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TAKING INTO ACCOUNT NIGHTTIME ANNOYANCE IN THE  
CALCULATION OF THE PSOPHIC INDEX

Jacques Francois

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| 16. Abstract<br>This paper discusses the annoyance factor caused by air traffic noise on the residents of areas near airports. The psophic index is used to predict the level of overall annoyance suffered on the average by residents around airports. The method of calculation differentiates between daytime and nighttime annoyance. |  |  |  |
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TAKING INTO ACCOUNT NIGHTTIME ANNOYANCE IN THE  
CALCULATION OF THE PSOPHIC INDEX

Jacques Francois

Contents

|   | Pages |
|---|-------|
| Introduction  | 1     |
| I      Variation of Overall Annoyance as a<br>Function of the Psophic Index | 4     |
| II     Distribution of Annoyance Over<br>24 Hours                           | 5     |
| III    Variation of the Annoyance as a<br>Function of the Psophic Index     | 12    |
| Conclusions   | 21    |
| Appendix I      Time of Getting Up and<br>Going to Bed                      | 22    |
| Appendix II     Nighttime Annoyance as a<br>Function of the Age             | 24    |

Introduction

The Commission of the Environment of the General Civil Aviation Board is now considering the difficulties which may be raised by taking into account nighttime traffic in assessing the

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

/1\*

annoyance caused by the noise of the aircraft.

We know that the purpose of the French "psophic index" is to predict the level of overall annoyance suffered on the average by residents around airports. The method of calculation of the index differentiates between daytime annoyance (from 6 a.m. to 10 p.m.) and nighttime annoyance (10 p.m. to 6 a.m.).

The psophic index penalizes greatly each night flight by applying the coefficient 10 (that is, an aircraft movement between 10 p.m. and 6 a.m. is considered as 10 movements).

Thus the calculation of the index is based on a number of hypotheses or assumptions:

- the night period is considered for all residents around airports (or for most of them) as 10 p.m. to 6 a.m.;
- at any time between 10 p.m. and 6 a.m., a flight causes additional annoyance;
- the value of this additional annoyance is constant over the entire period: it is 10 times greater than between 6 a.m. and 10 p.m.

To be operational, an index implies necessarily simplifying hypotheses. Its purpose is to predict the reactions of the average individual and not the reaction of each individual considered separately; an index disregards necessarily some parameters of very small weight, not to complicate the calculation unnecessarily. But we are right to question ourselves about the validity of the hypotheses and the possibly excessive nature of the simplifications that they imply. Moreover that the definition of nighttime and the weighting of night traffic are based much more on "common sense" than on the results of precise investigations. /2

The purpose of this paper is to furnish answer elements to these questions on the basis of the examination of the situation around Orly and Roissy. The results described in the next few pages are based on the association of 2 types of data: data

relating to traffic (psophic index, average number of movements) and the answers of residents near these 2 airports to a survey conducted in 1975 on the request of the Ministry of the Quality of Life. A sampling of about 500 residents around Roissy and 1000 near Orly, between the ages of 20 and 65, had been questioned.<sup>1</sup>

It should be specified that the study described below is of limited range, since it is based on the answers of residents near airports to a very small number of questions. In the 1975 survey, centered around the study of the repercussions of aircraft noise on residents near airports, the approach to annoyance at night, annoyance during sleep were approached in a very marginal manner. The questions asked do not lend themselves to a very thorough analysis of the problems posed by nighttime annoyance. The result is that hasty conclusions should not be drawn from the results, which represent indications, assumptions rather than a rigorous demonstration.

Meanwhile, we could question the validity of the assessment of nighttime annoyance established on the basis of the statements of the persons questioned. Not only does this evaluation not take into consideration the objective quality of sleep (such as could be measured by the modifications in the EEG, the observations of awakenings, etc.), but is also based on testimony. Now we are aware of the want of connection between the judgement given about one's sleep, when one wakes up, and the objective characteristics of the latter. But if the judgement referring to a certain night is not a reliable indication, it seems that some trust can be placed in statements relating to a long period, a habitual state, especially when the answers of a large group of persons are collected. Furthermore, if we consider that the object of the psophic index is to foresee the level of the sensation of annoyance (and not the level of any physiological disorder), it seems

3

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<sup>1</sup>The results of this survey may be found in the report "The Repercussions of Aircraft Noise on the Mental Stability of Residents Around Airports, IFOP (French Public Opinion Institute), September 1975".

legitimate to take as basis the annoyance expressed and to study the relation with the index N.

I. Variation of the Overall Annoyance as a Function of the Psophic Index

/4

There are clear differences in the characteristics of the traffic of the two airports studied:

-- the average number of daily movements is much higher in Orly than in Roissy: about 400 movements as compared with 250;

-- during the nighttime period (i.e., from 10 p.m. to 6 a.m.), the number of movements is similar, of the order of 20, that is 5% of the Orly traffic, 7% of the Roissy traffic. But after night flights are weighted by 10, the night traffic component is a little lower in Orly (35% as compared with 42% in Roissy).

-- on the whole, the nature of the Roissy traffic is homogeneous: the daytime and nighttime traffic involve the same type of aircraft. On the contrary, in Orly, night traffic may be divided into 2 periods: night flights tend to be concentrated in the period 10 to 11 p.m., while the aircraft are of the same type as in the daytime: from 11 p.m. to 6 a.m., because of the ban on flights, movements are rare and involve almost exclusively aircraft producing little noise.

In these circumstances, if the psophic index took very poor consideration of the nighttime annoyance, one should note the appearance of anomalies (such as different translations or slopes) when the relation between overall annoyance and the psophic index of the two airports is compared. The results shown on Graph 1 seem very satisfactory: the relation between the psophic index and the intensity or frequency of the annoyance is very coherent from one airport to the other. It makes it possible to consider that the index N permits with satisfactory validity the prediction

/5

of the annoyance level. Consequently, the possibly poor consideration of the nighttime annoyance does not affect the overall validity of the index in Orly and Roissy. This favorable indication on the quality of the index will nevertheless have to be qualified to some extent as a result of the analyses described in the next few pages.

## II. Distribution of Annoyance Over 24 Hours

/6

The results described in this chapter come from the answers of residents near Roissy and Orly to the following question:

Normally, at what times of the day do you hear noises which annoy you?

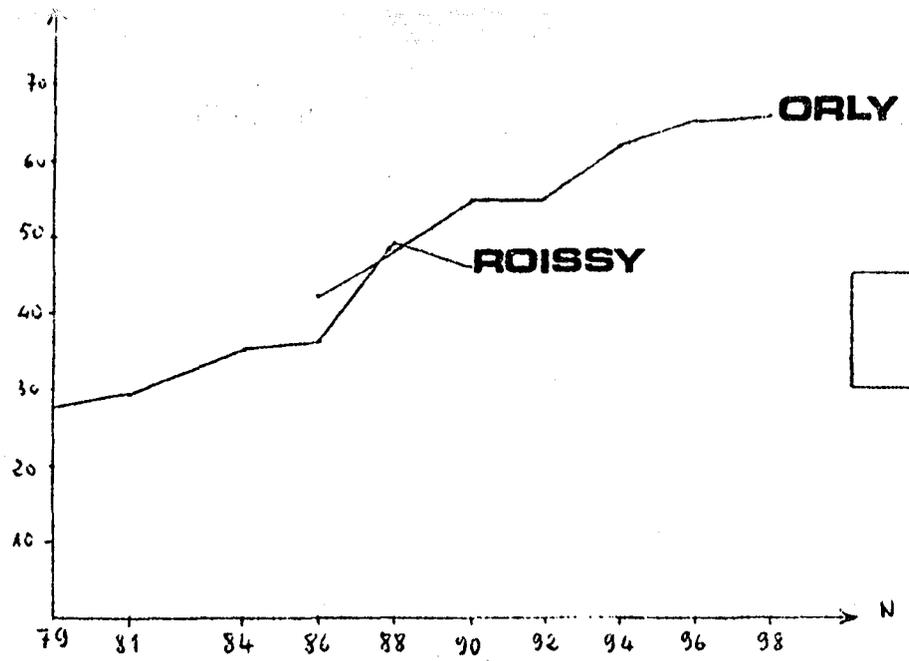
- in the early morning (6 to 8 a.m.)
- during the morning (8 a.m. to noon)
- at lunchtime (noon to 2 p.m.)
- in the afternoon (2 to 7 p.m.)
- at dinner time (7 to 9 p.m.)
- during the evening (9 to 11 p.m.)
- at night (11 p.m. to 6 a.m.)
- at no time

It may be noted that this time is not directly related to the noise of aircraft: it comprises all noises, including those heard outside the residence (in particular in the cases of employed persons). It should also be noted that the intervals of time were proposed to the interviewees as indication and should not be taken into account rigorously. Finally, the distinction between evening and night was fixed at 11 instead of 10 p.m. which complicates a little the analysis of the results as a function of the psophic index.

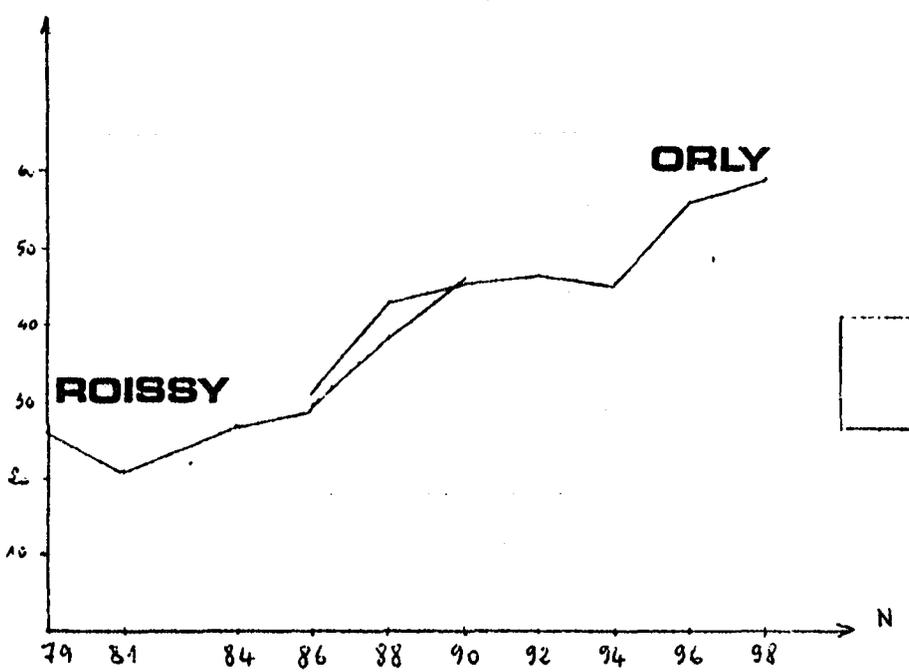
Graph 1 (see page 6)

Key:

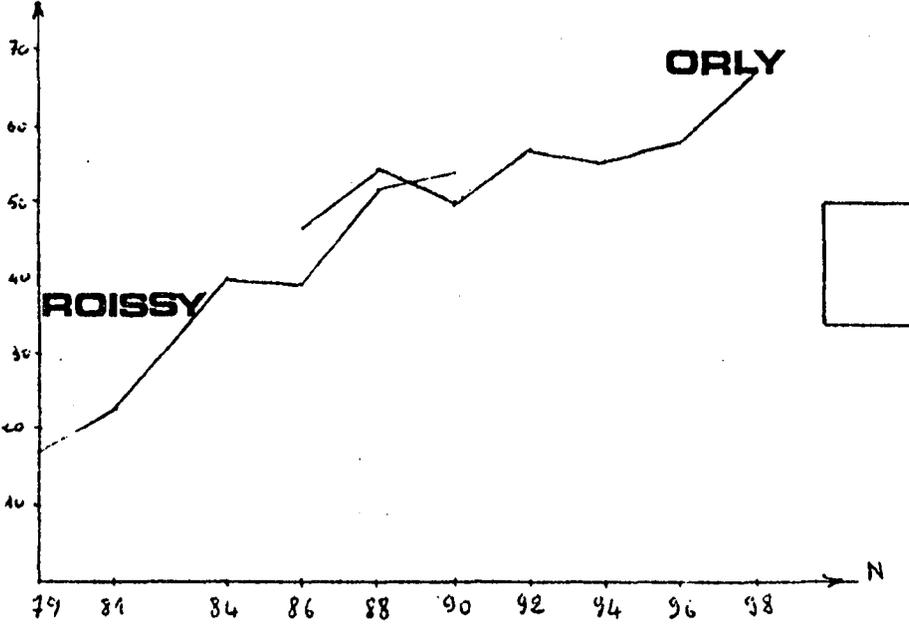
1. highly annoyed by the aircraft noise,
2. annoyed very often by the aircraft noise,
3. aircraft noise is very loud.



1



2



3

This question was asked of a national sampling of about 1000 French persons between the ages of 20 and 65. Within the sampling, we separated the answers of the residents of Paris and its suburbs (that is, about 170 persons).

The answers of the Parisians represent in some way a standard which makes it possible to classify the answers of residents near airports. Indeed, the sampling of the Parisians is diversified and random as regards noise exposure; it consists of persons exposed to the various ambient urban noises (automobile traffic, noises of the neighbors, etc...). If there was no aircraft noise, the residents of Roissy and especially of Orly could have indicated an annoyance similar to that of this sampling. /7

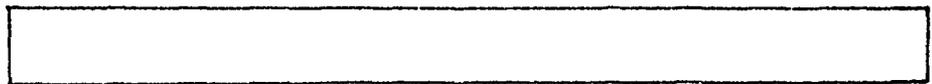
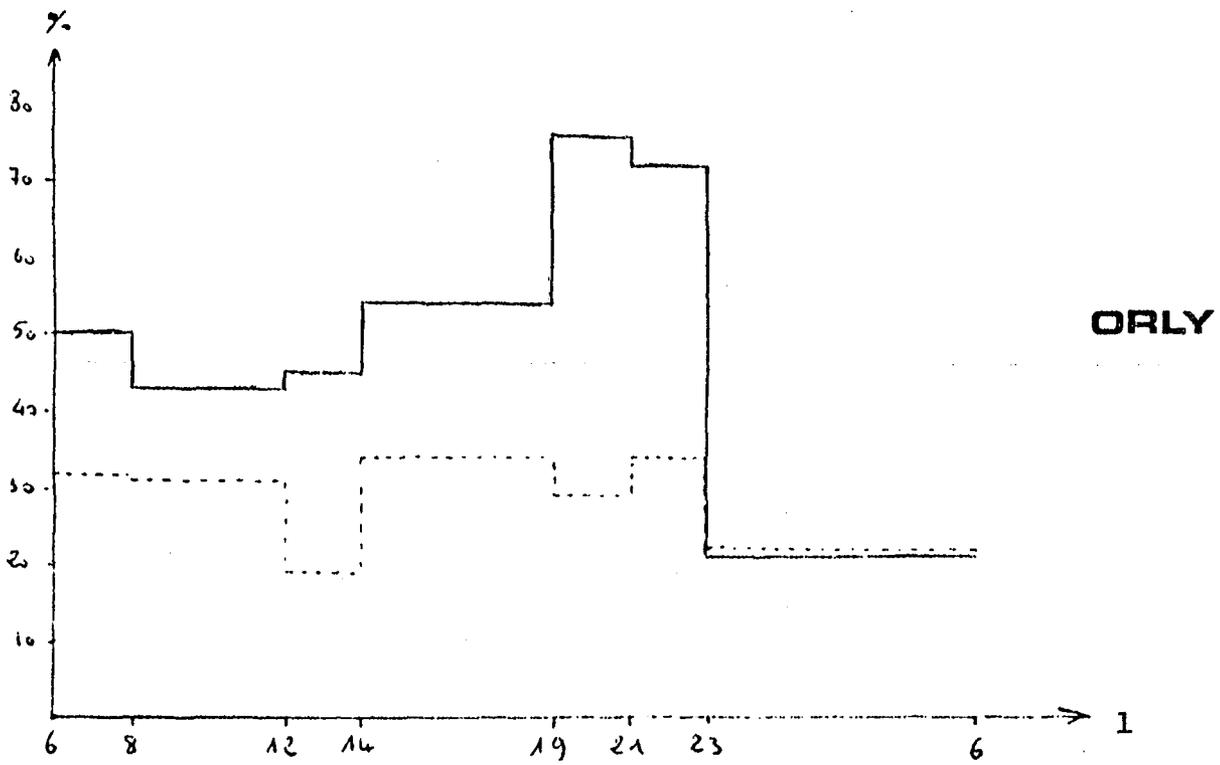
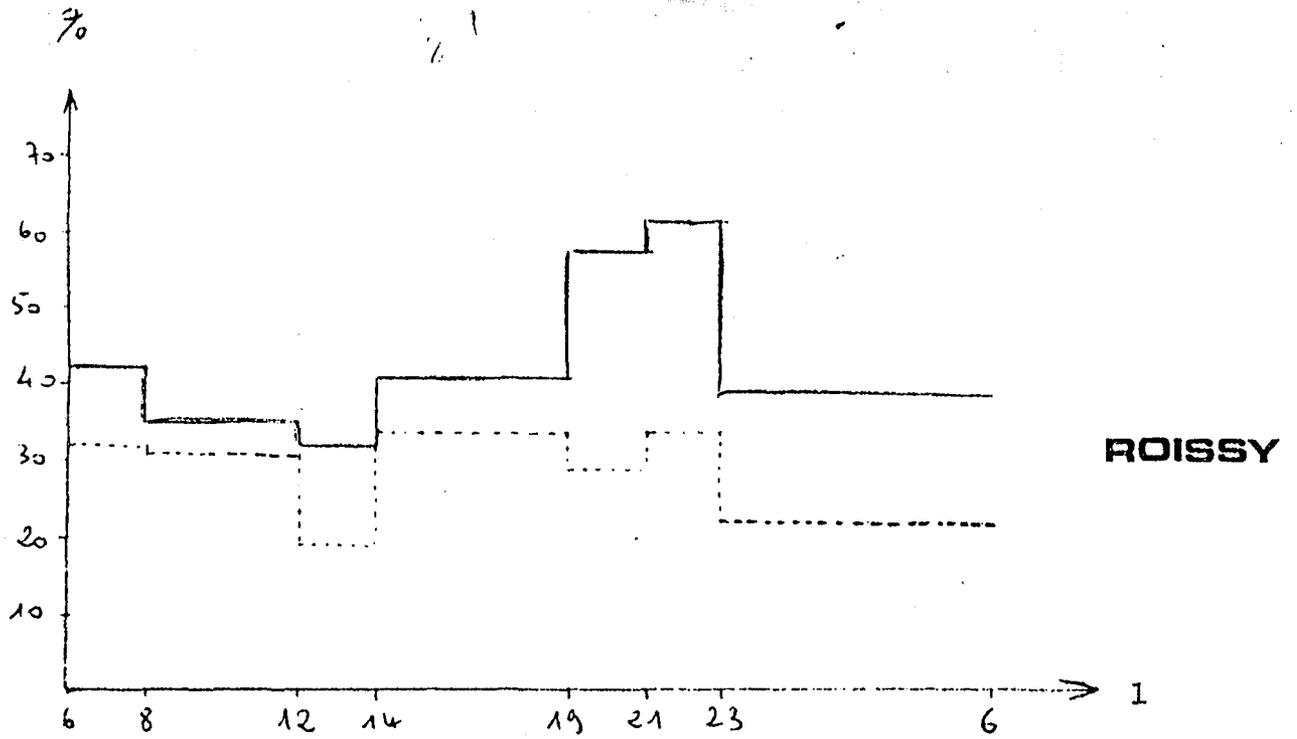
Graph 2 permits the comparison of the variation of the proportion of persons annoyed by the noises over the 24 hours among the residents near Roissy, Orly and the Parisians.<sup>1</sup>

The proportion of Parisians annoyed by the ambient noise is fairly constant, with 2 exceptions: it drops at lunchtime (noon to 2 p.m.) and at night (11 p.m. to 6 a.m.).

It may be considered roughly that the proportion of the Roissy residents annoyed by noise is stable over the 24 hour period, except in the evening (9 to 11 p.m.) when it increases by 20%. This proportion is higher at any moment than that experienced by the Parisians. On the other hand, in Orly we can distinguish 3 periods: from 6 a.m. to 7 p.m., the proportion of persons annoyed by the noise, much higher than in Roissy, is fairly stable, it increases by about 20% during the evening; but it drops very noticeably at night (from 11 p.m. to 6 a.m.) to the point when it is similar to what is observed for all the Parisians. This last phenomenon illustrates the efficiency of /8

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<sup>1</sup>But we should not compare in absolute value the results obtained around Roissy and Orly, since the two samplings of residents are not distributed in an identical manner as a function of the psophic index.



— 2  
 - - - 3

Graph 2 (see page 8)

Key:

1. hours, 2. residents near airports, 3. Paris and its suburbs.

the ban on the use of the airport at night, even though a few flights are authorized.

In the final analysis, one is led to believing that the critical period, in terms of annoyance, is now during the evening, when the spread is maximum between the answers of the persons residing near the 2 airports and those of the average of the Parisians.

This phenomenon as well as more generally the variations of the persons annoyed over a 24 hour period may be explained by 2 non-exclusive hypotheses:

-- these variations may express directly the unequal distributions in the air traffic;

-- they may reflect the modifications of the sensitivity to noise over a 24 hour period, related in particular to the diversity in the activities of individuals.

To assess the value of these phenomena, we plotted on a same graph (Graph 3) the proportion of persons annoyed by the noise over the different times of day and the distribution of the aircraft movements (expressed in the average hourly number of movements during the same intervals of time).

