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COMMUNITY REACTIONS TO AIRCRAFT NOISE IN THE VICINITY OF AIRPORT
A COMPARATIVE STUDY OF THE SOCIAL SURVEYS USING INTERVIEW METHOD

Yasutaka Osada

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16. Abstract A comparative study was performed on the reports of community reactions to aircraft noise. The direct and immediate reactions to aircraft noise such as perceived noisiness, interference with conversation, etc. and various emotional influences were most remarkable; indirect and long-term influences such as disturbance of mental work and physical symptoms were less remarkable.			
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COMMUNITY REACTIONS TO AIRCRAFT NOISE IN THE VICINITY OF AIRPORT
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Introduction

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The regions surrounding airports have long been troubled by aircraft noise since such noise is characterized by being much louder than other noise; as well as by intermittence and impulsiveness; high frequency components and by effect over a broad area. In particular, the noise has increased greatly, with the development of jet aircraft, larger aircraft and increased frequencies of arrival and departure, to the point that damage in the vicinity of airports has become a social problem. For that reason, numerous studies have been conducted on aircraft noise. In particular, research has been conducted for many years on methods of evaluating the "noisiness". Various methods have been proposed, and efforts at international standardization are underway [1,2]. There has been comparatively little research in areas other than "noisiness", such as the psychological or physiological effects. In particular, there are only few research studies on the effects of aircraft noise on the population in the vicinity of an airport [3]. Among these, studies on the relation between aircraft noise in the vicinity of an airport and the resulting effect on the population have been conducted at Heathrow Airport [4], Chitose in Hokkaido [5] and Osaka International Airport [6]. Last year, the Tokyo Research Institute for Environmental Protection conducted a questionnaire survey of injury to the populace due to aircraft noise in the vicinity of Yokota Airbase, and published the results [7,8]. The author also participated in this study, cooperated in the analysis of the results, and conducted a comparative study of the aforementioned airport results with the current results from Yokota

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

Airbase. In addition, in order to compare the extent of injury due to aircraft noise with that due to industrial noise or traffic noise, the results of questionnaire surveys, conducted on industrial noise at Amagasaki (9) and Osaka (9,10), and on traffic noise in Kyoto (11) and in the Tokyo area (12), were compared with those at Osaka Airport and at Yokota Airbase.

Method

Comparison on a uniform standard of several survey results conducted at various sites was quite difficult. First, there were differences in the site of noise measurement and in the measurement times. Next, there were differences in the questions asked of the populace in the questionnaire surveys, as well as differences in the methods of totalization. In this research, these differences were eliminated as much as possible by the methods discussed below. The degrees of noise in the vicinity of airports were standardized by NNI (Noise and Number Index). The NNI at all airports, excluding the survey at Chitose Airport, exhibit the degree of noise at each point. The NNI is computed by the following equation.

$$NNI = \overline{PNL} + 15 \log N - 80$$

Where, \overline{PNL} = energy average of PNdB
N = number of flyovers

Since the daily number of flyovers (about 100 times) and the contour of the noise level dB(A) are included in the Chitose Airport data, the NNI at the site where questionnaire surveys were conducted was estimated to be $\overline{PNL} = \overline{dB(A)} + 13$ [2]. The results at Osaka Airport are expressed by NNI, but the number of flyovers was monitored for eight hours in the day. Moreover, this level is based on the measured level in houses. First, five was added to expressed NNI for correction of the daily number of flyovers. The eight hours of measurement constitute the

time period of highest number of flyovers in the day. Moreover, since night flights are virtually restricted, the daily number of flyovers is at best double the number of flyovers during the eight hours in the day. The addition of $15 \log 2 = 4.5$ to the aforementioned NNI equation would be adequate. This value was rounded off to five. Moreover, 10 was then added in order to convert the indoor noise levels to outdoor noise levels. The difference between indoor and outdoor aircraft noise levels is about 10 dB in a conventional hour (13). Thus, in total, 15 was added to the NNI reported in the Osaka Airport survey. Conversely, in the case of Yokota Airbase, the NNI was computed from the daily outdoor monitor results, but the questionnaire survey points were selected from the regions of NNI exceeding 60, 50, 40, and 30. A precise NNI was not calculated at each point. Thus, the results at Yokota Airbase were compared with other data in which the NNI was assumed to be 65, 55, 45 and 35. In surveys on industrial noise and on traffic noise, the noise levels are all given in dB(A), but all measurements are indoor measurements, with the exception of the survey in the Tokyo area. Thus, 10 dB were added to all levels to unify them into outdoor levels. This is because the general sound insulation of homes was an average of 10 dB in the case of industrial noise as well.

