SUBJECTIVE RESPONSE TO NOISE IN SUMMER AND WINTER

by

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Abstract

Previous studies on subjective response to noise have been conducted during the summer months. These studies have served as the basis for noise standards and legislation; therefore an implicit assumption has been made that response to noise is similar in summer and winter. Whether or not this applies equally well to the winter months, which represent approximately one-half of the year, warranted investigation. Data on summer and winter responses to comparable noise levels were collected and hypotheses were tested for differences in response to overall noise levels and to specific noise sources. The results indicated that there were no significant differences between summer and winter responses.

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CHAPTER 1

INTRODUCTION TO THE PROBLEM

In the past, noise was one of the least studied of the major pollutants, yet according to Ittleson et al. noise is probably one of the most common types of stress in the urban context (1974:265). It was not until 1971 that sound and vibration were defined as contaminants under Ontario's Environmental Protection Act (1971: Section 1(c)). Today, a great deal of research has directly resulted from this act as well as others like it elsewhere. For example, the Ministry of the Environment has been studying intensively "...the noise control programs of other governments, the sources and characteristics of noise which give rise to complaints, methods of abating noise, variations of noise levels and noise measurement" (1976:3). Most of these studies have been undertaken during the summer months for convenience: it is easier to interview people about noise and to make noise measurements in good weather conditions. As a result of these studies noise standards have been set to protect people from noise pollution.

This paper focuses on the reliability of noise standards based on summer studies which do not use data on winter noise or response. Specifically, the paper deals with subjective response to noise and how this response varies (or may vary) by season of the year. The guiding question of this paper can be stated, "Is response to noise different in the summer than it is in the winter?" If the responses are different, then the question must be asked, "Why are they different?"

By drawing from some of the relevant literature, the terms "noise measurement" and "subjective response" will be explained more fully. In addition, reference will be made to previous studies with respect to the following: the purpose of the study; the time of year the study was conducted; the noise and response measurements used; and the final results of the study. Attention will be given to those studies used to create noise standards.

There are three aspects of noise which need to be included in noise measurement: sound pressure magnitude, frequency and time variation. Sound pressure magnitude describes the physical range of magnitude in sound pressure units between very faint sounds and loud sounds. The magnitude is so great that it is not practical to express it directly in pressure units. The magnitude is measured in decibels. The sound pressure level (SPL) is ten times the common logarithm of the ratio of the square of the sound pressure in question, to the square of a (stated or understood) reference sound pressure, which is almost always 20 micropascals (United States Environmental Protection Agency, 1974: A-1). In mathematical terms, sound pressure level SPL expressed in decibels is:

$$SPL = 10 \log \left(\frac{p^2}{p_0^2}\right)$$

where p is the pressure fluctuation and p_0 is the reference pressure. An intuitive understanding of the decibel is offered by Kryter, who points out that a ten decibel increase in most sounds causes a doubling in subjective magnitude of the noisiness (1959:72).

Frequency is another aspect of noise that needs to be included in noise measurement. According to Kryter, high frequency sounds tend to be more annoying than lower frequency sounds, even though they are equally as loud. An A-weighting is a weighting of the frequencies such that sounds at different frequencies are weighted in much the same way as the human ear hears them. The most common unit of noise measurement is the A-Weighted decibel (dBA).

The last aspect of noise considered in noise measurement is the time-varying nature of noise. It is possible to divide the time of day into periods (e.g. daytime, 7 a.m.-7p.m.; night, 11 p.m.-7a.m.) to obtain more information regarding the amount of noise at a particular time of the day. For a given time period there are percentile distributions of L_{90},L_{75},L_{50}, L_{25} and L_{10}, where L_{10} is the sound pressure level exceeded ten percent of the period. For example, a daytime L_{50} of 55 dBA means that 55 dBA is exceeded for 50 percent of the daytime period. One other time varying measurement used is

Leq or the "energy mean" given by the equation:

$$Leq = 10 \log\left[\frac{1}{t_2 - t_1} \int_{t_1}^{t_2} \frac{p^2(t)}{p_0^{\,2}}\, dt\right]$$

where $p(t)$ is the time varying sound pressure and p_0 is a reference pressure taken as 20 micropascals. In terms of understanding Leq the following example is useful. If for a five minute period some noise source produces the following decibel levels, each for one minute - 50,60,70,80 and 90 - the 5 minute Leq is 83 dB although the arithmetic mean of the levels is only 70. Leq is formulated in terms of the equivalent steady noise level which in the same period of time contains the same noise energy as the time varying noise.