The parallel variation of these two curves would tend to prove that sensitivity to noise remains constant over 24 hours. Well, significant shifts are observed, which may be interpreted as follows:

-- from 6 to 8 a.m., a relatively large number of residents near airports is disturbed by the noise, both in

Roissy and Orly. This anomaly may be related to the time the residents wake up. It would seem indeed (Comp. Appendix 1) that a large number of residents are not yet up between 6 and 7 a.m.; the early morning flights would cause an annoyance which the psophic index might underestimate to the extent that the "penalization" of night flights is no longer applied, from 6 a.m.;

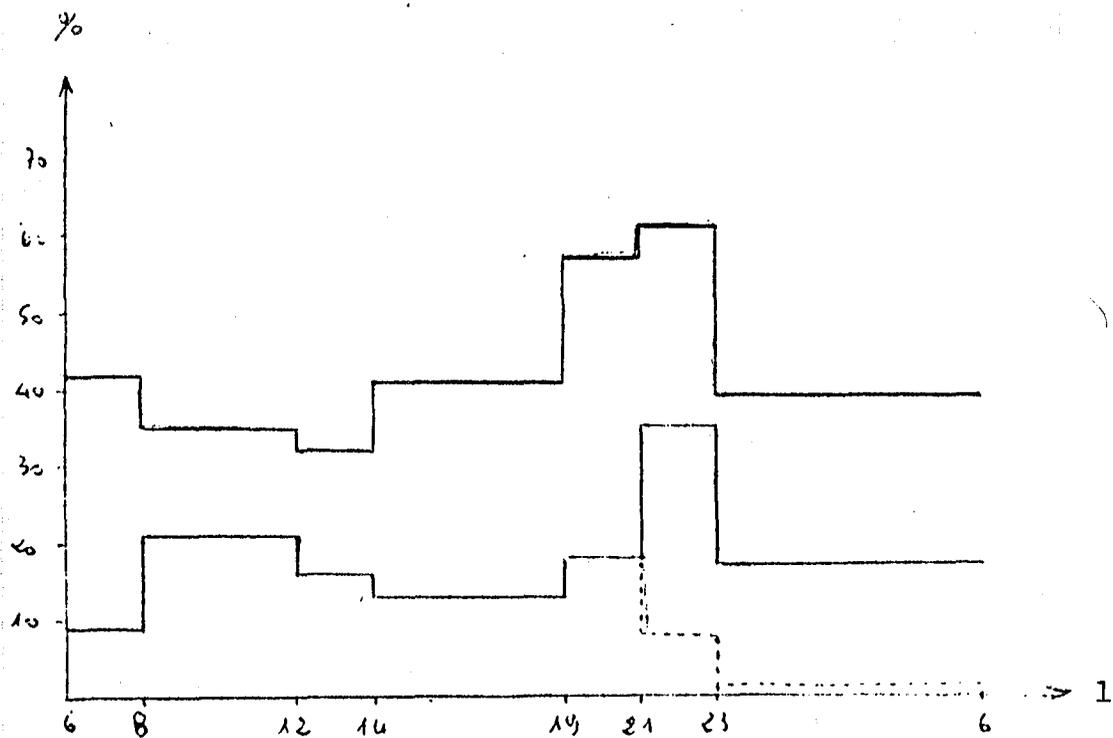
-- from 8 a.m. to 7 p.m., there is little variation in the hourly number of movements both in Roissy and Orly. The proportion of persons annoyed is fairly stable during this period. But the slight fluctuations of the traffic and the number of persons annoyed do not take place parallelly. Morning flights, it seems, are tolerated a little better than those in the afternoon;

-- in the early evening (7 to 9 p.m.), the extent of the proportion of airport residents annoyed by the noise corresponds fairly clearly to the large number of movements. The shift between the two curves is close to what is observed in the afternoon;

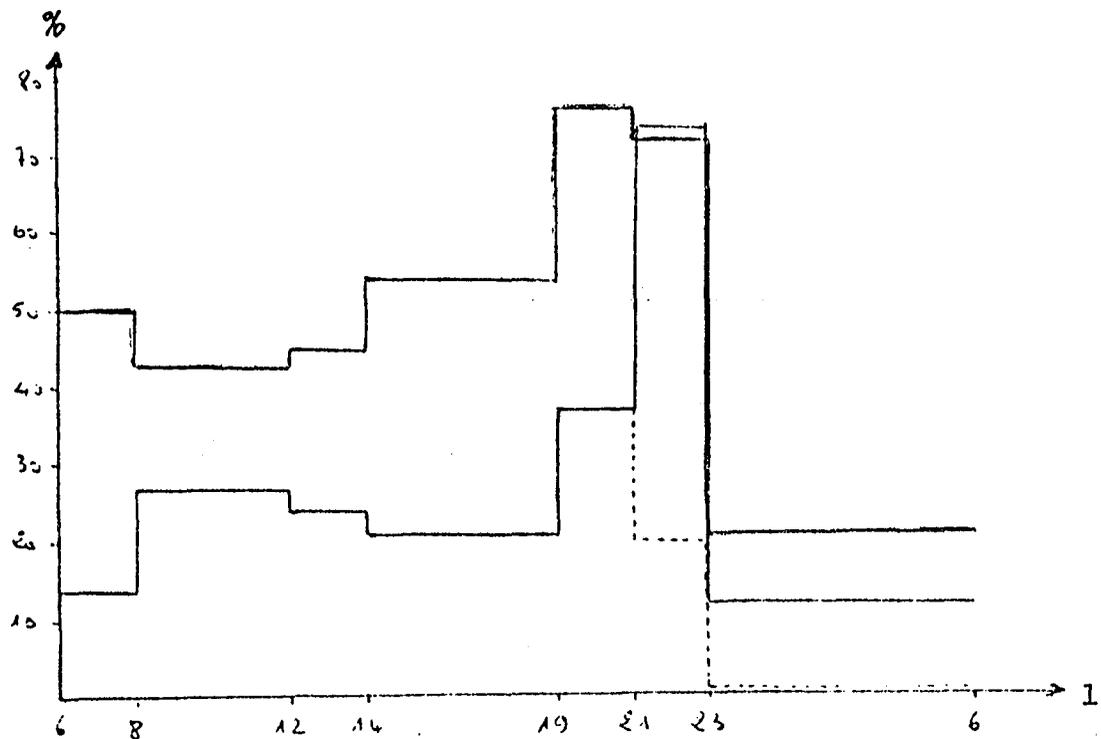
-- for the period from 9 to 11 p.m., we must take into account the fact that the average number of movements is multiplied by 10 during the second hour. The result is that the number of movements considered by the psophic index is much higher from 9 to 11 p.m. than from 7 to 9 p.m., whereas the real number of movements drops.

The Roissy results seem rather coherent and satisfactory: the proportion of persons annoyed from 9 to 11 p.m. corresponds better to the curve taking into account the weighting of the movements than to the curve of unweighted movements. The penalization of the flights carried out after 10 p.m. does indeed permit us to predict an increase of the number of persons annoyed as compared with the period 7 to 9 p.m., whereas the unweighted assessment would make us expect a reduction of this number. But it should be noted that the increase in the proportion of persons annoyed is not very great, so that weighting with a coefficient of less than 10 would have given more satisfactory results.

/10



**ROISSY**



**ORLY**

Graph 3

Upper curve: proportion of residents near airports, annoyed by the noise; Lower curve: average hourly number of movements per period considered.

——— with weighting by 10 at night (10 p.m. to 6 a.m.)  
 - - - - - without nighttime weighting

Key: 1. hours

This last remark applies even more clearly in the case of Orly: the absence of weighting of the flights between 10 and 11 p.m. would show very poor consistency with the large number of persons annoyed, but weighting leads to the opposite result. The weighting by 10 seems excessive, therefore, or at least too brutal: the "model" according to which 1 flight = 1 flight from 9 to 10 p.m., and 1 flight = 10 flights from 10 to 11 p.m. does not correspond truly to reality. It may be estimated that, though the penalization of night flights is justified, the weighting should be of progressive nature instead of occurring suddenly at the maximum rate;

-- from 11 p.m. to 6 a.m., that is during the period considered as nighttime in the questions put to the residents near airports, the results obtained do not permit us to question the validity of weighting of night flights. In Roissy, the number of residents annoyed at night is much more consistent with the average number of weighted movements than when the movements are not weighted in the assessment. In Orly, the number of persons annoyed seems small as compared with the number of weighted movements. But it should be recalled that these movements involve not very noisy aircraft, since the jet plane traffic is concentrated in the evening. Since the traffic is not of the same nature, the average number of movements does not represent at night a good noise indicator for Orly.

Therefore, when we pursue the analysis, we should no longer refer to the number of movements, but to the psophic index.

### III. Variation of the Annoyance as a Function of the Psophic Index /11

The psophic index takes into account the overall annoyance of the residents near airports and not the annoyance at any particular time of day. Nevertheless, we plotted on Graphs 4 to 6 the proportion of persons annoyed in each interval of time as a

function of the value of the index N which characterizes the site of their residence.<sup>1</sup> These graphs allow us to observe the slope of the curves and to compare the degree of sensitivity to noise during the day. Most of the curves obtained can be represented fairly easily by straight lines, the curves of Roissy and Orly being located one in the extension of the other. But it should be noted that:

-- the curves representing the period from 8 a.m. to 7 p.m. are the least satisfactory. This may no doubt be explained by the fact that the question posed related to noise in general (and not the noise of aircraft) without qualifying the intensity of the annoyance, and that, during this period, the other ambiantal noises (traffic, noise at the work place possibly located outside the residence area, etc.) cause considerable interference.

-- in the intervals 7 to 9 p.m. and 9 to 11 p.m., the slope of the straight lines is emphasized to a much greater extent, which reflects the high sensitivity to aircraft noise during this period, as was mentioned earlier.