The questions asked of the populace in the questionnaire surveys and the method of totalizing their responses varied in each survey, but since many of the questions were similar, there is little problem in comparison of them. In the surveys at Osaka Airport and at Yokota Airbase, the degree of injury was given in responses which were evaluated in five levels. In the former case, the results were rated 1 to 5 and were totalized, while in the latter case, the results were rated 0 to 4. Thus, the two were put on an equal standard by adding one to the latter rates. Moreover, in all surveys, the existence of various effects of noise (for example, conversation, daily activities etc.), and the degrees were asked. Thus, the percentage of people with a given disturbance was calculated for each effect, and this served as

the response rate of injury. The various survey results were then compared. This is the principal method of treatment using the current comparative research, and we decided to discuss more detailed points in the discussion on results.

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Results

1. Comparison of Populace Reactions in the Vicinities of Osaka Airport and Yokota Airbase

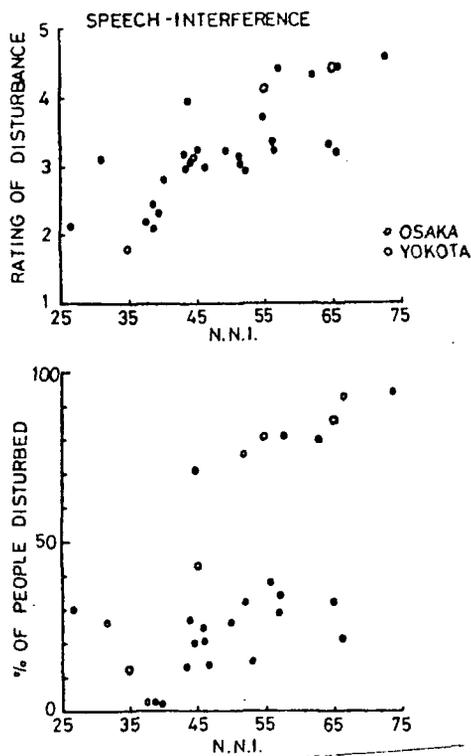


Fig. 1. Relation of speech interference to the level of aircraft noise in Osaka and Yokota.

Level of aircraft noise is expressed in outdoor N. N. I. where the number of flyovers for 24 hrs is applied. Degree of disturbance was rated using a scale ranging from 1 to 5 by the residents interviewed. Upper graph shows average rating of influence and lower one shows the percentage of people who rated the influence above 4 at each spot areas of surveys. Each open and closed circles indicate the average of 150-350 and 100 residents, respectively.

A survey of the populace in the vicinity of Osaka Airport was conducted in 1965. The aircraft noise was measured, primarily at 27 sites, for three days in April of that year. 100 households were selected from within a 500 mile radius at each site and questionnaire surveys in a total of 2,700 households, primarily on the wives, were carried out. The surveys in the vicinity of Yokota Airbase were carried out in 1970, but here, the results were based on the contour of the NNI achieved in the survey of the previous year. From zones where the NNI exceeded 60, 50, 40, and 30, there were 25, 35, 25 and 15 points chosen, respectively, according to the population densities of each zones. Ten households were selected from within a 150 m diameter of each point, and questionnaire surveys were conducted on a total of 1,000 housewives. Figs 1 to 3 illustrate a comparison of the survey results. The NNI in the horizontal axis in the figures is the outdoor, daily corrected value. The method has already been described. The closed circles in the figure represent

