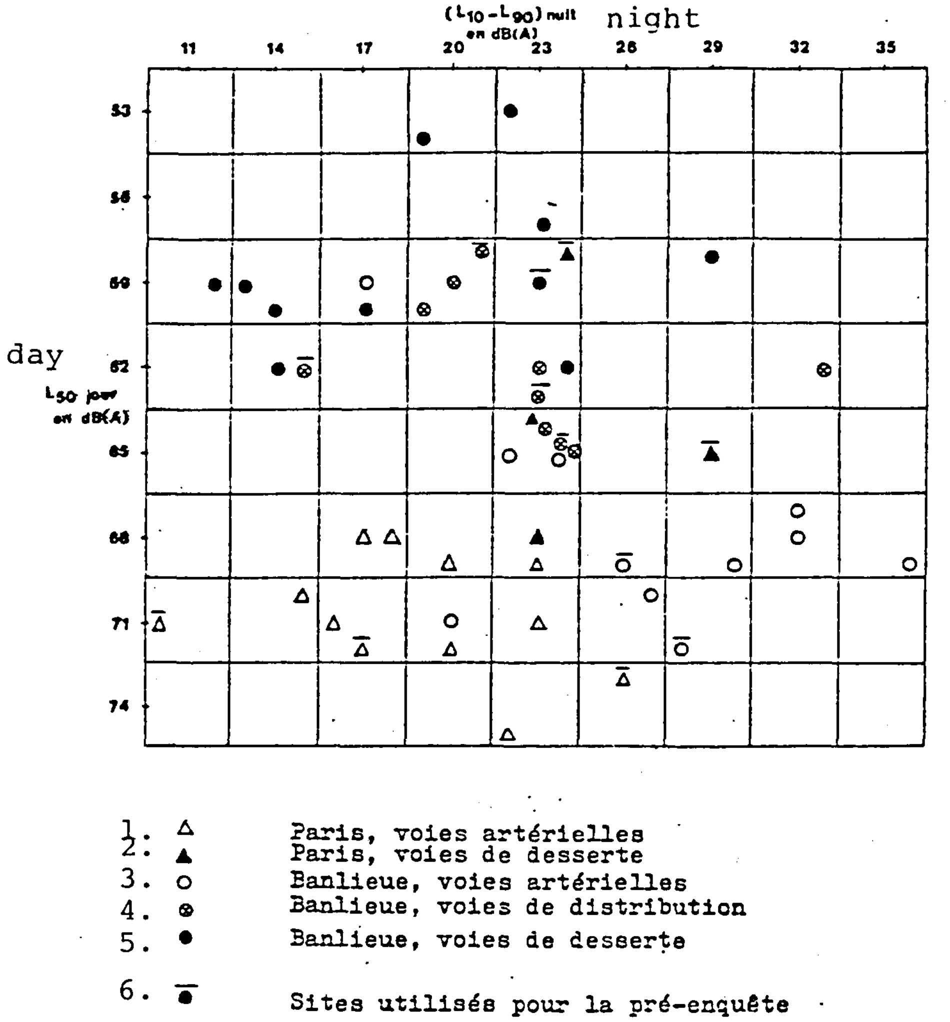
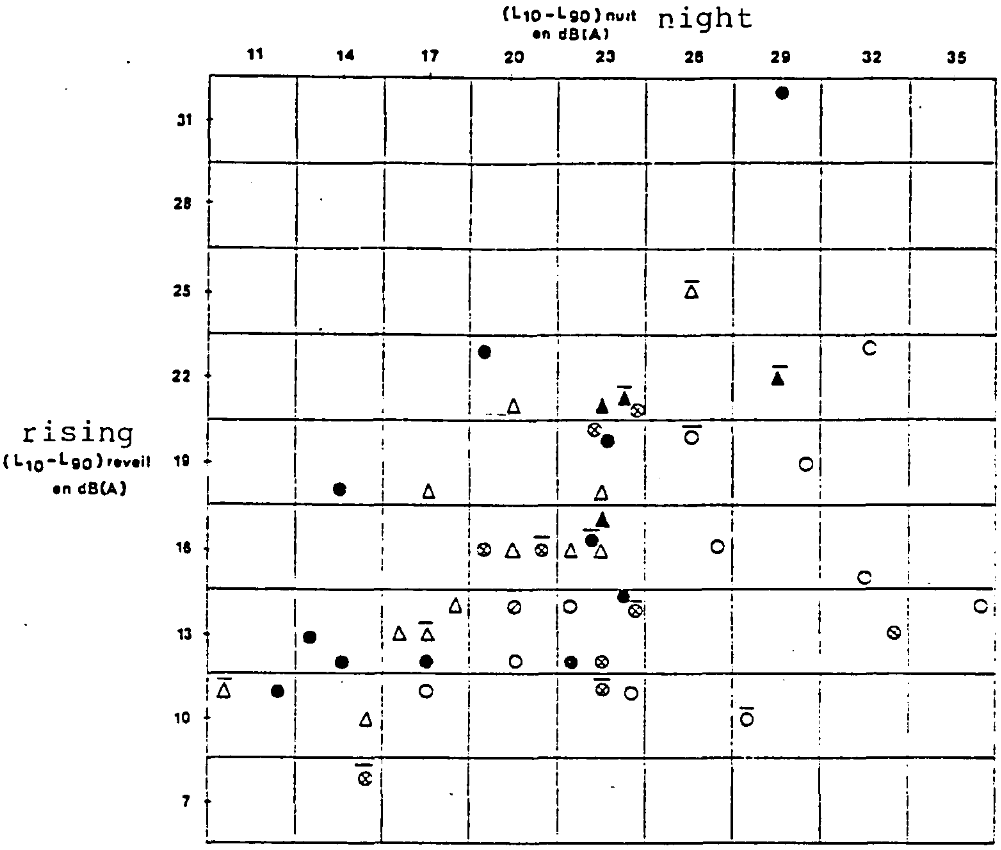


FIG. 67 - Sites Chosen for the Survey

KEY
1. Paris, main streets
2. Paris, service roads
3. Suburbs, main streets
4. Suburbs, delivery roads
5. Suburbs, service roads
6. Sites used for pre-survey



KEY
(See p 22)

1. △ Paris, voies artérielles
2. ▲ Paris, voies de desserte
3. ○ Banlieue, voies artérielles
4. ⊗ Banlieue, voies de distribution
5. ● Banlieue, voies de desserte
5. ● Sites utilisés pour la pré-enquête.

FIG. 68 - Sites Chosen for the Survey

The first bears on the values of: L_1, L_{10}, L_{50}, L_{90}, (L_{10} - L_{50}), (L_{10} - L_{90}) for the periods of rising-daytime-retiring-night: or 24 variables. /422

The second bears on the values of: L_1, L_{10}, L_{50}, L_{90}, L_{eq}, for all of the perios, or 25 variables.

The method of factorial analysis into principal compoenents permits expression of N variables as a function of the most restricted n of constructed variables, called factors. Such a representation is of course not perfect: the loss of information will be greater as, on the one hand the number n of factors retained is lower and on the other hand as the N variables are less dependent on each other. The graphic representation used here consists of representing each variable by a vector in the space of the retained factors. The analysis of the noise variables led us to retain 3 factors; the representation of the variables is done according to the principle of descriptive geometry, by orthogonal projection in the plane of factors I and II and in the plane of factors II and III. The representative vector of a variable is indicated on the graphs by a "variable point", the other end of the vector being the origin*.

With this representation, the analysis of proximities between "variable points" and factors immediately gives information on the meaning to be attributed to the factors. Likewise, the analysis of proximities between the various "variable points" gives information on their interrelations, which permits a rational selection of the noise variables useful for the rest of the study. Finally, the length of a vector representing a variable, that is, the distance that separates the "variable point" from the origin of the "vector", reports the quality of the representation of the vector considered by means of the retained factors: the closer this distance is to unity, the better the representation. /443

b) Results

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* The method of graphic representation is described in detail in 5.2.

Factorial Analysis with 24 Variables

L_1, L_{10}, L_{50}, L_{90}, $(L_{10} - L_{50})$, $({}_{10} - L_{90})$ for the periods of rising, daytime, retiring, night. FIG. 69 and FIG. 70.

The variables are divided into two groups. The first is in a circular arc near the end of factor I, the second is located near factor II. We ascertain that the simple values group themselves around I while the deviations are close to II. The simple values are divided according to a circular arc whose radius is almost equal to unity, (the latter is represented by the factor). The variance of these variable points is therefore almost totally explained by the two factors, factor I being predominant. The variable points closest to this factor I are L_1, L_{10}, and L_{50} of the four periods. Each of these variables may therefore serve to represent factor I. Factor II for its part may be nearly exactly represented by $(L_{10} - L_{90})$ for night.

Examination of the projection of the "variable points" in the plan of factors II and III indicates that the six "variable points" of a single period are nearly aligned, that is, are nearly situated in a plane of the three dimensional space of the factors. The planes of the periods, day, retiring, and night, are near one another. On the other hand, the plane of the period for rising is clearly distinguished from the others; it is nearly parallel to factor III. Thus, a good representation of the variables of the period for rising can only be obtained on the condition that factor III also be used, while we can be content with using the first two factors to represent the variables of the other periods.