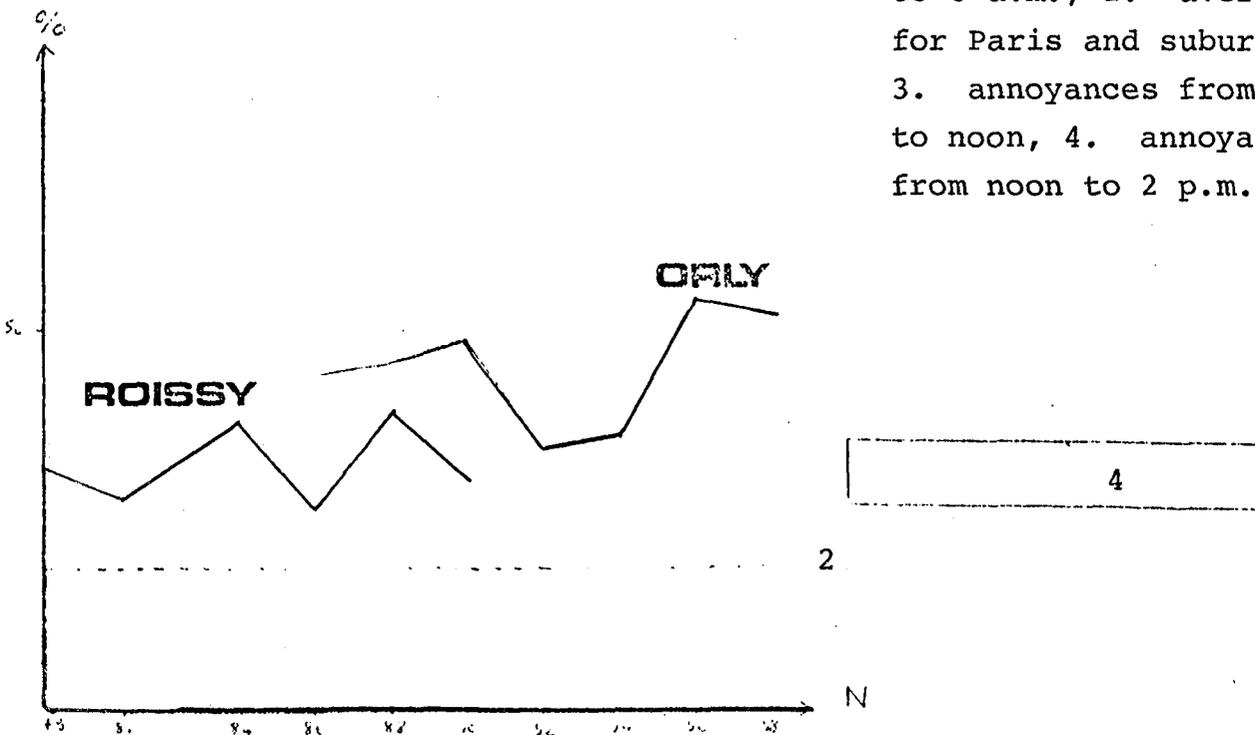
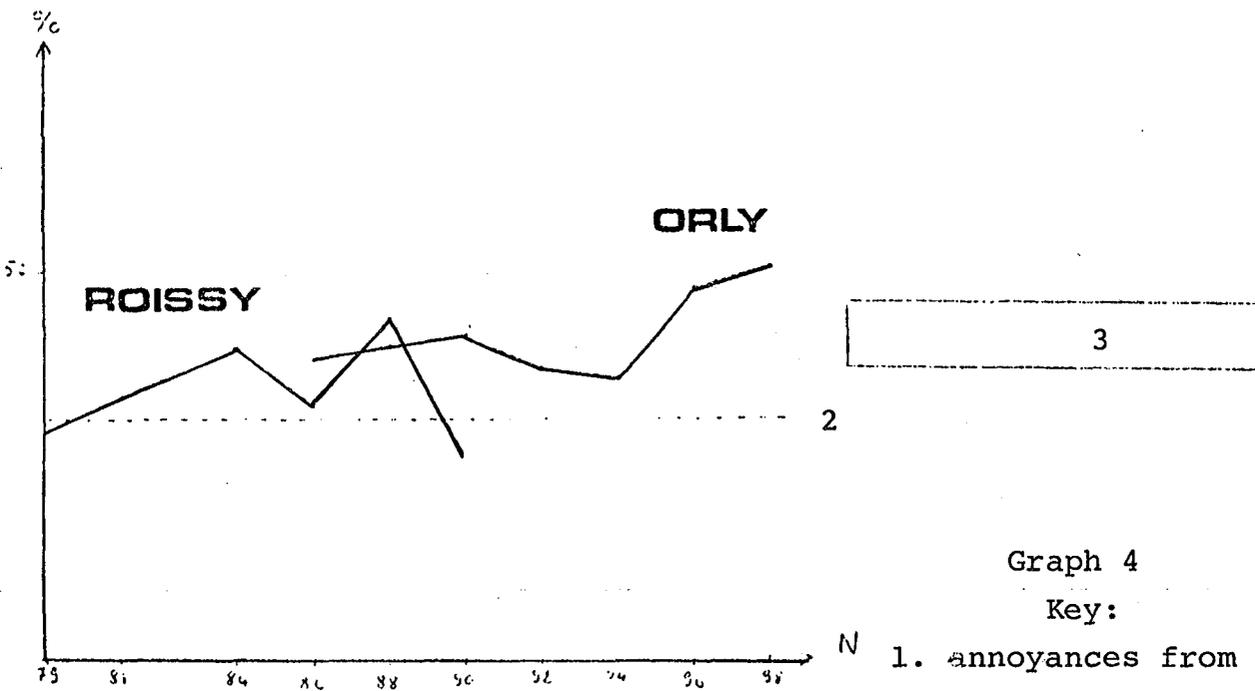
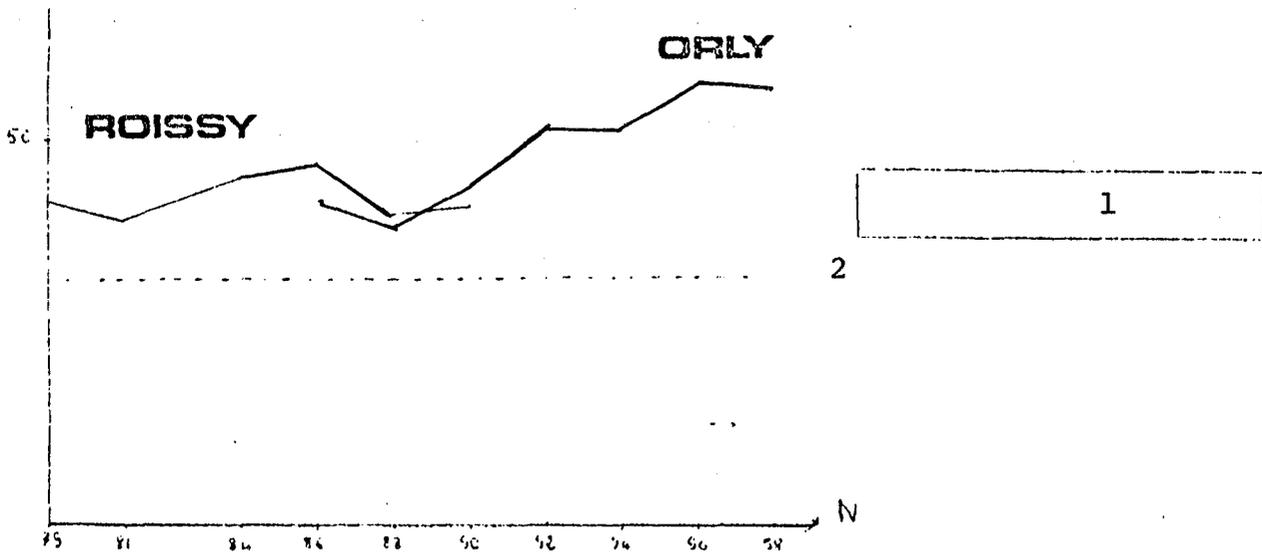
This poorer tolerance of noise may be explained by several reasons: contrast between the noise of aircraft and the low level of other noises, disturbance of activities such as watching TV, conversations, disturbance at the time of falling asleep.

-- the deviation between Roissy and Orly for nighttime annoyance is revealed very clearly: around the Charles de Gaulle airport, the proportion of residents disturbed by the noise between 11 p.m. and 6 a.m. increases greatly as a function of N beyond a threshold for  $N=84$ . On the other hand, around Orly, this proportion does not vary as a function of the psophic index and remains similar to the one observed among all the Parisians. This result should cause no surprise, since we are referring to an index of exposure

/12

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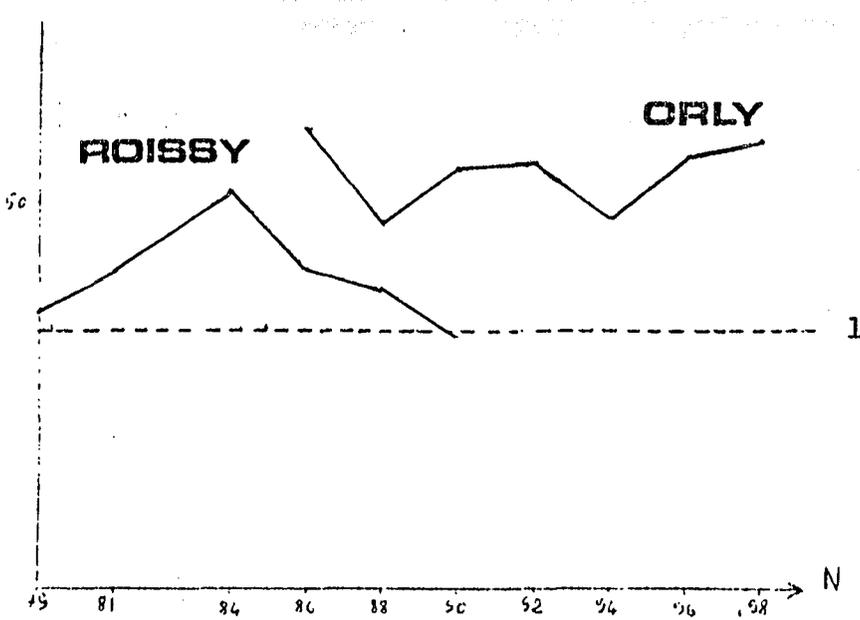
<sup>1</sup>We assigned to the 500 Roissy residents and the 1000 Orly residents the value of the index N of their residence on the basis of the maps of the networks of psophic curves established by the Paris Airport for 1975, the date when the interviews were conducted.



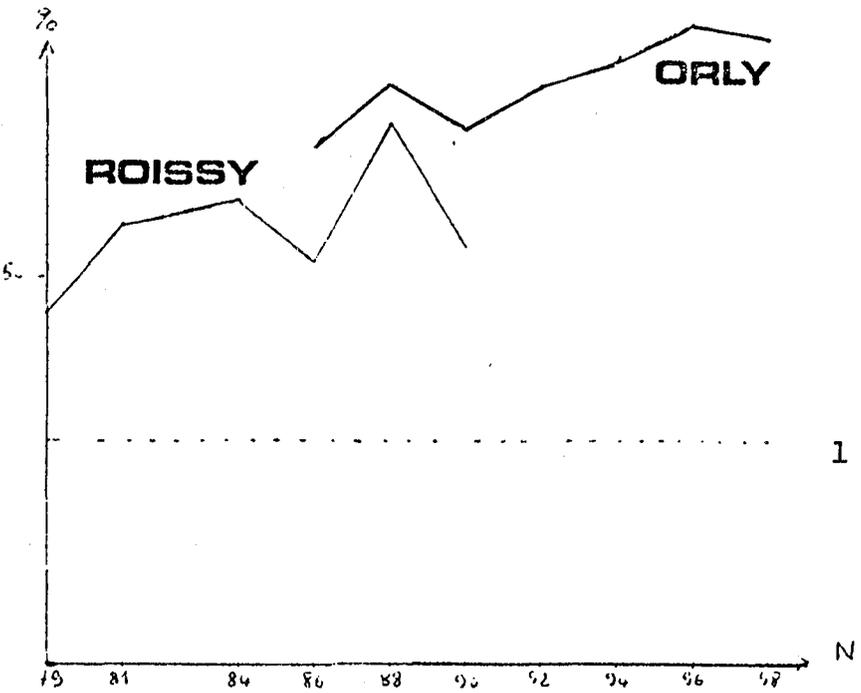
Graph 4

Key:

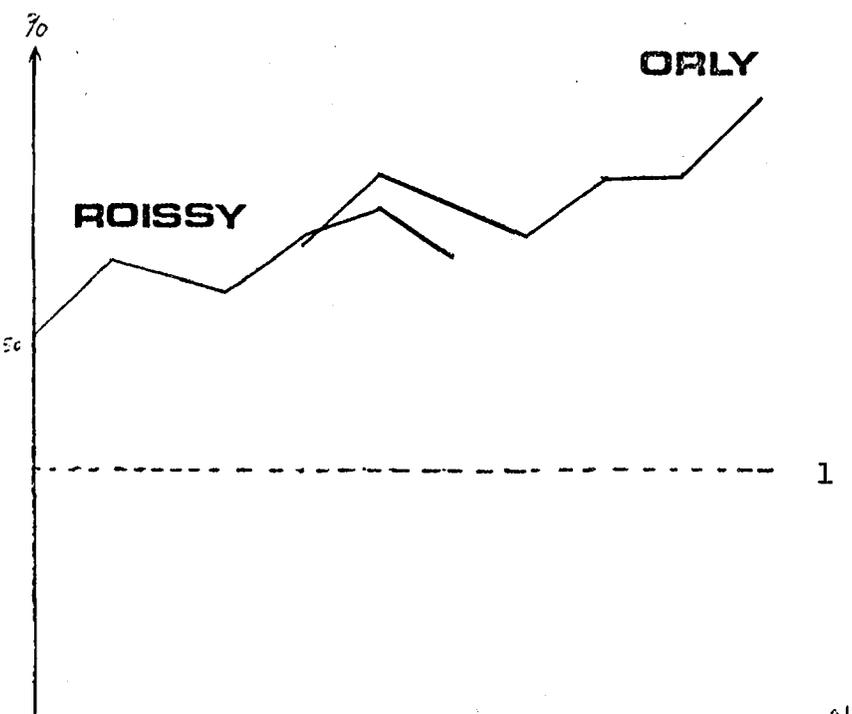
- 1. annoyances from 6 to 8 a.m.,
- 2. average for Paris and suburbs,
- 3. annoyances from 8 a.m. to noon,
- 4. annoyances from noon to 2 p.m.



2



3

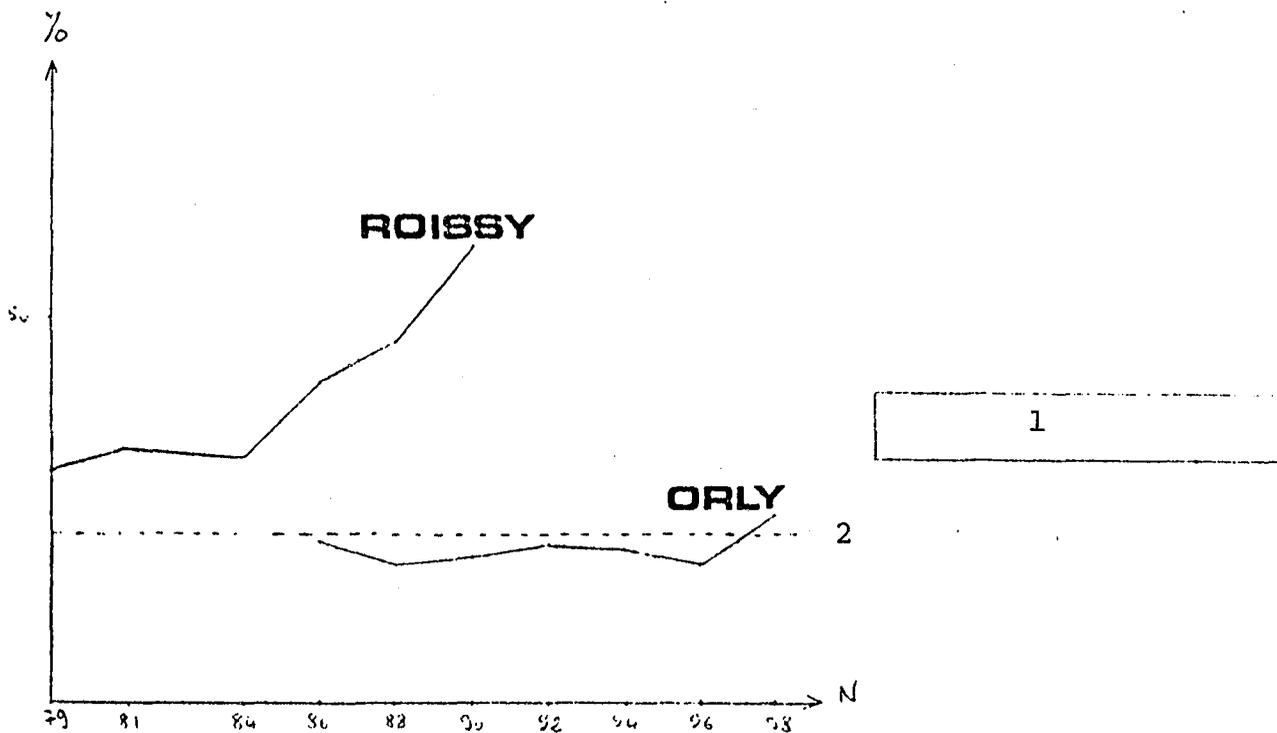


4

Graph 5

Key:

- 1. average for Paris and its suburbs,
- 2. annoyances from 2 to 7 p.m.,
- 3. annoyances from 7 to 9 p.m.,
- 4. annoyances from 9 to 11 p.m.



Graph 6

Key:

1. annoyances from 11 p.m. to 6 a.m.,
2. average for Paris and its suburbs.

to overall noise.

The hypothesis might have been put forward that a correction of the index which would take into account the number of movements during each interval of time would permit a better consistency between the results obtained in Orly and Roissy. Since the traffic distribution is not identical for these two airports, an index modulated per interval of time would cause a translation of the curves obtained.

Taking into account only the number of aircraft, that is, assuming an identical nature of the traffic for all the intervals

of time, the correction factors to be added to or subtracted from the overall index are as follows:

| Periods           | Orly  | Roissy | Difference between Orly and Roissy |
|-------------------|-------|--------|------------------------------------|
| 6 to 8 a.m.       | - 2.6 | - 2.9  | 0.3                                |
| 8 a.m. to noon    | + 0.3 | + 0.8  | 0.5                                |
| noon to 2 p.m.    | - 0.1 | - 0.6  | 0.5                                |
| 2 to 7 p.m.       | - 0.7 | - 1.3  | 0.6                                |
| 7 to 9 p.m.       | + 1.8 | 0      | 1.8                                |
| 9 to 11 p.m.      | + 4.7 | + 3    | 1.7                                |
| 11 p.m. to 6 a.m. | - 3   | - 0.2  | 2.8                                |

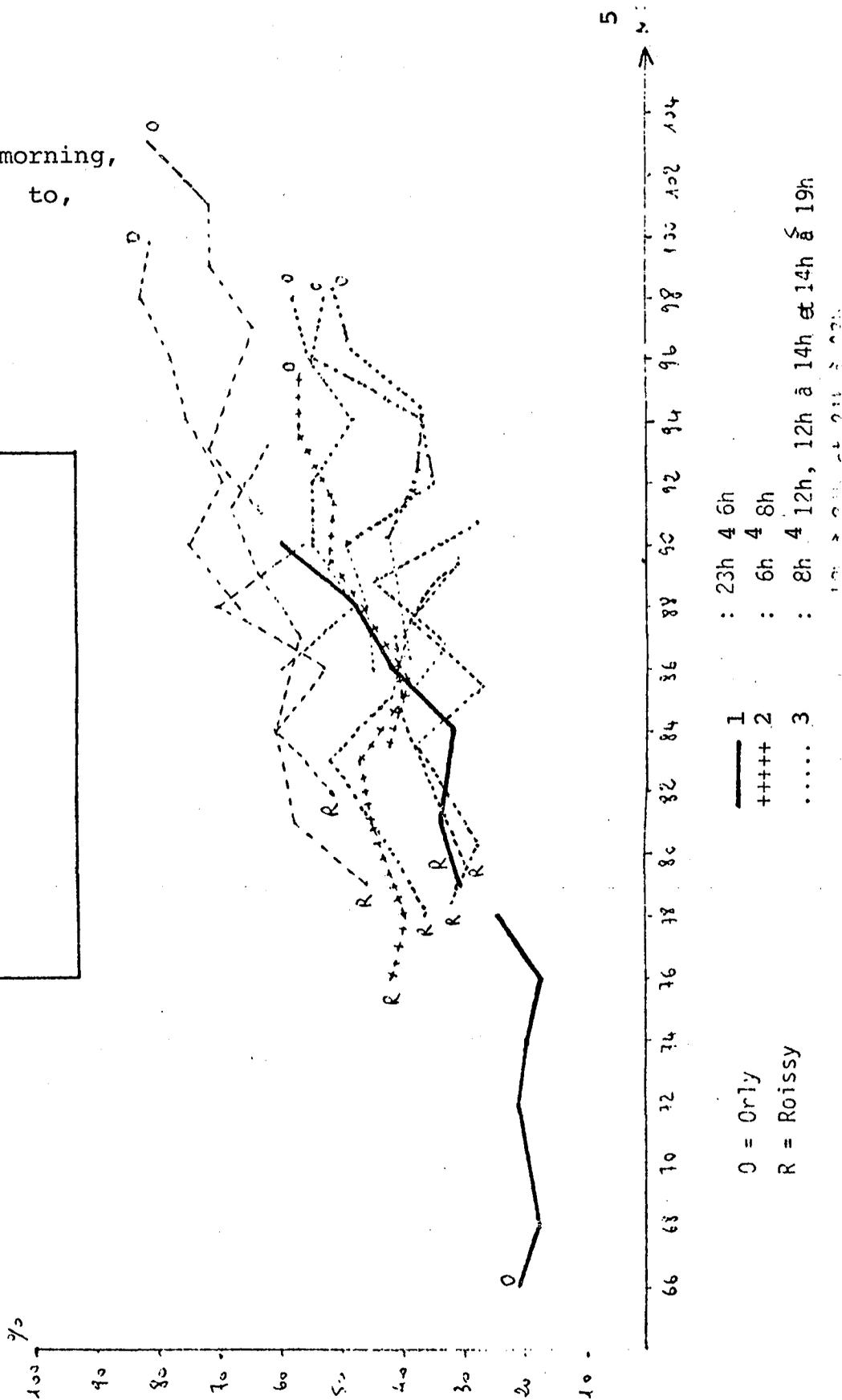
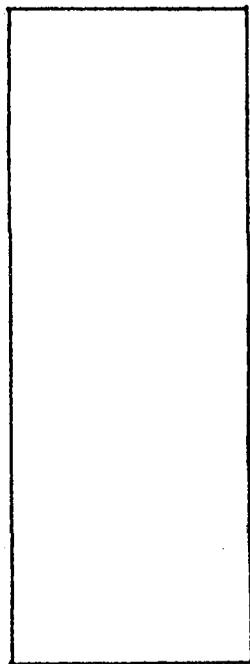
To take into account the special nature of the Orly traffic from 11 p.m. to 6 a.m. (low noise aircraft), an additional correction should be applied. It was estimated that 20 points should be subtracted from the index of that period.