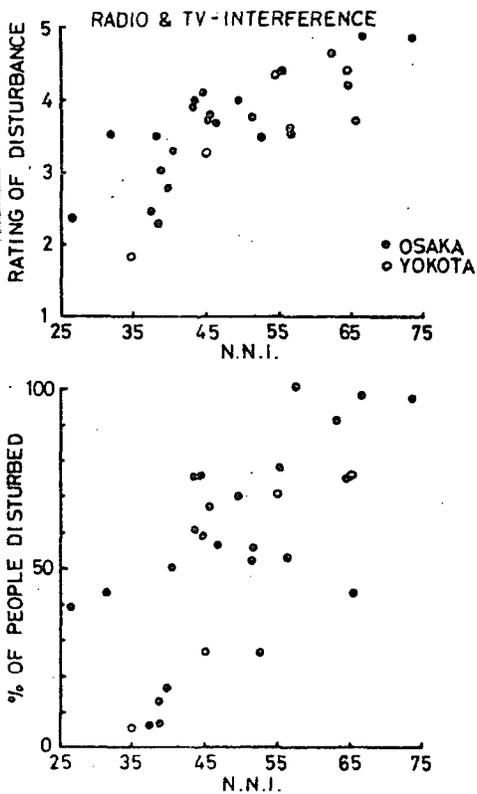


Fig. 2. Interference with listening in radio and TV related to the level of aircraft noise. Details are same as in Fig. 1.

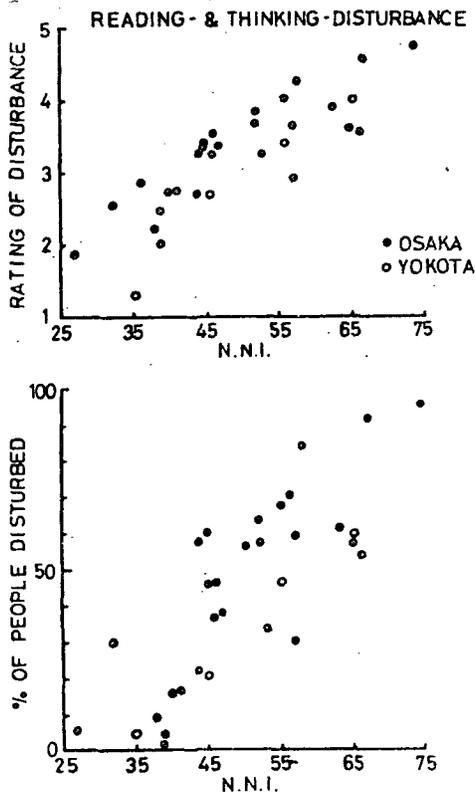


Fig. 3. Disturbance of reading and thinking related to the level of aircraft noise. Details are same as in Fig. 1.

Osaka. One point is from 100 households. The open circles represent Yokota. The point corresponding to NNI 35 is the result from 149 households; 45 is from 247 households, 55 is from 348 households and 65 is from 247 households (the response rate in Yokota survey was 99.1%). The results of disturbance to speech, radio-television reception, and reading-thinking, clearly did not differ greatly between the two surveys. Fig. 4 compares the rates of complaints of day-time sleep disturbance, emotional disturbance and physical influence.

The bent line represents the results from Osaka, while the broken line represents the results from Yokota.

The question on day-time sleep in Osaka was a single question, including night-time sleep disturbance. The figure indicates the percentage of people among those who responded to "day-time sleep is impossible." In Yokota, one question on day-time sleep was asked. The existence of the habit of day-time sleep was asked, and the degree of disturbance to people with that habit was asked. The figure illustrates the percentage of people who had the habit and complained of some disturbance. Such differences in questions seem to result in differences in the figure, yet the tendencies for the rate of complaints to rise with rise

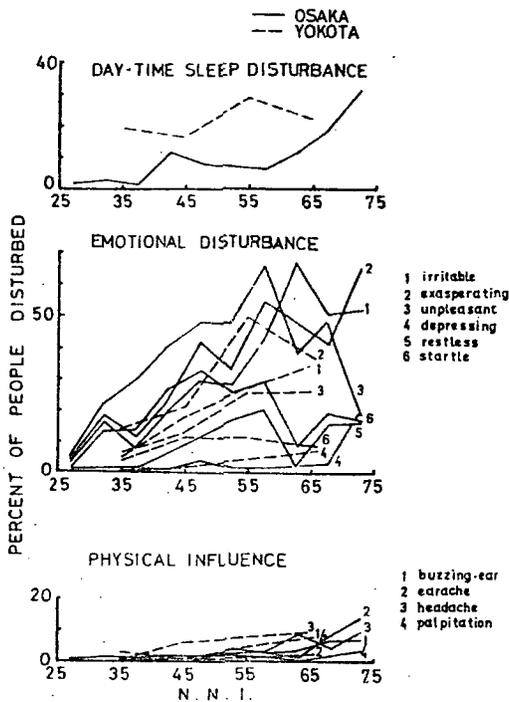


Fig. 4. Percentage of people disturbed related to the level of aircraft noise in Osaka and Yokota.