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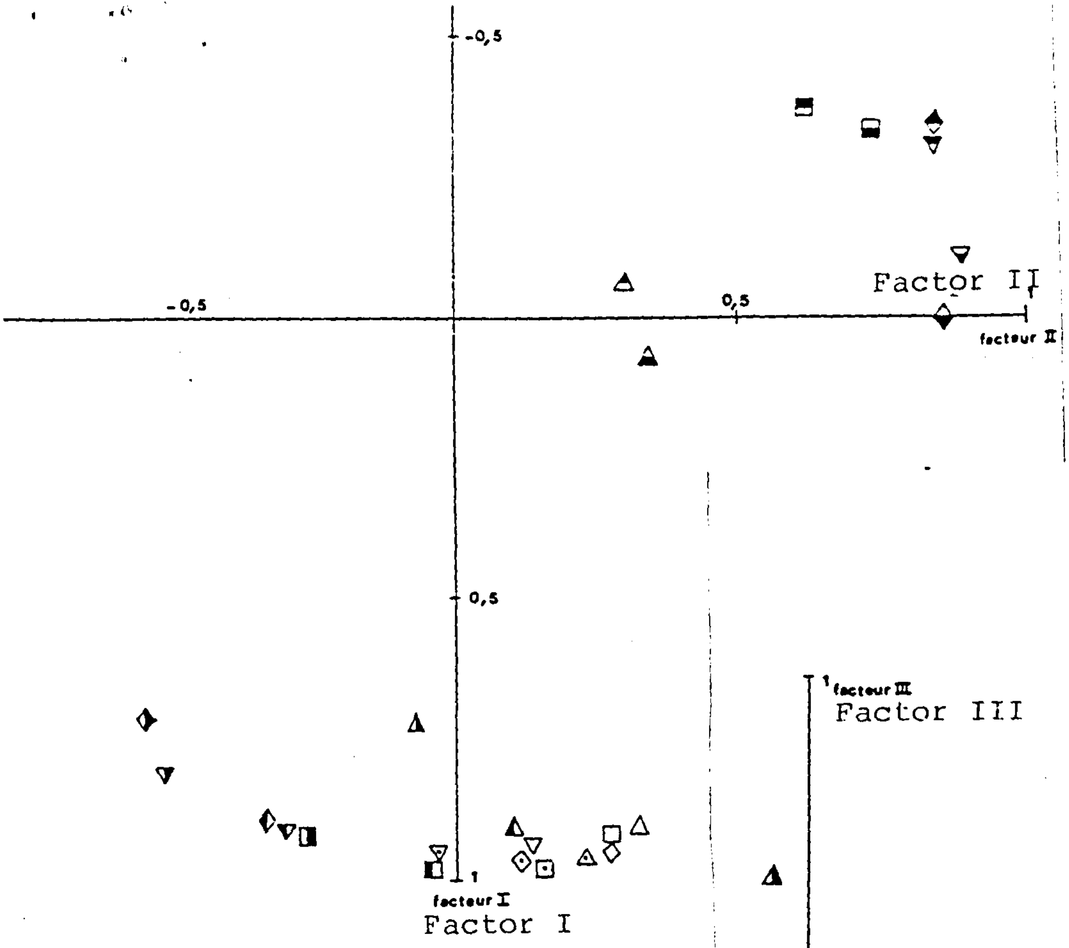
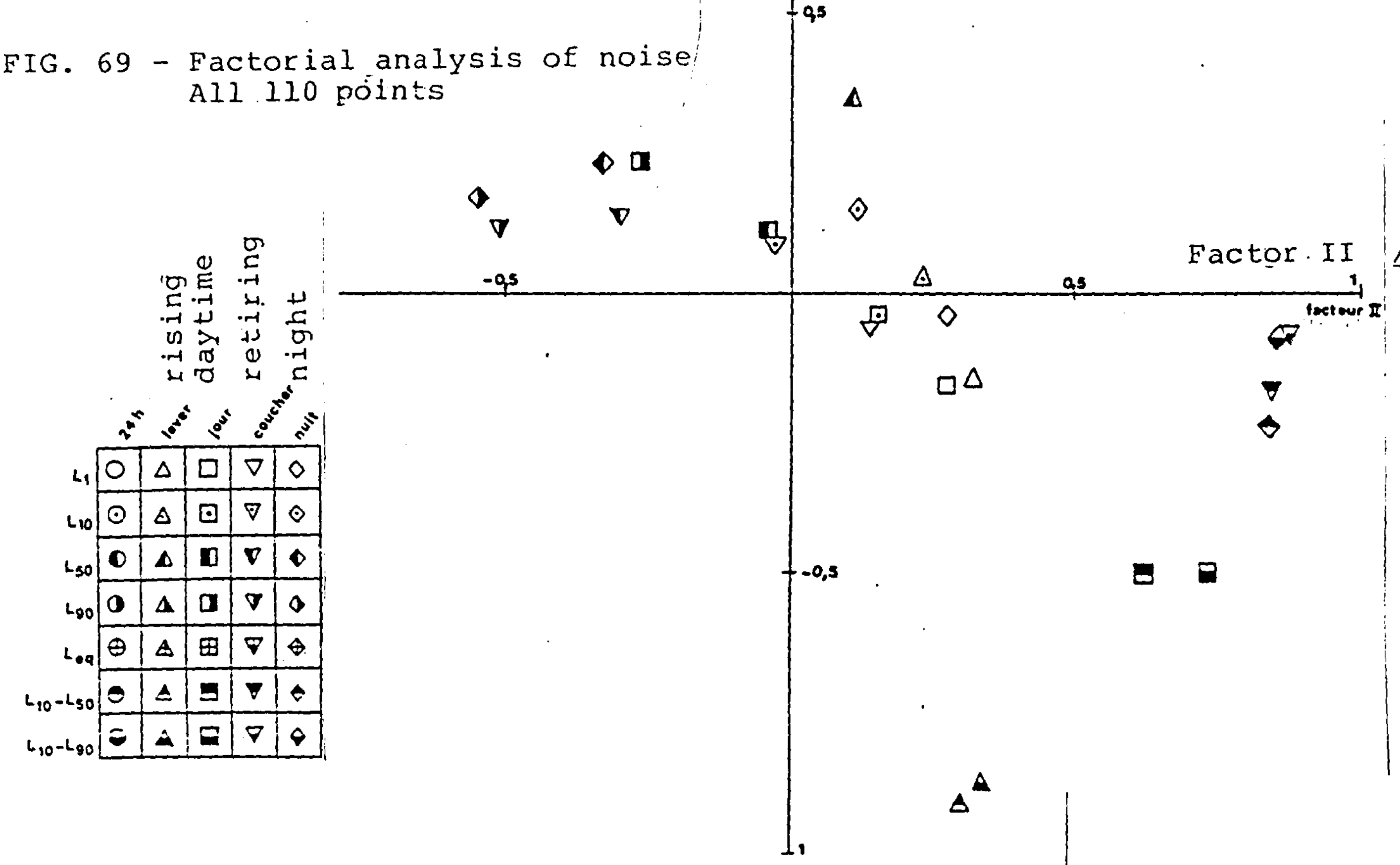


FIG. 69 - Factorial analysis of noise
All 110 points



/445

FIG. 70 - Factorial analysis of noise
All 110 points

To sum up, all of the 24 noise variables considered can be expressed, with good precision, by means of only three factors (three "dimensions"). /446

- factor I expresses the average noise level of the site being considered, whatever the period studied.

- factor II expresses the dispersion of the noise around the average level, for the periods of daytime, retiring, and night.

- factor III expresses the dispersion of the noise around the average level during the period of rising.

The necessity of introducing factor II to represent the period of rising can be explained, in our opinion, by the fact that the period of rising (0530 - 0830 hours) is a transition period between the night, when automobile traffic is practically nil, and the daytime, when it is intense (the noise level recordings show this transitory character perfectly). The study of the time when the interviewees rise indicates a difference of about one hour between Paris and the suburbs. It is likely that the same difference exists at the level of traffic density. Thus, schematically, the period of rising includes two different noise rates (night rate and day rate), in different proportion according to whether the site studied is in Paris or in the suburbs. The result is that the dispersion of the noise around the same average level will be different for Paris and the suburbs. To characterize each of these three retained factors, we have chosen one of the acoustic variables that was the closest to it.

We estimated that L_{50} for daytime best represented factor I, /447
$({}_{10} - L_{90})$ for night factor II, and $(L_{10} - L_{90})$ for rising factor III.

The following table shows the correlations among these different variables.

	rising $L_{10} - L_{90}$ Lever	daytime L_{50} jour	night $L_{10} - L_{90}$ nuit
rising $L_{10} - L_{90}$ lever	1	- 0,0240	0,428
L_{50} daytime jour		1	- 0,020
$L_{10} - L_{90}$ night nuit			1

We see that the correlations between:

$(L_{10} - L_{90})$ rising and L_{50} daytime

L_{50} daytime and $(L_{10} - L_{90})$ night

are not much different from 0 and we may therefore consider them to be independent variables. There is no independence between $(L_{10} - L_{90})$ rising and $(L_{10} - L_{90})$ night.

Factorial Analysis with 25 Variables

L_1, L_{10}, L_{50}, L_{eq}, for the periods of rising, daytime, retiring, night, 24 hours. FIG. 71 and FIG. 72. FIG. 71 is identical to FIG. 69; we find the same circular arc around factor I.

We note that L_{10} and L_{eq} are always very close to each other, whatever the period of the day.