/13

Graph 7 gives the proportion of persons annoyed by the noise for each interval of time as a function of the index corrected in this way.

The translations obtained lead to rather satisfactory results. It is true that during the periods of "lower sensitivity" to noise (8 a.m. to 7 p.m.) the nature of the answers is relatively uncertain because of the other ambiantal noises, and the answers do not increase coherently and regularly as a function of the exposure index. On the other hand, the results obtained during the evening for the residents near both airports are totally consistent: the proportion of persons annoyed is really summarized with single curves for the two airports with identical slopes. The graph shows plainly the "hypersensitivity to noise" from 7 to 11 p.m. The effect of the translation is also to render homogeneous the data relating to the annoyance from 11 p.m. to 6 a.m.; the results of Orly and Roissy are aligned on a curve which may constitute the first part of the curve in S which

- Key:
1. night, 2. morning,
  3. daytime, 4. to,
  5. corrected

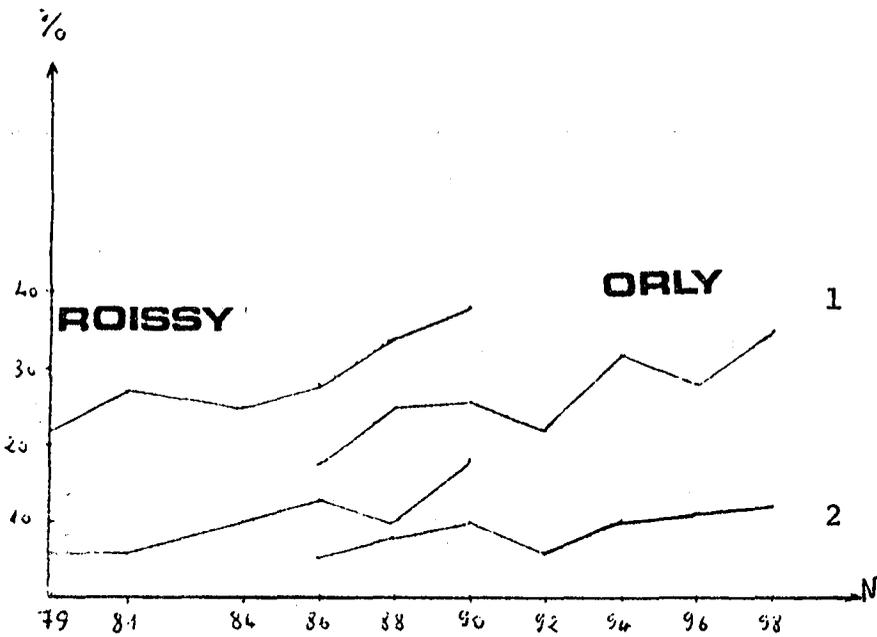
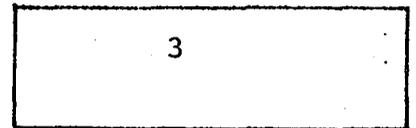
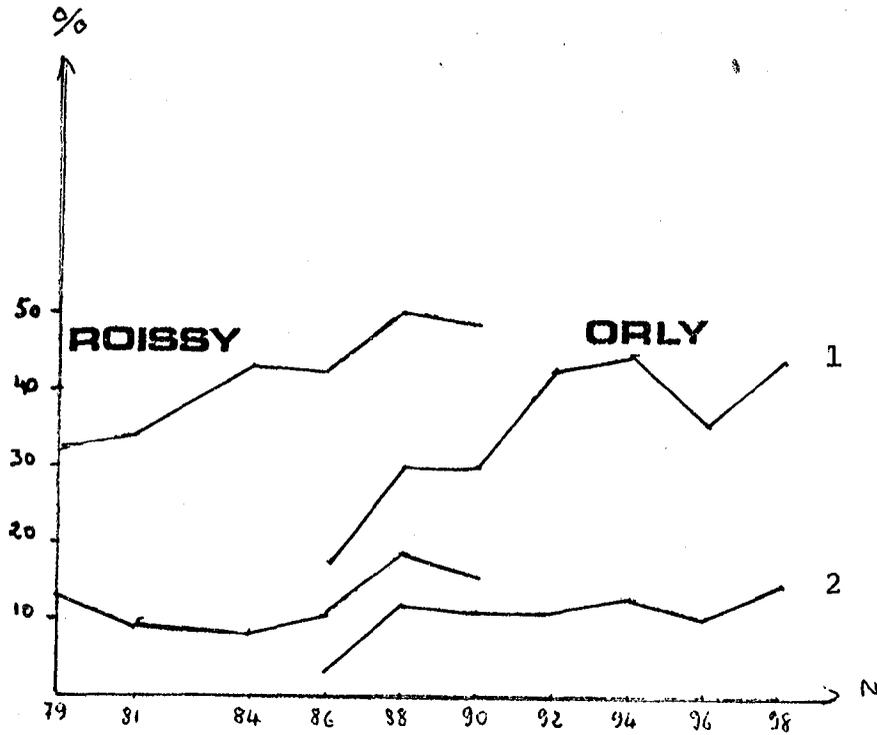


Graph 7

Proportion of residents near airports disturbed by noise in the different periods of time as a function of the corrected index.



of the environment. On the other hand, the occasional awakening really does vary as a function of the index, both for Orly and Roissy residents.



Graph 8

Key: 1. often + occasionally, 2. often, 3. % persons awakened by aircraft noise, 4. % persons prevented from sleeping by aircraft noise.

The analysis of the special consideration of night traffic in the assessment of annoyance caused by aircraft noise would require a very thorough survey of residents near airports: in particular we would have to study the nature of the annoyance at night, the variation of the intensity and the nature of the annoyance over 24 hours. The fragmentary nature of the data on which the present investigation is based permits us nevertheless to furnish a certain number of indications:

-- on the whole, the penalization of night flights in the calculation of the psophic index seems justified: weighting of the movements permits a better prediction of the proportion of persons annoyed by the noise than the evaluation without weighting. Moreover, the variation of the overall annoyance as a function of the psophic index established over a 24 hour period (and therefore including the nighttime traffic) is very satisfactory and coherent for both the airports studied. Even if the index does not account perfectly for the annoyance at night, the validity and sensitivity of the overall index are maintained in both these special cases;

-- but the results show that we have the right to question in two areas the validity of taking into account of the nighttime annoyance by the psophic index:

-- the suppression of weighting starting at 6 a.m. seems to be too early: an extension of the nighttime up to 7 a.m. would be more consistent with the collected data and would no doubt conform better to the habits of the French (of which only a minority is up at 6 a.m.);

-- the weighting by 10 of the index from 10 p.m. is applied too brutally, leading apparently to overestimating the annoyance felt from 10 to 11 p.m. A progressive multiplication factor would make it possible to obtain results more consistent with the answers of residents near the airports. One should also examine the benefit of a possible weighting of the evening flights which would compensate for the "hypersensitivity" observed among residents near airports during this period.

These results represent indications which should be confirmed and studied more thoroughly in subsequent investigations. In particular, this study does not give a precise answer to important questions such as: what is the weighting coefficient of night or evening traffic which would permit the best prediction of the intensity of the average annoyance? Is it legitimate to apply this penalization to flights producing little noise and whose noise is clearly below the awakening level?

## Appendix I

/17

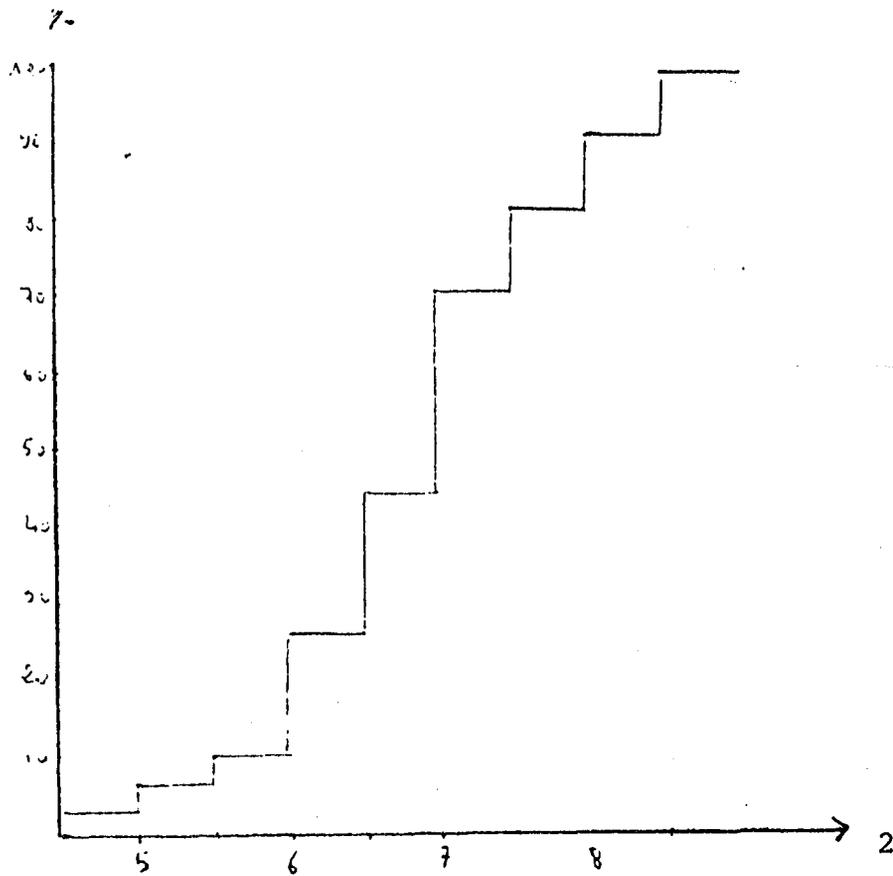
### Time of Rising and Going to Bed

Unfortunately, no statistical data are available on the time the residents of Orly and Roissy get up and go to bed. Perhaps these people adapt their behavior to some extent to the characteristics of their environment. Be that as it may, in the absence of more valid data, we may refer to the habits of the French as a whole. The graph on the next page indicates the results (cumulative percentages) obtained with a representative national sampling of the people 15 years old or older, questioned in December 1976.