Some differences can be seen between two surveys but that the percentage increases in accordance with noise level and that emotional influence is much more evident than physical symptom are common to each other.

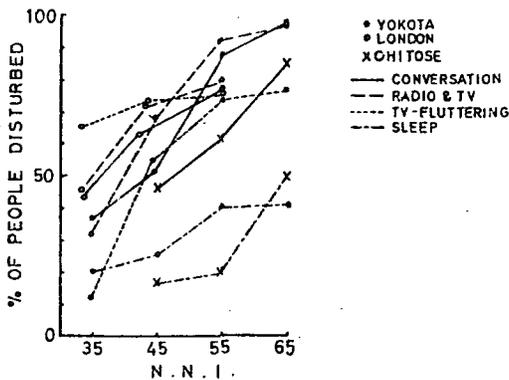


Fig. 5. Percentage of interview responses related to outdoor N. N. I. in London, Yokota and Chitose surveys. Some discrepancies observed might be resulted from the differences of their age of research, type of aircrafts, nationalities, etc.

in NNI were identical. The rate of complaints of emotional disturbance was higher in Osaka than in Yokota. There was no major difference in the rates of complaint of physical influence. We have discussed here the items which are compared. There were no major differences between the two studies in points other than emotional disturbance.

2. Comparison of Populace Responses in the Vicinities of Heathrow, Chitose and Yokota Airports

Fig. 5 compares the rates of response in the above three survey results. The survey results at Heathrow Airport are from the figure in the same report. The results at Chitose Airport are derived through an estimation of NNI from the daily number of flyovers and the dB(A), as discussed previously. The questionnaire survey results from six points, remaining after exclusion of the four points at which the effect of engine test noise was great and the points where there are only the households of the Self Defense Forces were employed. Since these six points included two points each in regions where NNI was 60, 50 and 40, the average complaint rates at each of

two points are illustrated. The survey results at Osaka Airport could

not be used here since the rate of complaints excluding the items on day-time sleep, emotional disturbance and physical effect were not reported.

Table 1. Outdoor Level of Aircraft Noise (A) in N. N. I. and of Industrial (I) and Road-traffic Noise (T) in dB (A) which produced Same Degree of Influence in the Community. These Levels were estimated from the Data of Field Surveys using Interview Method performed in Amagasaki (I), Osaka (I and A), Kyoto (T), Tokyo (T) and Yokota (A). Noise Levels which disturbed 10~90%, with a 20% step, of People Interviewed and which were rated in Average as 1~5 are Tabled.

Category of reactions	Survey, Noise and Unit	Level of noise which produced respective									
		% of people					average rating				
		10%	30%	50%	70%	90%	1	2	3	4	5
Noisiness	Osaka (I) dBA			50	55	75			52	72	
	Osaka (A) NNI			25	35	50			25	45	67
Interference with conversation	Osaka (I) dBA	50	60	67	77			52	77		
	Tokyo (T) dBA							55	75		
	Osaka (A) NNI	40	47	53	57	60		24	45	67	
	Yokota (A) NNI	25	35	43	52	60		32	45	33	
Interference with radio and TV	Osaka (I) dBA	50	60	70	80			45	68		
	Takyo (T) dBA						40	53	65	78	
	Osaka (A) NNI	25	38	48	58	75			35	55	
	Yokota (A) NNI	30	35	40	46	52		37	45	52	
Disturbance of reading and thinking	Osaka (I) dBA			47	55	70			40	55	72
	Tokyo (T) dBA								45	65	85
	Osaka (A) NNI		30	38	45	60			28	46	65
	Yokota (A) NNI		30	38	48				40	50	65
Emotional influences	Amagasaki (I) dBA	40	48	58	65	75					
	Osaka (I) dBA	45	52	60	68	75					
	Osaka (I) dBA				53	75					
	Kyoto (T) dBA	40	55	60	70						
	Osaka (A) NNI	25	30	35	42	62					
Physical symptoms	Amagasaki (I) dBA	50	65	77							
	Osaka (I) dBA	52	60	70	78						
	Osaka (I) dBA	40	65	85							
	Kyoto (T) dBA	40									
	Osaka (A) NNI	50	70	75							
Disturbance of daily life	Amagasaki (I) dBA	42	50	60	68	75					
	Osaka (I) dBA	48	55	62	70	75					
	Osaka (I) dBA		45	55	67	80					
	Kyoto (T) dBA		45	65							
	Osaka (A) NNI			35	45	60					
	Yokota (A) NNI		30	40	48	55					