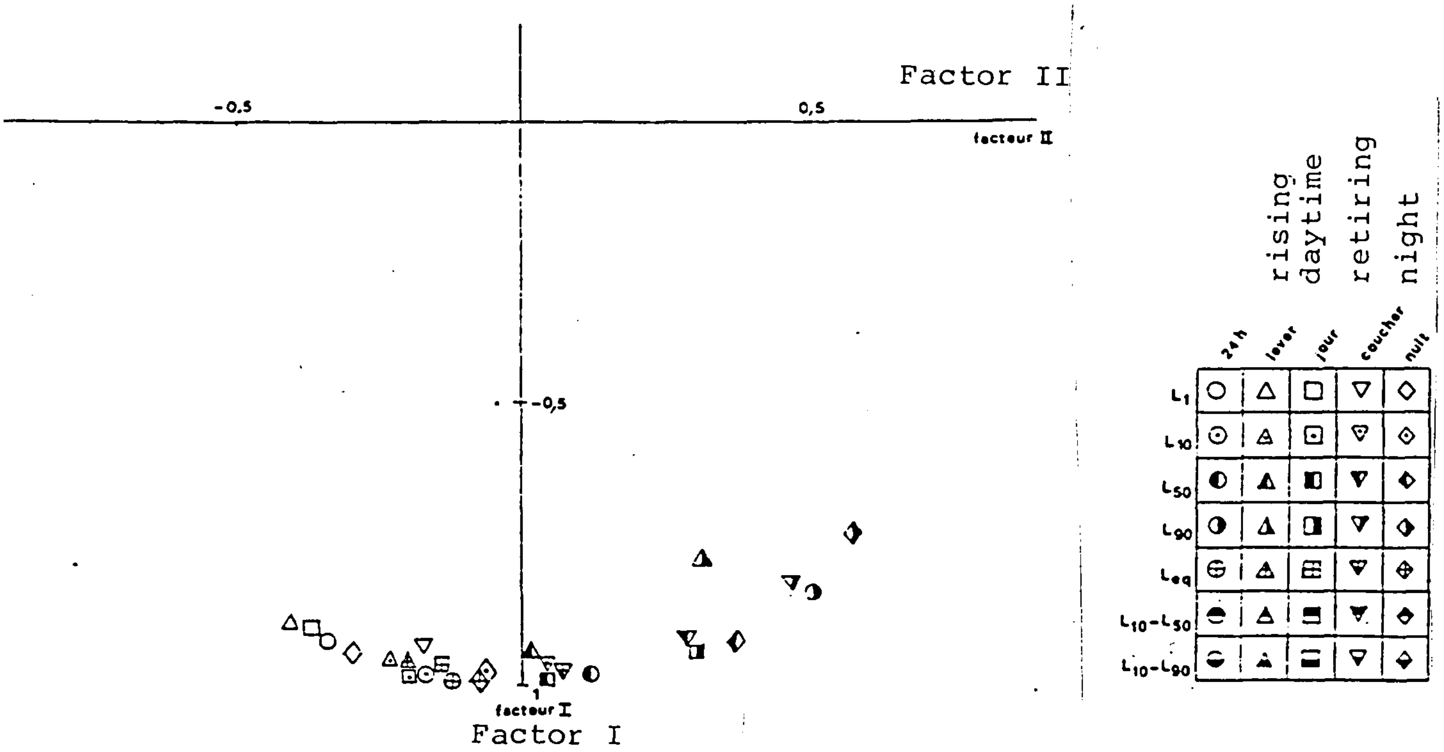


FIG. 71 - Factorial analysis of noise
All 110 points

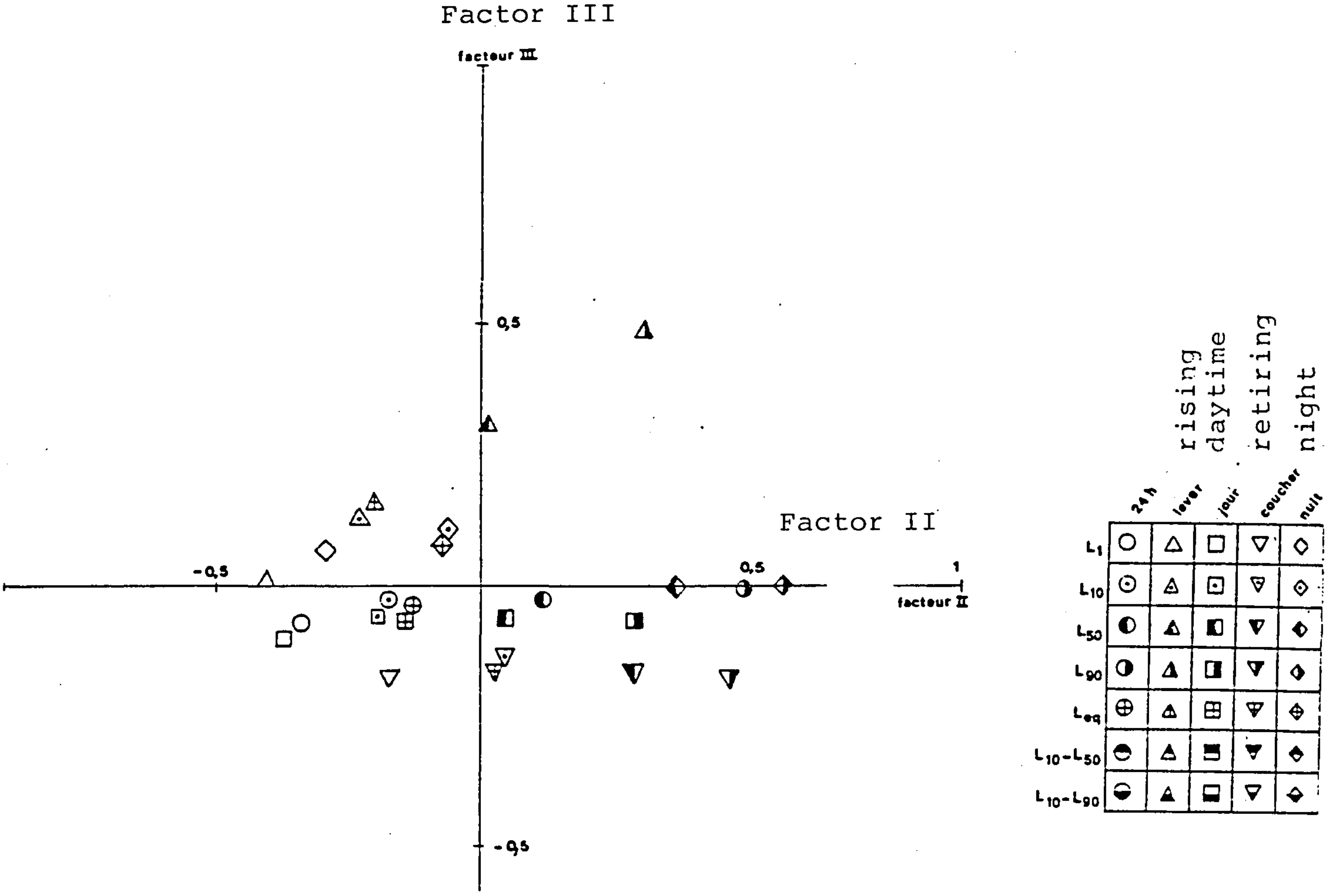


FIG. 72 - Factorial analysis of noise
All 110 points

FIG. 72 has the same appearance as FIG. 70. The variable points /450 of a single period delimit distinct planes in the three dimensional space, but which are close to each other. The 24 hours are seen to be mixed with the daytime, retiring, and night periods. Rising is distinguished clearly from the other periods again.

The following tables give the correlation coefficients among the acoustic variables studied.

Legends for Tables 9 to 13

Coefficients of correlation of the "noise" variables with each other.

Table 9 : Rising
Table 10 : Daytime
Table 11 : Retiring
Table 12 : Night
Table 13 : 24 Hours

Table 9 - Rising

		L_1	L_{10}	L_{50}	L_{90}	$L_{éq}$	$L_{10}-L_{90}$
RISING LEVER	L_1	1	0,954	0,825	0,560	0,948	0,290
	L_{10}	0,954	1	0,936	0,712	0,996	0,128
	L_{50}	0,825	0,936	1	0,877	0,953	-0,177
	L_{90}	0,560	0,712	0,877	1	0,747	-0,605
	$L_{éq}$	0,948	0,996	0,953	0,747	1	
	$L_{10}-L_{90}$	0,290	0,128	-0,177	-0,605		1
DAYTIME JOUR	L_1	0,963	0,927	0,798	0,550	0,918	0,275
	L_{10}	0,942	0,968	0,891	0,676	0,964	0,142
	L_{50}	0,844	0,919	0,916	0,755	0,926	-0,024
	L_{90}	0,699	0,806	0,870	0,802	0,823	-0,219
	$L_{éq}$	0,930	0,964	0,903	0,695	0,964	
	$L_{10}-L_{90}$	0,0417	-0,126	-0,362	-0,547		0,630
RETIRING COUCHER	L_1	0,888	0,892	0,812	0,618	0,891	0,139
	L_{10}	0,819	0,887	0,877	0,717	0,891	-0,007
	L_{50}	0,693	0,794	0,836	0,734	0,806	-0,136
	L_{90}	0,563	0,670	0,738	0,695	0,686	-0,222
	$L_{éq}$	0,835	0,892	0,868	0,709	0,896	
	$L_{10}-L_{90}$	0,165	0,070	-0,068	-0,221		0,392
NIGHT NUIT	L_1	0,964	0,982	0,895	0,654	0,978	0,189
	L_{10}	0,890	0,966	0,959	0,785	0,973	-0,013
	L_{50}	0,668	0,789	0,861	0,822	0,807	-0,266
	L_{90}	0,465	0,584	0,673	0,701	0,600	-0,328
	$L_{éq}$	0,908	0,973	0,950	0,769	0,979	
	$L_{10}-L_{90}$	0,261	0,176	0,051	-0,162		0,428
24 h	L_1	0,975	0,949	0,831	0,582	0,943	
	L_{10}	0,938	0,975	0,911	0,696	0,973	
	L_{50}	0,806	0,897	0,924	0,794	0,908	
	L_{90}	0,567	0,695	0,776	0,780	0,712	
	$L_{éq}$	0,932	0,970	0,913	0,707	0,971	