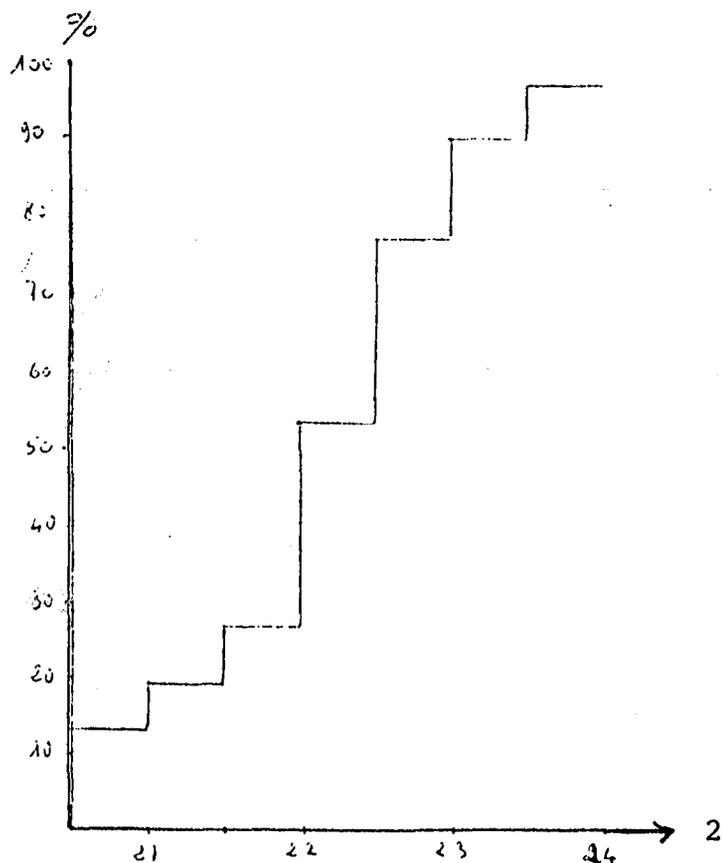
With the reservation of verifications to be carried out for communities living near the Parisian airports, the following information can be derived:

-- to consider as we do for the psophic index that the day begins at 6 a.m. does not seem to correspond to the real behavior, since only 10% of the French get up before 6, altogether 26% before 6:30 a.m. The validity of the method of calculation would no doubt be improved if the night period were extended to 7 a.m.;

-- on the other hand, in the evening, there is no reason to question the 10 p.m. cut-off adopted in the calculation of the index.



1



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Key:  
 1. time of rising,  
 2. hours, 3. time  
 of going to bed.

Time at which the French rise and go to bed. Sampling: French people of 15 years or more.

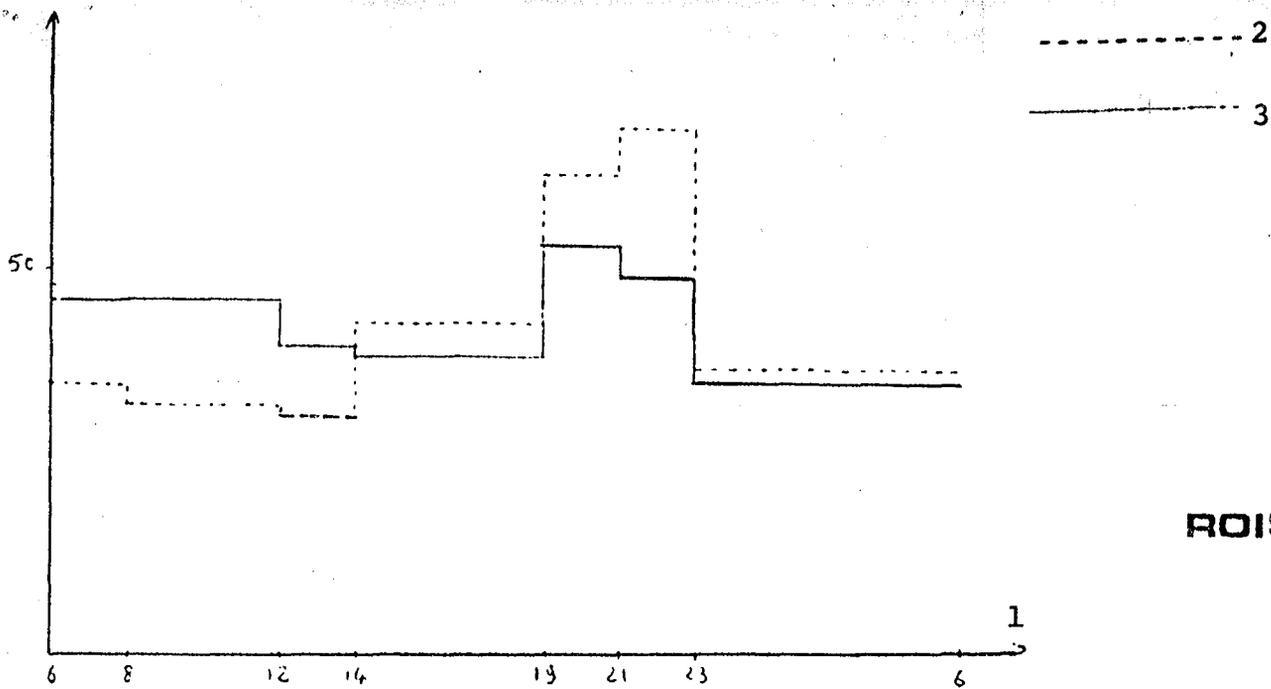
Nighttime Annoyance as a Function of the Age

This research was conducted with persons between the ages of 20 and 65 living near airports, which limits the examination of the variations of sensitivity to noise as a function of the age.

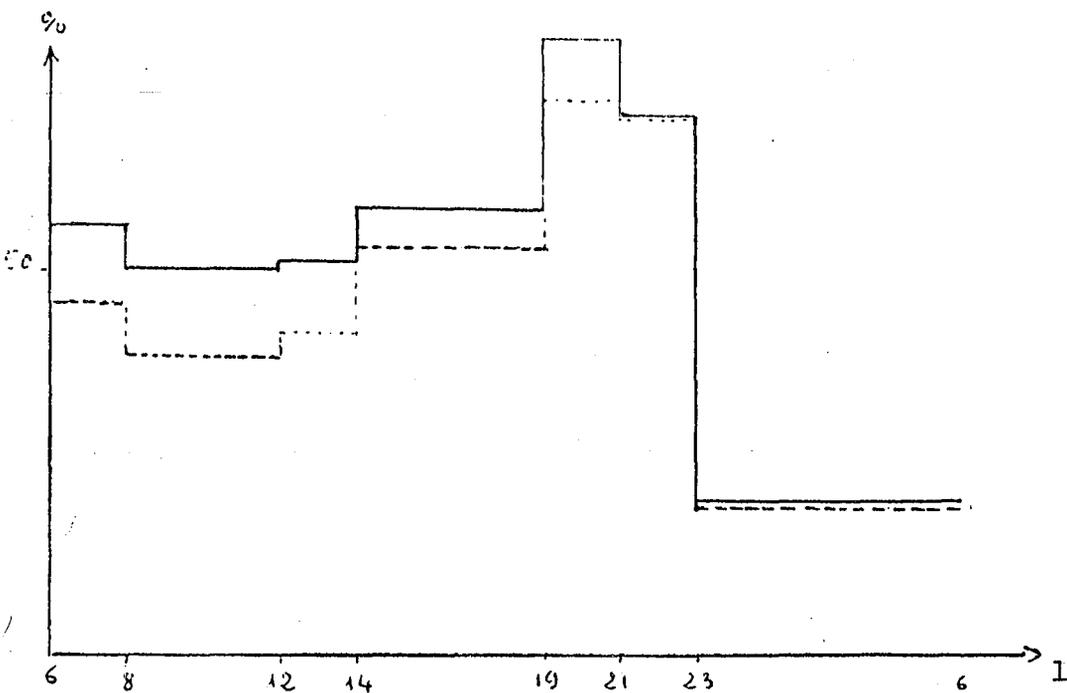
Nevertheless, the graphs given below seem to indicate that there does exist a relation between nighttime annoyance and age:

-- both around Orly and Roissy, the proportion of persons disturbed by noise from 11 p.m. to 6 a.m. is similar in the two extreme age groups (20 to 35 years old on one hand, 50 to 65 on the other). But when asked at what time of the day they were most annoyed by the noise, there were more older people among the Roissy residents answering that it was at night. The age may therefore contribute more to emphasizing the intensity of disturbance during sleep than to increasing the number of persons disturbed;

-- the proportion of persons who state that their sleep is disturbed and who feel that aircraft noise wakes them up seem to increase with the age, at least around Orly, where the sampling surveyed are in general in more noisy areas than in Roissy. The results do not inform us what would be the appearance of the curve which would be obtained from a sampling offering a wider range of ages: perhaps the annoyance increases regularly with the age, or the slope of the curve is emphasized beyond a certain threshold of age or noise level, or perhaps we could consider an S-shaped curve, showing a hyposensitivity among the younger, and hypersensitivity among the older persons.