Fig.5 indicates that the rate of complaints at Heathrow Airport, /124 when the NNI was low (below 45), was higher than that at Yokota Airbase for the items of speech interference, radio-television interference and sleeping disturbance. The rate at Chitose Airport was still lower than that at the former two. However, when the NNI exceeded 55, these differences, especially the differences between the former two, either vanished or reversed. Even if such differences exist, each rate of complaint rose with rise in NNI; the rate of radio-television interference became higher than the rate of sleep disturbance, and the rates of rise in the rate of complaints accompanying NNI increase were similar. The years of the three surveys differed, and the methods of noise measurement and of questionnaire survey differed, but the results were similar in terms of proportions.

3. Comparison of Populace Reaction due to Aircraft Noise, Industrial Noise and Traffic Noise

The different characteristics of aircraft noise from those of industrial noise and traffic noise were discussed in the introduction. Thus, a comparison of the survey results of the populace reaction in the vicinity of these airports with the reactions to industrial noise and traffic noise would be significant. In particular, an examination of the extent of aircraft noise which would induce the same degree of injury as industrial noise and traffic noise would be important, for the regulated standards and environmental standards concerning industrial noise and traffic noise have been announced, while those of aircraft noise are currently in the preparatory stage. Thus, in this research, we have compared the injury at Osaka Airport and Yokota Airbase with the injury due to industrial noise at Amagasaki [9] and Osaka [9,10], and with traffic noise in Kyoto [11] and in the Tokyo region [12]. In conducting the comparisons, the magnitude of each type of noise, at which the same level of injury was cited, was estimated from the viewpoint discussed above, and the interrelations were

examined.

The outdoor noise levels (NNI or dB(A)) at which 10, 30, 50, 70 and 90% of the respondees complained of injury (effect) were

determined from these survey data. In addition, the outdoor noise levels corresponding to rates 1, 2, 3, 4 and 5 for the questions which gave the degree of injury in the five stage rating were determined, and shown in Table 1. The methods of unifying the dB(A) in the report with the outdoor levels, and of unifying NNI with the figures for the number of daily flyovers, were as previously discussed. Moreover, the modification of the 0 to 4 rating in the survey at Yokota Airbase to 1 to 5 was already discussed. In the report on industrial noise at Amagasaki [9] and Osaka [9,10], since the relation between dB(A) and injury rate was illustrated, the injury rates are read from the figure, and the regression line in relation to dB(A) was determined by the method of least square. Thus, the dB(A) corresponding to each injury rate was determined. In the cases of Kyoto [11] and the Tokyo region [12], since calculation based on the method of least

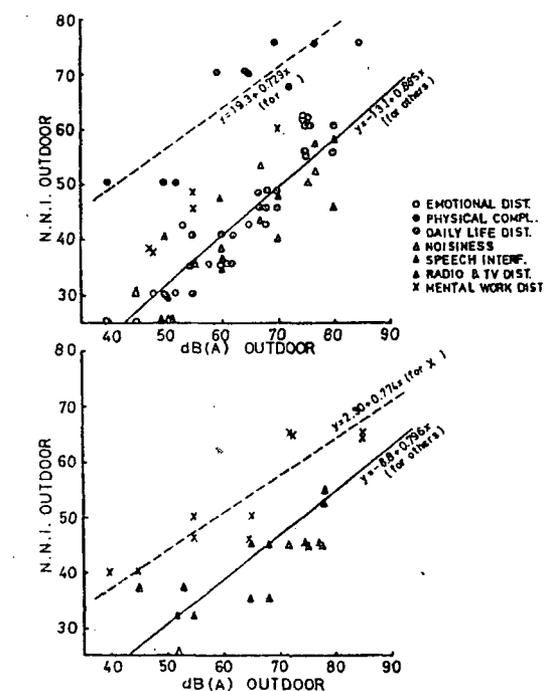


Fig. 6. Relationship between the level of aircraft noise in N.N.I. and that of industrial and road-traffic noise when they produce same degree of disturbance. This graph was introduced from the data in Table 1.

square was difficult, the injury rates were determined from the figure. Some aspects of the relation between the injury rate at Osaka Airport and NNI are based on the regression line, while others are estimated from the figure. The same is true in the case of Yokota Airbase.