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Table 10 - Daytime

		L_1	L_{10}	L_{50}	L_{90}	$L_{éq}$	$L_{10}-L_{90}$
RISING LEVER	L_1	0,963	0,942	0,844	0,699	0,930	0,0417
	L_{10}	0,927	0,968	0,919	0,806	0,964	-0,126
	L_{50}	0,795	0,891	0,916	0,870	0,905	-0,362
	L_{90}	0,550	0,676	0,755	0,802	0,695	-0,547
	$L_{éq}$	0,918	0,964	0,926	0,823	0,964	
	$L_{10}-L_{90}$	0,275	0,142	-0,024	-0,219		0,630
DAYTIME JOUR	L_1	1	0,961	0,873	0,740	0,951	-0,008
	L_{10}	0,961	1	0,960	0,859	0,995	-0,181
	L_{50}	0,873	0,960	1	0,954	0,975	-0,423
	L_{90}	0,740	0,859	0,954	1	0,888	-0,659
	$L_{éq}$	0,951	0,995	0,975	0,888	1	
	$L_{10}-L_{90}$	-0,008	-0,181	-0,423	-0,659		1
RETIRING COUCHER	L_1	0,917	0,951	0,917	0,833	0,948	-0,203
	L_{10}	0,856	0,941	0,977	0,934	0,953	-0,412
	L_{50}	0,733	0,853	0,946	0,974	0,881	-0,618
	L_{90}	0,589	0,725	0,844	0,921	0,760	-0,705
	$L_{éq}$	0,866	0,947	0,973	0,934	0,960	
	$L_{10}-L_{90}$	0,170	0,047	-0,115	-0,317		0,679
NIGHT NUIT	L_1	0,937	0,964	0,896	0,771	0,955	-0,065
	L_{10}	0,880	0,956	0,956	0,885	0,952	-0,296
	L_{50}	0,694	0,824	0,917	0,963	0,854	-0,640
	L_{90}	0,477	0,609	0,722	0,809	0,641	-0,658
	$L_{éq}$	0,895	0,966	0,958	0,885	0,972	
	$L_{10}-L_{90}$	0,234	0,132	-0,020	-0,205		0,589
24 h	L_1	0,990	0,974	0,892	0,763	0,965	
	L_{10}	0,949	0,995	0,966	0,871	0,996	
	L_{50}	0,834	0,934	0,992	0,971	0,953	
	L_{90}	0,584	0,719	0,821	0,899	0,753	
	$L_{éq}$	0,946	0,994	0,974	0,889	0,999	

Table 11 - Retiring

		L_1	L_{10}	L_{50}	L_{90}	$L_{éq}$	$L_{10}-L_{90}$
RISING LEVER	L_1	0,888	0,819	0,693	0,563	0,835	0,165
	L_{10}	0,892	0,887	0,794	0,670	0,892	0,070
	L_{50}	0,812	0,877	0,836	0,738	0,868	-0,068
	L_{90}	0,618	0,717	0,734	0,695	0,709	-0,221
	$L_{éq}$	0,891	0,891	0,806	0,686	0,896	
	$L_{10}-L_{90}$	0,139	-0,007	-0,136	-0,222		0,392
DAYTIME JOUR	L_1	0,917	0,856	0,733	0,589	0,866	0,170
	L_{10}	0,951	0,941	0,853	0,725	0,947	0,047
	L_{50}	0,917	0,977	0,946	0,844	0,973	-0,115
	L_{90}	0,833	0,934	0,974	0,921	0,934	-0,317
	$L_{éq}$	0,948	0,953	0,881	0,760	0,960	
	$L_{10}-L_{90}$	-0,203	-0,412	-0,618	-0,705		0,679
RETIRING COUCHER	L_1	1	0,940	0,835	0,704	0,960	0,084
	L_{10}	0,940	1	0,951	0,834	0,989	-0,064
	L_{50}	0,835	0,951	1	0,949	0,944	-0,343
	L_{90}	0,704	0,834	0,949	1	0,839	-0,605
	$L_{éq}$	0,960	0,989	0,944	0,839	1	
	$L_{10}-L_{90}$	0,084	-0,064	-0,343	-0,605		1
NIGHT NUIT	L_1	0,914	0,879	0,768	0,639	0,889	0,114
	L_{10}	0,906	0,946	0,879	0,764	0,941	-0,016
	L_{50}	0,799	0,907	0,957	0,925	0,912	-0,364
	L_{90}	0,580	0,704	0,796	0,859	0,711	-0,536
	$L_{éq}$	0,921	0,943	0,880	0,774	0,950	
	$L_{10}-L_{90}$	0,122	-0,005	0,195	- 0,393		0,703
24 h	L_1	0,924	0,871	0,758	0,622	0,883	
	L_{10}	0,944	0,944	0,864	0,739	0,951	
	L_{50}	0,898	0,976	0,960	0,863	0,968	
	L_{90}	0,693	0,800	0,884	0,912	0,821	
	$L_{éq}$	0,947	0,953	0,883	0,765	0,961	

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Table 12 - Night

		L_1	L_{10}	L_{50}	L_{90}	$L_{éq}$	$L_{10}-L_{90}$
RISING LEVER	L_1	0,964	0,890	0,668	0,465	0,908	0,261
	L_{10}	0,982	0,966	0,789	0,584	0,973	0,176
	L_{50}	0,895	0,959	0,861	0,573	0,950	0,051
	L_{90}	0,654	0,785	0,822	0,701	0,769	-0,162
	$L_{éq}$	0,978	0,973	0,807	0,600	0,979	
	$L_{10}-L_{90}$	0,189	-0,013	-0,266	-0,328		0,428
DAYTIME JOUR	L_1	0,937	0,880	0,694	0,477	0,895	0,234
	L_{10}	0,964	0,956	0,824	0,609	0,966	0,132
	L_{50}	0,896	0,956	0,917	0,722	0,958	-0,020
	L_{90}	0,771	0,885	0,963	0,809	0,885	-0,205
	$L_{éq}$	0,955	0,962	0,854	0,641	0,972	
	$L_{10}-L_{90}$	-0,065	-0,296	-0,640	-0,658		0,569
RETIRING COUCHER	L_1	0,914	0,905	0,799	0,580	0,921	0,122
	L_{10}	0,879	0,946	0,907	0,704	0,943	-0,005
	L_{50}	0,768	0,879	0,957	0,796	0,880	0,195
	L_{90}	0,639	0,764	0,925	0,859	0,774	-0,393
	$L_{éq}$	0,889	0,941	0,912	0,711	0,950	
	$L_{10}-L_{90}$	0,114	-0,016	-0,364	-0,536		0,703
NIGHT NUIT	L_1	1	0,958	0,754	0,537	0,965	0,230
	L_{10}	0,958	1	0,876	0,670	0,994	0,094
	L_{50}	0,754	0,876	1	0,887	0,882	-0,320
	L_{90}	0,537	0,670	0,887	1	0,684	-0,676
	$L_{éq}$	0,965	0,994	0,882	0,684	1	
	$L_{10}-L_{90}$	0,230	0,094	-0,320	-0,676		1
24 h	L_1	0,959	0,906	0,726	0,513	0,922	
	L_{10}	0,968	0,969	0,839	0,623	0,978	
	L_{50}	0,871	0,955	0,941	0,753	0,951	
	L_{90}	0,654	0,782	0,962	0,950	0,797	
	$L_{éq}$	0,962	0,970	0,861	0,650	0,981	

Table 13 - 24 Hours

		L_1	L_{10}	L_{50}	L_{90}	$L_{éq}$
RISING LEVER	L_1	0,975	0,938	0,806	0,567	0,932
	L_{10}	0,949	0,975	0,897	0,695	0,970
	L_{50}	0,831	0,911	0,924	0,776	0,913
	L_{90}	0,582	0,696	0,794	0,780	0,707
	$L_{éa}$	0,943	0,973	0,908	0,712	0,971
DAYTIME JOUR	L_1	0,990	0,949	0,834	0,584	0,946
	L_{10}	0,974	0,995	0,934	0,719	0,994
	L_{50}	0,892	0,966	0,992	0,821	0,974
	L_{90}	0,763	0,871	0,971	0,899	0,889
	$L_{éa}$	0,965	0,996	0,953	0,753	0,999
RETIRING COUCHER	L_1	0,924	0,944	0,898	0,693	0,947
	L_{10}	0,871	0,944	0,976	0,800	0,953
	L_{50}	0,758	0,864	0,960	0,884	0,883
	L_{90}	0,622	0,739	0,863	0,912	0,765
	$L_{éa}$	0,883	0,951	0,968	0,821	0,961
NIGHT NUIT	L_1	0,959	0,968	0,871	0,654	0,962
	L_{10}	0,906	0,969	0,955	0,782	0,970
	L_{50}	0,726	0,839	0,941	0,962	0,861
	L_{90}	0,513	0,623	0,753	0,950	0,650
	$L_{éq}$	0,922	0,978	0,951	0,797	0,981
24 h	L_1	1	0,965	0,855	0,619	0,963
	L_{10}	0,965	1	0,945	0,738	0,997
	L_{50}	0,855	0,945	1	0,850	0,955
	L_{90}	0,619	0,738	0,850	1	0,763
	$L_{éq}$	0,963	0,997	0,955	0,763	1

5.2. Note on Factorial Analysis into Principal Components /456

5.2.1. Aim of the Factorial Analysis

At the end of a survey or measuring program, there is a vast rectangular table of numerical data whose dimensions are such that they are an obstacle to quick understanding of the information thus gathered.

For example, in the case of this study, each of the 700 hundred persons interviewed during the survey answered 60 sometimes multiple questions, that is, they provided a certain number of responses: the table of gathered data therefore contains about 70,000 numerical values.

Likewise, the acoustic measuring program provided more than thirty different physical parameters, measured at more than a hundred different sites.

Thus, inasmuch as possible, the user of a great number of numerical values will seek, in order to understand them better, to represent these statistical data in a small space, with a minimum of loss of information.

This reduction of the data is the aim of the factorial analysis; the method used here is analysis into principal components, which does not depend on any hypothesis regarding the structure of the variables studied, unlike analysis into common factors and specific factors.

4.2.2 Description of the Method

For each of n individuals of a group, we took n variables of different types.

By "individual" we must understand here the person interviewed /457 in the case of the survey or the place of measurement in the case of the acoustic measurements. As for "variables", they are the questions or the acoustic parameters measured.

The individual, designated by the index i, can be represented by a point in the space of p dimensions R^p, the components of this point being the values of the p variables corresponding to this indvidual.

In this "space of the variables" R^p, a cloud of n points corresponds to the total of n individuals.