**ROISSY**

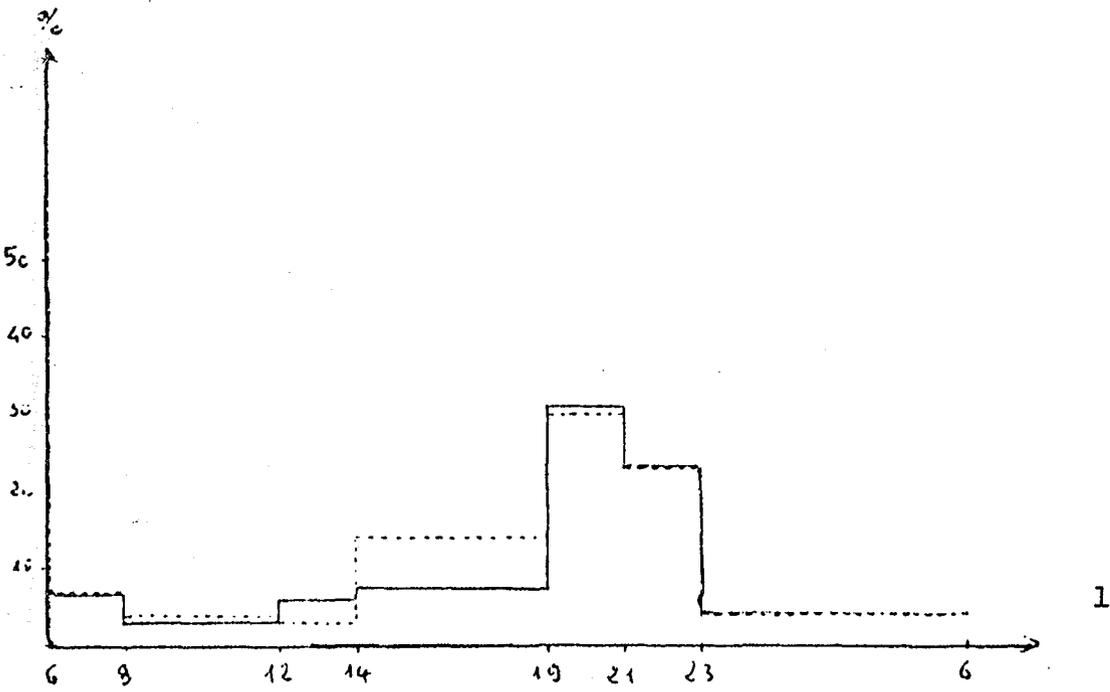
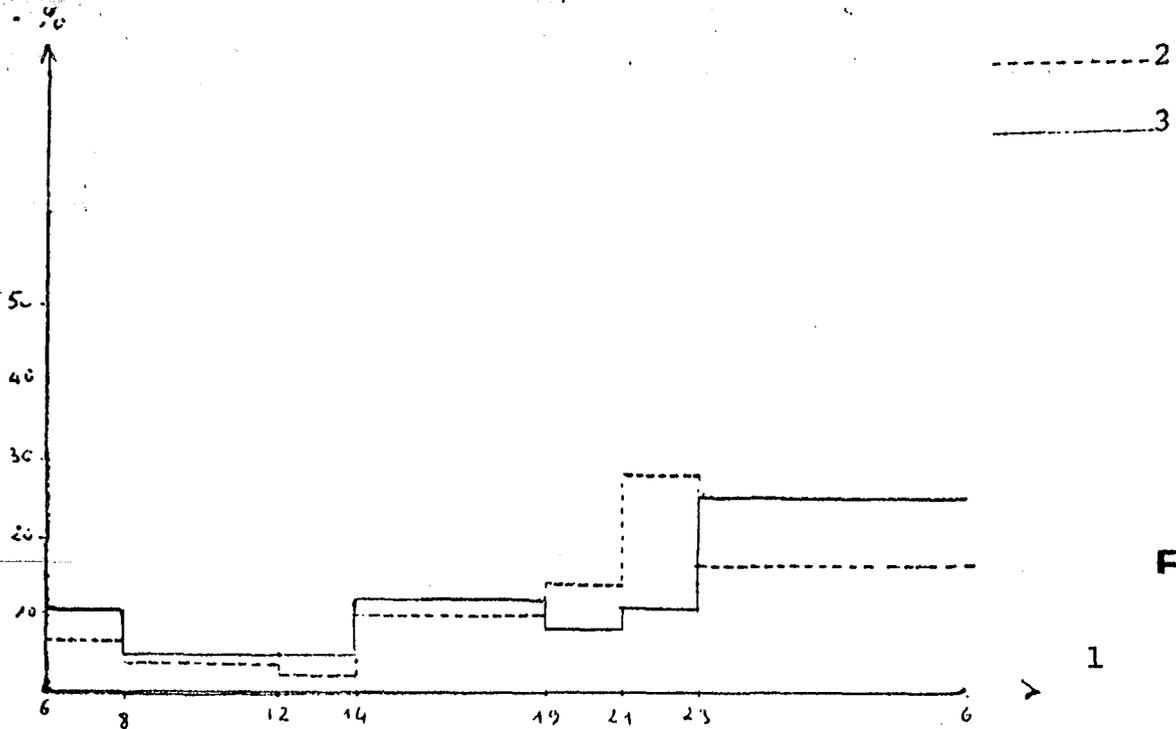


**ORLY**

Times when one is disturbed by the noise.

Key:

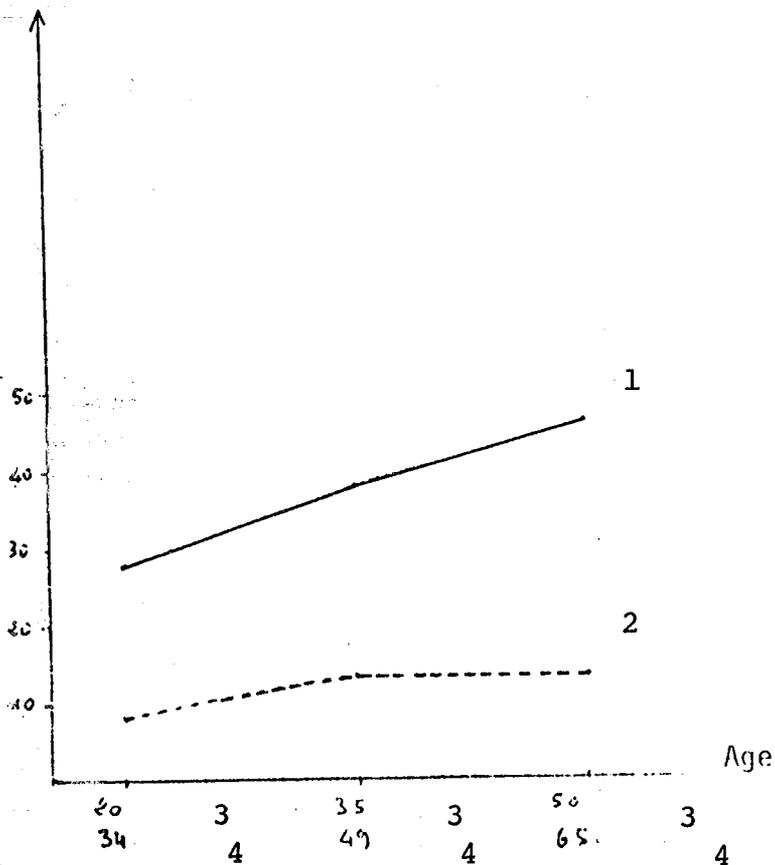
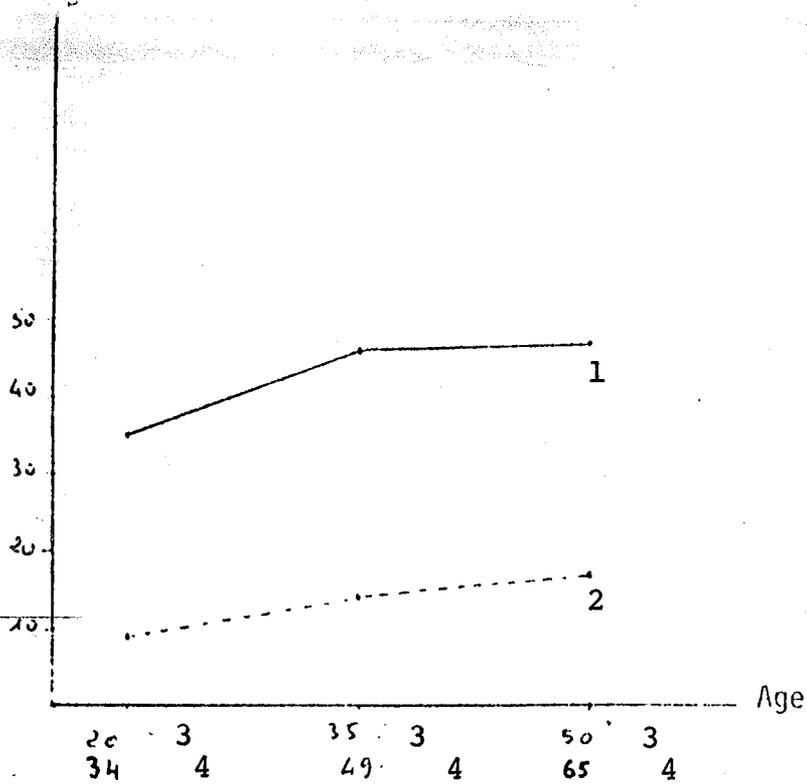
1. hours, 2. 20 to 35 years, 3. 50 to 65 years.



Time when the annoyance is most intense.

Key:

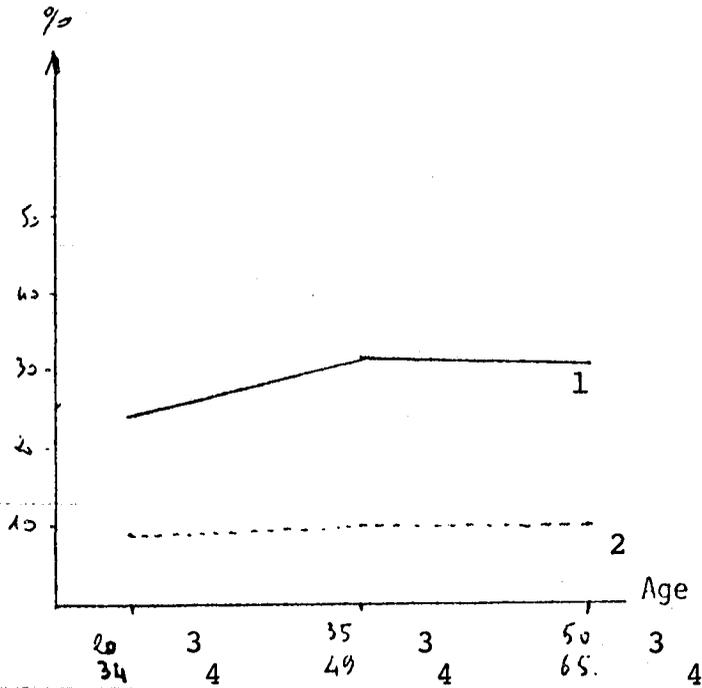
- 1. hours, 2. 20 to 35 years, 3. 50 to 65 years.



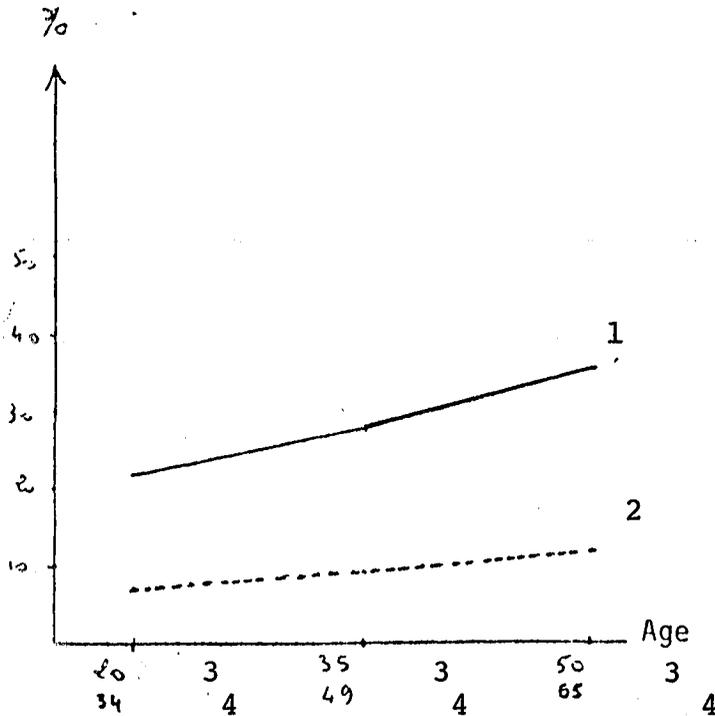
Percentages of persons awakened by the aircraft noise.

Key:

- 1. often + occasionally, 2. often, 3. to, 4. years.



**ROISSY**



Key:

1. often + occasionally,
2. often, 3. to,
4. years.

**ONLY**

Percentage of persons prevented from sleeping by the noise of aircraft.