Since Table 1 notes the NNI and dB(A) which induced the same percentage of respondents or rating of complaint, the relation between these dB(A) and NNI could be determined. Fig. 6 illustrates the results. The upper half of the figure gives the relation between NNI and the dB(A) which produce same percentage of respondents. Except for the physical effects, the points reveal a distribution along a straight line. A regression line was produced of $y = -13.1 + 0.885 x$ (x: outdoor noise level dB(A); y: outdoor NNI based on daily number of flyovers). The figure reveals that NNI + 20 corresponds to the dB(A) at which virtually the same percentage of complaint is induced. The physical effects, differ from other injuries and have a relation in which the values of NNI and dB(A) do not differ greatly. The effect on reading and thinking is at a higher level than other injuries except that of physical effect. However, even if this is excluded, the regression line is barely affected. The correspondence between NNI + 20 and dB(A) also is unchanged. The lower half of the figure is a view from the rates. Here, the effects on reading and thinking clearly occupy a high position than the complaints of "noisiness", interference in speech and radio-television disturbance. Thus, the regression lines were calculated for the effects on reading-thinking, and for other effects. The latter resembles closely the regression line in the top half of the figure except for physical effects. The result is a value of dB(A) which induces the same degree of injury as NNI + 20. The regression line regarding only the effects of reading and thinking is $y = 2.30 + 0.774 x$. This line virtually satisfies the point group of effect on reading and thinking in the upper half of the figure.

Considerations

The results of the surveys at Osaka Airport and at Yokota Airbase are very similar in degree of satisfaction if NNI is converted into

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Table 2. Community Reactions Produced by Aircraft Noise summarising the Data of Surveys in Yokota, Osaka, Chitose and London.

Place of survey	Reactions*	Outdoor N.N.I. for 24 hrs flyovers					
		20~	30~	40~	50~	60~	70~
Yokota	Interf. with conversation	%	35	51	87	97	
		rating	1.8	3.0	4.1	4.4	
	Interf. with telephons	%	45	47	96	98	
		rating	1.8	3.1	4.3	4.7	
	Interf. with radio & TV	%	32	68	95	98	
		rating	1.0	3.3	4.4	4.4	
	Interf. with reading and thinking	%	32	38	68	81	
		rating	1.3	2.6	3.3	4.0	
Osaka	Interf. with day-time sleep	%	31	35	64	68	
		rating	1.6	2.4	3.0	3.1	
	Emotional & physical infl.	%	12	21	58	63	
	Influence on children	%	15	42	70	69	
	Influence on babies	%	31	50	85	67	
	Noisiness	rating	3.5	4.0	4.5	5.0	5.5
		% above 4	50	85	95	95	100
		% above 5	10	38	63	83	97
Chitose	Interf. with conversation	rating	2.3	2.9	3.4	4.0	4.5
		% above 3	60	85	90	95	100
		% above 4	20	40	55	60	80
	Interf. with radio & TV	rating	3.0	3.5	4.0	4.5	5.0
		% above 3	60	90	95	95	100
		% above 4	25	40	62	80	90
	Interf. with reading and thinking	rating	2.6	3.2	3.8	4.4	5.0
		% above 3	45	85	90	95	100
London		% above 4	10	30	55	75	85
	Disturb. daytime sleep	%	3	10	6	15	25
	Emotional influences	%	50	75	90	93	95
	Physical influences	%	2	8	8	17	45
	Disturb. children's study	%	28	64	91	100	100
	Interf. with conversation	%		46	62	86	
	Interf. with night sleep	%		16	20	51	
	Disturb. mental work	%		15	32	56	
London	Emotional influences	%		10	13	41	
	Physical influences	%		9	9	36	
	Noisiness	rating	1.5	2.0	3.0	3.5	
	Startle	%	38	47	57	62	
	Disturb. fall in sleep	%	19	26	38	57	
	Awake during the sleep	%	36	47	60	70	
	Disturb. rest	%	21	30	38	50	
	Disturb. radio & TV	%	38	51	73	78	
TV pictures flicker	%	55	64	75	78		
London	Vibration of houses	%	38	51	72	77	
	Interf. with conversation	%	28	45	68	79	