We may define a distance d between two individuals k and m:

(1)
$$d^2_{km} = \sum_{i=1}^{p} (x_{ki} - x_{mi})^2$$

x_{ki} designates the value of the variable i for the individual k. With this metric, the distance is zero between two perfectly similar individuals since the variables that correspond to them have the same values (case of two persons providing identical responses to the questionnaire). On the other hand the distance is great if the variables related to the two individuals are all very different.

Analysis into principal components consists of seeking a sub-space of small dimention such that the distances between the projections of the individuals in this sub-soace are are as close as possible to the real distances measured in space R^p.

Case of a Sub-Space with One Dimension

We will first of all study, in the first stage, the one-dimensional (a straight line D) meeting this condition.

Let u be the single vector that defines the sought line D, of /458
components u_1, u_2, .., u_p and x_k, x_m two individual points.

The distance d'_{km} between the orthogonal projections of these two points on line D is obtained by the scalar product:

(2) $$d'_{km} = \sum_{i=1}^{p} u_i \left(x_{ki} - x_{mi} \right)$$

The method consists of determining the p components u_i of the vector u which gives the maximum sum of the squares of the distances $(d'_{km})^2$ relative to all of the possible pairs of points x_k and x_m, that is, which maximize:

(3) $$d'^2 = \sum_{k=1}^{n} \sum_{m=1}^{n} \left(\sum_{i=1}^{p} u_i \left(x_{ki} - x_{mi}\right) \right)^2$$

$$= \sum_{k=1}^{n} \sum_{m=1}^{n} \left(\sum_{i=1}^{p} u_i \left(x_{ki}-x_{mi}\right) \right)\left(\sum_{j=1}^{p} u_j \left(x_{kj}-x_{mj}\right) \right)$$

The indices can be inverted:

(4) $$d'^2 = \sum_{i=1}^{p} \sum_{j=1}^{p} u_i u_j \left[\sum_{k=1}^{n} \sum_{m=1}^{n} \left(x_{ki}-x_{mi}\right)\left(x_{kj}-x_{mj}\right) \right]$$

The term in brackets can be written:

(5) $$\sum_{k=1}^{n} \sum_{m=1}^{n} \left(x_{ki} x_{kj} + x_{mi} x_{mj} - x_{mi} x_{kj} - x_{ki} x_{mj} \right)$$

$$= n \sum_{k=1}^{n} x_{ki} x_{kj} + n \sum_{m=1}^{n} x_{mi} x_{mj}$$

...

$$- \left(\sum_{m=1}^{n} x_{mi} \right)\left(\sum_{k=1}^{n} x_{kj} \right) - \left(\sum_{k=1}^{n} x_{ki} \right)\left(\sum_{m=1}^{n} x_{mj} \right)$$ 7459

The first two terms of this expression (5) are equal; the last two are also, since

$$\sum_{m=1}^{n} x_{mi} = \sum_{k=1}^{n} x_{ki} = n\, x_{.i},$$ noting x_i the average of all of the individuals of variable i.

Expression (5) becomes

$$2\,n\left(\sum_{k=1}^{n} x_{ki}\; x_{kj} - n\; x_{.i}\; x_{.j}\right)$$

For factor $2\,n^2$, this expression is the covariance v_{ij} of the variables i and j.

Equation (4) can therefore be written

$$d'^2 = 2\;n^2 \sum_{i=1}^{p}\sum_{j=1}^{p} u_i\; u_j\; v_{ij} \tag{6}$$

or, in matrix notation, with V the matrix of variances-covariances of the variables studied

$$d'^2 = 2\;n^2\;{}^t u\,\bar{V}\,u \tag{7}$$

Find the components u_i that maximize d'^2 and solve the following equation

$$\sum_{i}^{p} \frac{\delta d'^2}{\delta u_i}\, du_i = o$$

$$\sum_{i}^{p} \frac{\delta}{\delta u_i}\left(\sum_{k=1}^{p}\sum_{j=1}^{p} u_k\; u_j\; v_{kj}\right) du_i = o \tag{8}$$ /460

respecting the relationship

$$\sum_{i=1}^{p} u_i^2 = 1 \tag{9}$$ since the vector u is unitary

or

$$\sum_{i=1}^{p} u_i\; du_i = o \tag{10}$$

Equation (8) can also be written

$$\sum_{i=1}^{p}\sum_{j=1}^{p} u_j\; v_{ij}\; du_i = o \tag{11}$$

For equation (11) to be respected no matter what the vector of respective equation (10), it is necessary that

$$\sum_{j=1}^{p} u_j \quad v_{ij} \quad = \quad \mu u_i,$$ whatever i may be

(Lagrange multiplier method)

or, in matrix representation

(12) $\mu\, {}^t u = {}^t u \cdot V,$ μ being a constant to be determined.

now, ${}^t u V = {}^t (Vu),$, the covariance matrix V being symmetrical

(12) we write

(13) $Vu = \mu u = \mu I u$

or

(14) $(V - \mu I).\ u = o,$ which shows that u is one of the p values /461 proper λ_i of matrix V, u being the corresponding vector.

Equation (7) then becomes

$$d'^2 = 2\, \bar{n}^2.\ {}^t u.\ (\lambda_i u) = 2\, n^2 \lambda_i \ (u\ {}^t u)$$

Now ${}^t u\, u = 1,$ the vector u being unitary.

(15) $d'^2 = 2\, n^2 \lambda_i$

The maximum value of d'^2 therefore corresponds to the greatest of the values proper. Covariance matrix V is a symmetrical matrix positively defined: all of its proper values are positive.

Thus the unitary vector that defines the one-dimensional subspace on which is projected the cloud of individuals with as little deformation as possible (in the sense adopted here) is the proper vector of the matrix of the covariances corresponding to Q greatest proper values.

The q proper vectors, after standardization, also define a normalized base of this sub-space; we will call these proper unitary vectors "factors".

Each of these factors has the property of extracting independently from the other factors a part of the information relative to the prox- /462 imities of the individuals, in proportion of the proper value that corresponds to it (see equation 15). Thus, the sum of the proper values related to the factors defining the sub-space of projection measures the proportion of information contained in the sub-space.

5.2.3. Example : Case of 2 Variable

Let us consider as an example the case of p = 2 variables. The space of the variables is a space of two dimensions and therefore able to be represented graphically (FIG. 73). The variables will be supposed to be centered at the origin.

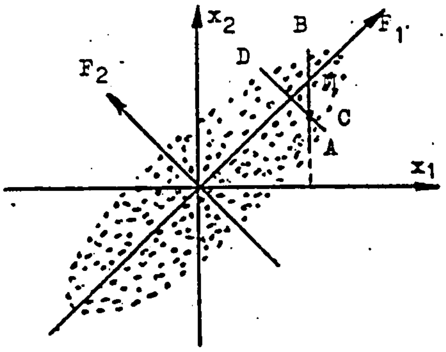

FIG. 73

If the two variables x_1 and x_2 have a non-zero covariance, the cloud of individuals shows an elongated form. Knowing only variable x_1 for an individual M, does not permit exact knowledge of variable x_2, but it does give certain information on x_2, since we know that M is situated on segment A B.

If F_1 and F_2 are respectively the large axis and the small axis of the cloud of points of "elliptical" shape, we see that, of all possible projection axes, it is axis F that best describes in a single dimension the cloud of individuals: knowing the value of F_1 for an individual M, we know that M is situated on segment CD, which is shorter than segment AB. F_1 is one of the factors sought by the analysis into principal components (that which corresponds to the largest of two proper values of the matrix 2 x 2 of covariance associated with the cloud of points. /463

Of course, only simultaneous knowledge of the two factors F_1 and F_2 permits exact knowledge of the position of an individual within the cloud of points.

5.2.4. Graphic Presentation of the Results

A first type of graphic presentation of the results is one which consists of representing all of the individuals by their projections in the sub-space of retained factors, it being understood that the number of factors does not exceed two (plane representation), or three at the most.

We will now explain another type of representation, used in the case of this study.

Let us suppose the variables centered and reduced (the origin is at the center of gravity of the cloud of individuals, the unit by which each variable is expressed is the standard deviation of this variable).

Let us calculate the correlation coeffecient between the factor f_1 of unitary vector u_1 (components u_{im} in the base of the variables) and the variable x_j :

(16) $$c\ (f_i\ ,\ x_j) = \frac{\text{covar}\ (f_i\ ,\ x_j)}{\sqrt{\text{var}\ (x_j)\ .\ \text{var}\ (f_i)}}$$ /464

The value f_{ki} of factor f_i for individual k is

$$f_{ki} = \sum_{m=1}^{p} u_{im} \cdot x_{km}$$

Therefore

$$\text{covar}\ (f_i\ ,\ x_j) = \frac{1}{n} \sum_{k=1}^{n} x_{kj} \sum_{m=1}^{p} u_{im} \cdot x_{km}$$

$$\text{covar}\ (f_i\ ,\ x_j) = \frac{1}{n} \sum_{m=1}^{p} i_{im} \sum_{k=1}^{n} x_{kj}\ x_{km}$$

The variables being centered,

$$\frac{1}{n} \sum_{k=1}^{n} x_{kj}\ x_{km} = v_{jm}$$

where

$$\text{covar}\ (f_i\ ,\ x_j) = \sum_{m=1}^{p} v_{jm}\ u_{im}$$

(17) $\text{covar}\ (f_i\ ,\ x_j) = \lambda_i\ u_{ij}$, since u_i is a proper vector of matrix V.

On the other hand

$$\text{var}\ (f_i) = \frac{1}{n} \sum_{k=1}^{n} \left(\sum_{m=1}^{p} u_{im}\ x_{km} \right)^2 \text{, car } f_i \text{ ,}$$

a linear combination of centered variables, is centered. /465

$$\text{var}\ (f_i) = \frac{1}{n} \sum_{k=1}^{n} \left(\sum_{m=1}^{p} u_{im}\ x_{km} \right) \left(\sum_{r=1}^{p} u_{ir}\ x_{kr} \right)$$

$$= \sum_{m=1}^{p} .u_{im} \sum_{r=1}^{p} u_{ir} \left(\frac{1}{n} \cdot \sum_{k=1}^{n} x_{km}\ x_{kr} \right)$$

$$= \sum_{m=1}^{p} u_{im} \sum_{r=1}^{p} u_{ir}\ v_{mr}$$

In matrix notation

$$\mathrm{var}\ (f_i) = t_{ui}\ V_{ui}$$

$$= t_{ui}\ \lambda_i\ u_i$$

(18) $\mathrm{var}\ (f_i) = \lambda_i\ ({}^t u_i\ u_i) = \lambda_i$, u_i being a proper unitary vector.