* %: percentage of people disturbed by the noise; rating: average rating of disturbance or influence with a scale ranging from 1 to 5; % above 3, 4, and 5: percentage of people who rated the disturbance or influence above 3, 4, and 5, respectively using the scale described.

the outdoor daily number of flyovers. In a comparison of Heathrow Airport, Chitose Airport and Yokota Airbase, there were differences in survey period, airport scale, types of airplanes and in national characteristics, and then the results were not similar enough. However, the percentage of complaints rose with increase in NNI, and there was a degree of similarity in the rising curves. Moreover, a common point

to these four surveys was that complaints of disturbance in conversation and of radio-television interference were higher than other complaints, followed by order by disturbances in reading-thinking, and sleeping disturbances. These may be because reception interference is a direct, immediate effect of aircraft noise, while disturbance to reading and thinking is a more indirect, long-term effect, and also because night flights are much more infrequent than are day flights. The rate of complaints of speech and TV reception disturbance exceeded 50% when NNI was in the 40's. Disturbance to reading and thinking exceeded 50% when NNI was in the 50's. In addition to these items, the other items in each survey were added, and Table 2 illustrates the results, where the conversion to daily outdoor NNI was made. This table illustrates the relation between NNI and each degree of disturbance. These data would be useful in land utilization in the vicinity of airports and in setting environmental standards for aircraft noise.

Fig. 6 estimates the extent of injury due to aircraft noise in comparison with the injury due to traffic noise and industrial noise, which are typical urban noises. This figure illustrates the relation between the extent of the NNI of aircraft noise and the dB(A) of industrial noise and of traffic noise which induces the same level of injury. The virtually linear relation between the two indicates that NNI is a unit which reflects the degree of injury as effectively as dB(A). Moreover, the fact that the regression line of physical effect diverges from other regression lines indicates that there is little complaint of physical effect from aircraft noise. Moreover, the regression line of disturbance to reading and thinking diverges from that of reception disturbance. The same is true in this case. Specifically, although the peak level of aircraft noise is high, it is very intermittent, and since the interval between occurrences is long, the long-term, intermittent effect is lower than that of continuous noise such as industrial noise or traffic noise.

The figures reveal $NNI + 20 = dB(A)$ with regard to emotional effect, disturbance to everyday life and reception disturbance. $dB(A)$ is the median value, less than fifty. Consequently, the injury received from NNI 40 would be virtually equal to that of 60 $dB(A)$ of industrial noise or traffic noise. This estimate also would be useful for determining land utilization and environmental standards in the vicinity of an airport.

Summary

We have compared the results of questionnaire surveys on the populace living in the vicinities of Heathrow Airport, Chitose Airport, Osaka Airport and Yokota Airbase. In calculating the NNI (Noise and Number Index) based on the daily number of flyovers and on the outdoor level of aircraft noise, the relations between the percentage of injury and the rate of complaints of injury in each survey were studied. These coincided closely in the surveys of Osaka Airport and of Yokota Airbase, but there were differences in the survey results at Heathrow Airport, Chitose Airport and at Yokota Airbase. However, the rise in the injury rate with increase in NNI, and the degree of injury was greatest on conversation and radio-television reception, followed in order by disturbance of reading-thinking, and disturbance of sleep. This was common to all three surveys. A table illustrating the relation between NNI and degree of injury was prepared following correlation of these survey results.

The questionnaire surveys from Amagasaki, Osaka, Kyoto and Tokyo were used to compare the effects of aircraft noise with those of industrial noise and of traffic noise. In each survey, the levels of $dB(A)$ and of NNI which induced similar rates of injury were determined, and correlation figures revealed a linear relation between them. The level in noisiness, emotional effect, disturbance in

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everyday life, disturbance to conversation and interference in radio-television reception is $NNI + 20 = \text{dB(A)}$. A comparison of the above effects with disturbance to reading-thinking and physical effects indicates that the effect of aircraft noise on the latter two is slight. These points should be considered in light of the characteristics of aircraft noise.

In conclusion, the author would like to thank Mr. Tomio Mochizuki, of the Tokyo Research Institute for Environmental Protection, Noise Division; Professor Toshikazu Igarashi, of Tokyo University; Professor Takeo Yamamoto, Faculty of Engineering, Kyoto University, and Assistant Professor Shinya Watanabe, Faculty of Medicine, Hokkaido University.

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