Finally,

var $(x_j) = 1$, since the variables are reduced. Then, according to (16), (17) and (18)

$$c\ (f_i\ ,\ x_j) = \frac{\lambda_i \qquad u_{ij}}{\sqrt{\lambda_i}}$$

(19) $c\ (f_i\ ,\ x_j) = u_{ij}\ \sqrt{\lambda_i}$

We have just seen that if the variables are reduced the factors are not (equation 18): This is due to the elongated form of the cloud of points. /466

This is why we will now show the individuals, not in the factorial sub-space R^q belonging to the space of origin R^p, but in a factorial space of q dimensions where the unit with which each factor f_i is expressed is the standard deviation of the factor. Let g_i be these new factors.

(20) $g_i = \frac{f_i}{\sqrt{\lambda_i}}$, since $\mathrm{var}\ (f_i) = \lambda_i$;

the factors g_i are carried by the same unitary vectors u_i as the factors f_j. As before, we will consider the q factors g_i corresponding to the q factors f_i retained for the representation of the individuals, that is, we limit our knowledge of the individuals to their projections in the sub-space of the q first factors.

The coordinates of the individuals in this new space of factors g_i are given by

$$g_{ki} = \frac{1}{\sqrt{\lambda_i}} \cdot f_{ki} = \frac{1}{\sqrt{\lambda_i}} \sum_{m=1}^{p} u_{im} \; x_{km} \; , \quad i = 1,2,.... q$$

The cloud of points representing the individuals is now "spherical" in form, since, like the factors f_i, the factors g_i are at right angles two by two and their variance is equal to unity.

Let us consider, in this space, the p points y_j (j = 1, 2, ... p) having for coordinates $u_{ij} \cdot \sqrt{\lambda i}$ (i = 1, 2 ..., q), that is, the coefficients of correlation of the variable j with the factors f_i. These points y_j will be called "variable points".

We immediately conceive a first interpretation of this representation: the proximity of a variable point y_j and a factor g_i represented by the extremity of its unitary vector u_i, means that the variable x_j is in close correlation with the factor f_i, that is, the factor f_i even has the same "significance" as the variable x_j. /467

The analysis of the proximities between variable points and factors therefore immediately gives information on the meaning to be attributed to the factors.

Let us return to the sub-space R^q of the factors f_i. (FIG. 74) An individual k is represented by a point M'_k projection on this sub-space of the point M_k representing this individual in the space of origin R^p. M_k is defined by its factorial coordinates:

$$f_{ki} = \sum_{m=1}^{p} u_{im} \; x_{km} \quad , \quad i = 1, 2, ..., q$$

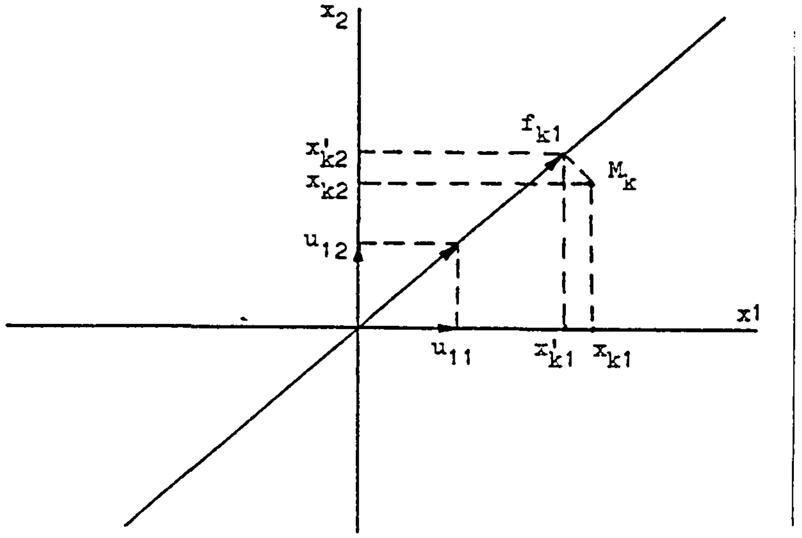

FIG. 74

Knowing these q factorial coordinates, it is evidently not possible to calculate exactly, by going in reverse, the value x_{kj} of the variable j for the individual k; for that it would be necessary to know the p factorial coordinates of the individual. We can, however, obtain from it an estimate x'_{kj}, which will be better, since as we have seen the projection on R^q will cause the least possible deformation of the cloud of origin of the individuals, that is, the number q of factors retained will be great. /46

(21) $$x'_{kj} = \sum_{i=1}^{q} u_{ij} \; f_{ki},$$, which can also be written

$$x'_{kj} = \sum_{i=1}^{q} u_{ij} \sqrt{\lambda_i} \; . \; \frac{f_{ki}}{\sqrt{\lambda_i}}$$

$$= \sum_{i=1}^{q} u_{ij} \sqrt{\lambda_i} \; . \; \xi_{ki}$$

now, g_{ki} ($i = 1, \ldots\ldots q$) are the coordinates of the least M''_k representing the individual k in the sub-space of the factors g_i.

$$x'_{kj} = \overline{OY_j} \times \overline{OM''_k}$$

In the sub-space of the factors g_i, the orthogonal projection of the point M''_k representing the individual k on the "variable vector" $\overline{OY_j}$ provides the best estimate of the value of the variable j for the individual k.

Finally, let us calculate the variance of x'_j, estimate of the variable x_j.

Let us first show that the factors f_i are without correlation two by two. /469

$$\underset{\neq}{\text{covar}\ (f_i , f_m)} = \frac{1}{n} \sum_{k=1}^{n} \left(\sum_{r=1}^{p} u_{ir} \quad x_{kr} \right) \left(\sum_{s=1}^{p} u_{ms} \quad x_{ks} \right)$$

$$= \sum_{r=1}^{p} u_{ir} \sum_{s=1}^{p} u_{ms} \left(\frac{1}{n} \sum_{k=1}^{n} x_{kr} \quad x_{ks} \right)$$

$$= \sum_{r=1}^{p} u_{ir} \sum_{s=1}^{p} u_{ms} \quad v_{rs}$$

In matrix notation

$$\text{covar}\ (f_i , f_m) = {}^t u_i \ V \ u_m$$

$$= \lambda_m \quad {}^t u_i \quad u_m$$, since u_m is proper vector of matrix V.

$$\text{covar}\ (f_i , f_m) = o$$, since u_i and u_m are two different proper vectors of matrix V, and therefore orthogonal.

Therefore according to (21)

$$\text{var}\ (x'_j) = \sum_{i=1}^{q} u^2_{ij}\ \text{var}\ (f_i)$$

$$= \sum_{i=1}^{q} u^2_{ij}\ \lambda_i$$

The variance of x'_j is therefore equal to the length of the vector $\overline{OY}_j$. Recalling that var $(x_j) = 1$, since the variables are reduced, we see that the length of the vector $\overline{OY}_j$ represents the proportion of the variance of the variable j, explained by the q factors f_i retained, or in other words the measurement of the quality of the representation of the variable j by the restricted space of the factors f_i.

5.3. Note on the Correlation Coefficient /470

The correlation coefficient r measures the linear connection existing between two variables; it can vary from - 1 to + 1. Knowing the variable x , the value of the coefficient indicates the precision with which one may infer the variable y.

If knowing x the variable y is found exactly determined, the connection between x and y is said to be functional (r = 1). If on the other hand the knowledge of x does not give any information on the position of y, we say that x and y are independent. Finally, knowledge of x can permit us to situate y in a group of values distributed according to a law having parameters different from those of the marginal distribution of y; we then say that x and y are in stochasic connection or in correlation.

We must note that the correlation coefficient can be significantly different from zero for different values according to the size of the sample; the table below gives an idea of these values, which can be very low.

Size of sample	600	400	200
r significantly ≠ 0 at threshold $p = 0.05$	0.08	0.10	0.14

This table explains why coefficients as low as those that we have found in this study are considered highly significant.

5.4. List and Function of the Principal Programs Used in the NSU Processing /471

5.4.1. Friedman Analysis

1 - Programs
BSU 4, BSU 5, BSU 6, BSU 7

2.- Sub-Programs
TWOAC, RANKC, CSTB (CSTBD)

3 - Function

When the response is marked on at least an ordinal scale, we can test the hypothesis that k paired samples are taken from the same population by using the Friedman analysis of rank variance.

The pairing consists either of putting the same subject in the k situations (which is sometimes impossible, e.g., if the k situations are age groups), or by taking k subjects having the same set of characters (e.g., sex, level of point from noise, exposure of dwelling, etc...) and distribute then "by chance" in the k situations.

In our case, it is evident that this second way of pairing was retained, since a subject is characterized only by his membership in a single class of each criterion.

Table 14 /472

Parameters of pairing			Variable tested noise in previous dwelling				
L_{10}-24h	satis[illegible] with section	exposure	1	2	3	4	5
60dB (A)	3	5	7 (5)	6 (3,5)	4 (2)	6 (3,5)	3 (1)
60dB (A)	3	5	3 (1)	7 (5)	5 (3,5)	4 (2)	5 (3,5)
58dB (A)	2	5	6 (5)	5 (3)	5 (3)	4 (1)	5 (3)
Total of ranks per column			R_1=11+...	R_2=11,5+...	R_3=8,5+...	R_4=6,5+...	R_5=7,5+.

In the columns of the variable tested (Table 14), the figures not in parentheses are the responses marked on the ordered scale (here, 1 to 7), and the figures in parentheses are the ranks of these responses in a row, with those that are equal in the middle. The analysis is done on the ranks for each paired group, here a row, if the zero hypothesis is true in each column, we can find close by the same number of 1's, of 2's, ...of k's.

Friedman has shown that when the number of rows and/or columns is not too small, X_r^2 is distributed approximately like a chi-two with k-1 degrees of freedom.

$$\chi_r^2 = \frac{12}{Nk\ (k+1)} \sum_{j=1}^{k} (R_j^2) - 3\ N\ (k+1)$$

in which N = number of rows

K = number of columns

R_j = number of ranks in the number j column

4. Remarks /473

The IBM programs were modified so as to hold and then print the sum of the ranks in the columns (the R_j's) and the averages of the responses in the cases where they are on a scale of intervals.

For further information see:

- Non-Parametric Statistics (S. Siegel)
- IBM SSP 1130 TWOAV and RANK

5.4.2. Spearman Correlation Coefficient

1 - Programs

BSU 13, BSU 14, BSU 15

2 - Sub-Programs

RANKC, SPEAR, TIE, CSTB (or CSTBD)

3 - Function

The responses being marked on at least an ordinal scale, the Spearman correlation coefficient permits testing of the correlation between two variables measured on a single group of subjects (e.g., rank of students in a class at the beginning and then at the end of a year).

We begin by ranking the responses in one variable, then in the other.

/474

students	beginning of year	end of year	d_1^2
A	10 (3)	12 (4)	1
B	8 (2)	7 (2)	0
C	12 (4)	11 (3)	1
D	15 (5)	16 (5)	0
E	5 (1)	6 (1)	0

Table 15

In the example of Table 15, there is the response (studen statement), then the rank in parentheses (in inverse order from the usual, which has no importance).

We now calculate

$$r_s = \frac{1 - 6 \sum_{i=1}^{N} d_i^2}{N^3 - N}$$

in which

r_s = Spearman coefficient

d_i = the difference in rank between the two responses of one subject

N = the number of subjects

We also make a correction that takes into account the number of equal responses for a given rank.

The first time, while going trhough the sites in order to get comparable noises, we draw the histograms of the "annoyance" variables. The second time, we normalize the distribution by using the percentages of numbers of subjects calculated during the previous stage. /476

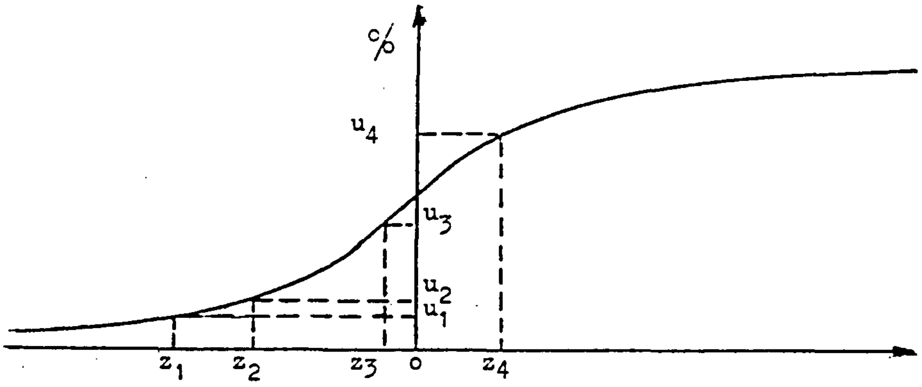

FIG. 75

u_i = cumulative percentage for class i

z_i = corresponding statement, if the normality of the distribution is accepted

5.4.5. Statistics on the Raw Parameters

1 - Program
BSU 19

2 - Sub-Programs
CSTB, HIST

3 - Function

Two statistics are provided by this program; they bear on the distribution of the subjects in relation to the noise. /477

5. 4 - Remarks

The IBM programs were modified for reasons of occupation of the memory.

For further information see /475

- Non-Parametric STatistics (S. Siegel)
- SSP 1130 IBM SRANK, RANK, TIE

5.4.3. Histograms of the Responses

1 - Program
BSU 11

2 - Sub-Program
CSTB (or CSTBD)

3 - Function

This program traces horizontal histograms on the printer by means of stars. It also prints the number of subjects per class and the partial and cumulative frequencies calculated on the number of persons responsing; it also gives the percentage of persons not responsing.

5.4.4. Standardization of the Annoyance Scales

1 - Programs
BSU 17 and BSU 18

2 - Sub-Programs
HIST, PARAB, FGAUS, CSTB (or CSTBD)

3 - Function

The object is to standardize the ordinal scale (1, 2, 3, etc.) of different annoyance scales under the hypothesis of normality.

a) The first consists of two-dimensional tables:

$L_{10} - L_{90}/L_{50}$

and L_{10}/L_{50}

b) The second, of histograms giving the number of persons for the different classes of a noise, all of the others being taken together (horizontal representations with partial and cumulative frequencies).

5.4.6. Two-Dimensional Tables

1 - Program
BSU 21

2 - Sub-Programs
CSTB (or CSTBD), TADIN

3 - Function

It is a question of constructing distribution tables, with relation to two variables, of the nubmer of subjects. It is possible to go through them in order to retain only part of the sample.

The program also prints the totals by row and column of the numbers of subjects of a category of a variable.

5.4.7. Histograms with TRI

1 - Program
BSU 23

2 - Sub-Programs
HIST, CSTB (or CSTBD) /478

3 - Function

This program permits us to obtain the histogram of a variable on a sub-sample while retaining only the subjects corresponding to certain values of other variables. For example, a histogram of the daytime annoyance in 7 points on men less than 40 years old and possessing a car.

The histogram is horizontal and the partial and cumulative frequencies are printed.

5.4.8. Pointer

1 - Program

BSU 30

2 - Sub-Programs

The S/P IBM of the curve plotter

3 - Function

This program allows examine the subjects on a plotter by following two variables with possible sorting so as to retain only one sub-sample.

5.4.9. Median, Mean, Variance

1 - Programs

BSU 31 and BSU 32

2 - Sub-Programs

The S/P of IBM for the curve plotter

3 - Function

This program sorts the subjects that interest us (sub-sample) /479 and calculates the mean, the variance and the standard deviation of the sample thus obtained.

The ranks the responses in order of increase and calculates the cumulative frequencies and then prints them; this permits us to find the desired quantities by simple interpolation afterward.

5.4.10. Factorial Analysis

1 - Programs
FACT 1, FACT 2, FACT 3

2 - Sub-Programs
CORRU, EIGEN, TRACE, LOAD, VARMX, DATA, CSTB (or CSTBD)

3 - Function
See annex concerning factorial analysis.

4 - Remarks

We have used the programs and sub-programs of the SSP 1130 IBM, modifying them in order to adapt them to the dimensions of our problem and to the details of our data.

See SSP 1130 IBM FACTO and the S/P mentioned in FACTO.

5.4.11. Multiple Regression

1 - Program
REGR 1, REGR 2, REGR 3

2 - Sub-Programs
CORRU, ORDER, MINV, MULTR, DATA, CSTB (or CSTBD)

3 - Function /480

To gauge a sample or a sub-sample, a linear model of the type:

$$y - a_1 x_1 + a_2 x_2 + \ldots, + a_n$$

This is done in the direction of the least squares.

4 - Remarks

As for the factorial analysis, the IBM programs were modified to fit the dimensions of our problem.

See SSP 1130 IBM REGRE and the S/P references.

5.5. - Facsimile of the Questionnaire /481

SOCIAL SCIENCES DIVISION

Psychosociological Study
of Noise
in the Paris Area

Col :

1	2	3	4
	5		

Interviewer:

Acoustic measurements made, street: n°

6	7	8	9

10
1

7482

1 - Have you at least one window overlooking ..X.. street?

Yes................ 3
No 2

11 ☐

2 - We would like to have your opinion regarding the noise that you hear from the street when you are in your apartment during the day.
(show booklet, page 3)*

1 2 3 4 5 6 7

very satisfied — very unhappy

12 ☐

3 - And during the night?
Would you please indicate your position on the graduated line?
(show booklet, page 3)*

1 2 3 4 5 6 7

very satisfied — very unhappy

13 ☐

4 - Are you generally satisfied living in this section of town?

Yes 3
No 2
Don't know 1

14 ☐

* Interviewer's booklet.

5 - Are you satisfied in regard to:

	Yes	No
a - The public services (local govt., P.O.)	☐	☐
b - The schools	☐	☐
c - The stores	☐	☐
d - The doctors and pharmacists	☐	☐
e - The public transport	☐	☐
f - The proximity to place of work	☐	☐
g - The noise in the building	☐	☐
h - The amusements	☐	☐
j - The neighbors	☐	☐
k - The noise from the street	☐	

15 16
☐☐

(write the total number of yes answers in the numbered boxes in the right-hand margin)

6 - Would you please rank the following items, going from the most satisfactory to the least satisfactory? (show the forms)

	rank
a - The amusements	☐
b - The proximity to place of work	☐
c - The public transport	☐
d - The noise from the street	☐
e - The noise in the building	☐
f - The schools	☐
g - The neighbors	☐
h - The stores	☐
j - The public services (local govt., P.O.)	☐
k - The doctors and pharmacists	☐

17 ☐☐ 18
19 ☐☐ 20
21 ☐☐ 22
23 ☐☐ 24
25 ☐☐ 26
27 ☐☐ 28
29 ☐☐ 30
31 ☐☐ 32
33 ☐☐ 34
35 ☐☐ 36

7 - Among the following situations, for which does the presence of noise seem:
(show booklet, page 4)

	1	2	3	4	5	6	7	
indifferent								intolerable
a - When you read	1	2	3	4	5	6	7	
b - When you listen to radio or TV	1	2	3	4	5	6	7	
c - When you are at table with family or guests	1	2	3	4	5	6	7	
d - In the evening when you go to sleep	1	2	3	4	5	6	7	
e - At night while you sleep	1	2	3	4	5	6	7	
f - In the morning just before you wake up	1	2	3	4	5	6	7	

37 ☐
38 ☐
39 ☐
40 ☐
41 ☐
42 ☐

8 - When you read in a room overlooking ..x.. street (1), does the nose from the street disturb you if you leave the window open?

Yes 3
No 2
Don't know 1

43 ☐

(1) Indicate the name of the street where the measurements were made.

9 - With the windows closed, does the noise from .... street disturb you when reading:
(show booklet, page 2)

Very often 5
Often 4
Rarely 3
Never 2
No response 1

44 ☐

10 - Do you have a radio?

Yes 3
No 2
No response 1

45 ☐

11 - (if yes to 10)
Where do you listen to the radio most often?

a - In a room not overlooking ......street ... 2
b - In a room overlooking ....street 1

46 ☐

12 - (for 11, a and b)
Can you hear the radio with the window open without being disturbed by the noise from .... street?

Yes .... 3 (skip 13)
No 2
Don't know 1

47 ☐

/486

13 - Does the noise from ..... street disturb you when you listen to the radio with the window closed?

Yes 3
No 2
Don't know 1

48 ☐

14 - Do you have a TV?

Yes 3
No 2
Don't know 1

49 ☐

15 - (if yes to 14)
Where do you usually watch TV?

a - In a room not overlooking .... street ... 2
b - In a room overlooking ..... street 1

50 ☐

16 - (for 15 a and b)
Can you watch TV with the window open without being disturbed by the noise from ..... street?

Yes .... 3 (skip 17)
No 2
Don't know 1

51 ☐

17 - Does the noise from ..... street disturb you when you watch TV with the window closed?

Yes 3
No 2
Don't know 1

52 ☐

Do you generally have to close the window because of the noise from ..... street?

18 - When you have guests 53 ☐

Yes 3
No 2
No response 1

19 - At family mealtime 54 ☐

Yes 3
No 2
No response 1

20 - How many rooms are there in your apartment, counting the kitchen? 55 ☐ 56 ☐

21 - How many of them overlook ..... street? 57 ☐
(if all, go to 27)

22 - When you open a window that does not overlook ..... street, do you hear noise from this street? 58 ☐

Yes 3
No .... 2 (go to 24)
Don't know .... 1 (go to 24)

/488

23 - (if yes to 22)
Are the noises that you hear
Intolerable 3
Somewhat tolerable 2
Completely tolerable 1

59 ☐

24 - Do you hear other noises?
Yes 3
No 2
(if no go to 27)

60 ☐

25 - (if yes to 24) Which ones? (show booklet, page 5)
Neighbors - noises in the building........... 1
Noises in the yard (shop, children, trash cans) 2
Activities near the building (commerce, swimming pool, garage)........................ 3
Train - Airplane - Subway 4
Other 5

61 ☐

26 - Are the noises that you hear
Intolerable 3
Somewhat tolerable 2
Completely tolerable 1

62 ☐

27 - Does your bedroom overlook ..... street?
Yes 3
No 2

63 ☐

28 - What time do you usually go to bed?
(show booklet, page 6)
before 2130 hours 1
between 2130 and 2230 hours 2
between 2230 and 2330 hours 3
between 2330 and 0030 hours 4
after 0030 hours 5

64 ☐

29 - Do you have difficulty falling asleep?
very often 5
often 4
rarely 3
Never .... 2 (skip 30)
Don't know .... 1 (skip 30)

65 ☐

30 - (if 5-4-3)
What is the main reason?
(show booklet, page 7)
Noise from the street 1
Physical discomfort 2
Noise in the building 3
Noise in the apartment 4
Nervous fatigue 5
Other cause 6
What? .....

66 ☐

31 - Are you awakened during the night? (show booklet, page 2)
very often 5
often 4
rarely 3
never .... 2 (skip 32-33-34)
don't know .... 1 (skip 32-33-34)

67 ☐

32 - What is the main reason?
(show booklet, page 8)

68 ☐

Physical discomfort 2
Noise in the building 3
Noise in the apartment 4
Nervous fatigue 5
Noise from the street 1
Other cause 6
What? .....

33 - In this case do you awaken with a start?

69 ☐

Yes 3
No 2
Don't know 1

34 - Do you have difficulty falling asleep again?

70 ☐

Yes 3
No 2
Don't know 1

35 - Do you dream? (show booklet, page 2)

71 ☐

Very often 5
Often 4
Rarely 3
Never .... 2 (skip 36)
Don't know .... 1 (skip 36)

36 - (if 5-4-3)

Do you usually remember your dreams?

Yes 3
No 2
Don't know 1

72 ☐

37 - Do you use medication to sleep better?
(show booklet, page 2)

very often 5
often 4
rarely 3
never 2
no response 1

73 ☐

38 - What time do you usually get up?
(show booklet, page 9)

before 0530 hours 1
0530 - 0630 hours 2
0630 - 0730 hours 3
after 0730 hours 4

74 ☐

39 - Do you wake up earlier than you would like to in the morning? (show booklet, page 2)

very often 5
often 4
rarely 3
never .... 2 (skip 40)
don't know .... 1 (skip 40)

75 ☐

40 - What is the main reason? (if 5-4-3)
(show booklet, page 10)

Noise in the building	3
Noise in the apartment	4
Nervous fatigue	5
Noise from the street	1
Physical discomfort	2
Other cause (e.g., airplane, train, subway)	6

What? .....

76 ☐

CARD No. 2

1	2	3	4

5 ☐

n°

6	7	8	9

10 2

11 ☐

41 - How long have you lived in this dwelling?
(show booklet, page 11)

less than 6 months	1
from 6 months to 2 years	2
from 2 to 5 years	3
from 5 to 10 years	4
more than 10 years	5
have never moved	6

(skip 42 and 43)

/493

42 - In your previous dwelling did you hear

much less 1
less 2
as much 3
more 4
much more 5

noise than in your present dwelling during the day?

12 ☐

43 - In your previous dwelling did you hear

much less 1
less 2
as much 3
more 4
much more 5

noise than in or present dwelling at night?

13 ☐

44 - Do you think you can live with noise for a long time?

yes 3
no 2
don't know 1

14 ☐

45 - We would like to know what you think of the following opinions:
(show booklet, page 1)

fully agree 3
agree somewhat 2
do not agree at all 1

/494

A - Nothing can be done about the noise from the street.
B - Noise from the street cannot be avoided.
C - Noise from the street can be reduced but not eliminated.
D - If one noise is completely eliminated, another one would appear which was hidden until then.

15 ☐
16 ☐
17 ☐
18 ☐

46 - Do you think you are more nervous since you have been living here?

Yes 3
No 2
Don't know 1

19 ☐

47 - We would like to know what you think of the following opinions:
(show booklet, page 1)

fully agree 3
agree somewhat 2
do not agree at all,..... 1

A - Noise finally throws the organism out of balance.
B - Continuous noise causes people to take tranquilizers.
C - Noise affects people without their knowing it.
D - Noise is certainly at the root of many nervous depressions.

20 ☐
21 ☐
22 ☐
23 ☐

/495

I want to list some situations for you two by two. For each of these pairs please tell me which situation requires the most quiet for you.

	1	2
1 -	When you read	or when you are at table with family or guests.
2 -	In the evening when you go to sleep	or when you listen to radio or TV.
3 -	In the morning during your last moments of sleep	or when you are at table with family or guests.
4 -	When you read	or at night when you are sleeping.
5 -	When you listen to radio or TV	or in the morning during your last moments of sleep.
6 -	When you are at table with family or guests	or at night when you are sleeping.
7 -	When you read	or at night when you go to sleep.
8 -	At night when you are sleeping	or when you listen to radio or TV.
9 -	In the morning during your last moments of sleep	or when you read.
10 -	In the evening when you go to sleep	or at night when you are sleeping.
11 -	When you listen to radio or TV	or when you read.
12 -	When you are at table with family or guests	or in the evening when you go to sleep.
13 -	At night when you are sleeping	or in the morning during your last moments of sleep.
14 -	When you listen to radio or TV	or when you are at table with family or guests.
15 -	In the evening when you go to sleep	or in the morning during your last moments of sleep.

24
25
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37
38

48 - In your opinion is the street noise that you hear from your apartment during the day generally (show booklet, page 13)

1 2 3 4 5 6 7

very tolerable — totally intolerable

39 ☐

49 - In your opinion is the street noise that you hear from your apartment during the night generally (show booklet, page 13)

1 2 3 4 5 6 7

very tolerable — totally intolerable

40 ☐

50 - In total, considering both day and night, the noise from the street is, in your opinion (show booklet, page 13)

1 2 3 4 5 6 7

very tolerable — totally intolerable

41 ☐

51 - Sex

Man 1
Woman 2

42 ☐

52 - Marital status of person interviewed

Single 1
Married 2
Widow 3
Divorced 4

43 ☐

53 - In what age category are you?

21 to 30 1
31 to 40 2
41 to 50 3
51 to 60 4
61 or older 5

44 ☐

54 - What is your profession (or that of the householder) (specify job, qualifications, hierarchical position, and nature of the business. If the person is retired, mention this and indicate the profession at the time of retirement)? (For coding, see attached document.)

45 ☐

APARTMENT LAYOUT

7499

55 - During the day (between 0700 and 2200 hours) how much time do you usually spend in your dwelling? (Max. 15 hours)

46 47 ☐☐

56 - During the night (between 2200 and 0700 hours) how much time do you usually spend in your dwelling? (Max. 9 hours)

48 ☐

57 - How many persons in all live in this dwelling?

49 50 ☐☐

58 - Do you have an automobile?

Yes 3
No 2
No response 1

51 ☐

59 - (if yes)

Do you use it

every day 3
on weekends 2
for vacations 1

52 ☐

60 - Identification of the interviewee

- City
  Paris 2
  Suburbs 1

53 ☐

- Department
- Street and number
- Stairway
- Floor
- Name

No. of the point

54 55 56 ☐☐☐

End of Document