Response to noise is collected by asking people questions about noise. Questionnaires are administered by mail, telephone, or household interviews. Depending on the aims of the research,many different kinds of questions are asked. For example, people may be asked about the kinds of noises and the characteristics of these noises which they find disturbing. Often questions are asked to discover the behavioural characteristics of the respondent. Questions which elicit attitudes to noise incorporate unipolar and bipolar scales. A unipolar scale has a number of points along it which measure a one way response. For example, the respondent is asked to record his degree of disturbance along a

5 - point scale from not at all disturbed to extremely disturbed. It is often better to use a bipolar scale in order to allow for a full range of response to gain more information. For example, a noise rating is requested along a 9 - point scale from extremely agreeable to extremely disturbing with a neutral midpoint.

Studies dealing with noise and response measures include the Central London study conducted by Griffiths and Langdon in 1967. The purpose of the study was to establish the extent of dissatisfaction caused by different levels of noise from urban motorways. Unfortunately, the time of year of the data collection was not mentioned by the study. By failing to indicate the time of year of the data collection, the authors have shown, implicitly at least, that this was unimportant to their results. Griffiths and Langdon found that the direct noise measures such as L_{90}, L_{50} and L_{10} were poor predictors of response based on median dissatisfaction scores. A better predictor was a weighted combination of L_{10} and L_{90} called the traffic noise index (TNI) defined by the equation,

$$TNI = 4(L_{10}-L_{90}) + (L_{90}-30)$$

where 30 is a constant which may be subtracted to yield more convenient numbers (1968:21). To obtain a response measurement

Griffiths and Langdon asked respondents to rate noise along a 7 - point scale (from definitely satisfactory to definitely unsatisfactory. The mid-point of the scale (don't know) was removed to arrive at the median dissatisfaction score which was subsequently correlated with the sound levels. To remove the mid-point from ordinal data to obtain better correlations is questionable from a statistical point of view, therefore the results from subsequent statistical tests cannot be reliable.

In 1967, the District of the Region of Paris requested a study on the reaction to transportation noise of people living near highways. The noise was monitored during the spring although this information for response was missing. Noise levels L_{90}, L_{50}, and L_{10} were measured. Response indexes were calculated so that a value of 0 indicated that a person had no unfavourable reactions to noise whereas a value of 10 indicated that all reactions towards noise were unfavourable. There was a strong relation indicated between the median noise levels (L_{50}) and the annoyance indices (Alberta Transportation, 1975: 3-9). If the median annoyance index was plotted against L_{50} then the median annoyance index of 2.5 occurs at L_{50} = 63.5 dBA. It was concluded that L_{50} = 60 to 65 dBA at the building facade was the critical level in the daytime on weekdays but not at peak traffic times (Alberta Transportation

1975: 3-10).

A study in the United States by Bolt, Beranek and Newman in 1971 attempted to determine various types of motor vehicle noises which were annoying to people. Response data were collected in late winter and early spring, and noise measurement after that, but information on the exact time of the noise measurement was not given (1971:106). Since approximately one-half of the sites were in Los Angeles and the other half of the sites were in Boston and Detroit, the variation in climate alone was enough to suggest that the season was not an important factor in the study. Various noise levels (L_{90}, L_{50}, L_{10} and L_1) were obtained in addition to Leq, TNI and the Noise Pollution Level (LNP) defined by,

$$L_{NP} = Leq + K.\sigma$$

where σ is the standard deviation of the instantaneous level and K is a constant equal to 2.56. Respondents were asked to rate neighbourhood noisiness along a 7 - point scale from one "not noisy at all" to seven "unbearably noisy". In addition respondents were asked to respond to particular motor vehicle noise situations along a 7-point scale from "scarcely annoying at all" to "unbearably annoying" (1971:76). In a review of this study by Alberta Transportation, they indicated that strong correlations were found between several of the noise levels and judgments of site noisiness, however correlations were weak between noise levels and motor vehicle annoyance.

A study by Hall and Taylor during the summer of 1975 attempted to find a measure to predict the percentage of the population likely to be disturbed by any given transportation noise environment (1975:1). A number of measures were used including the percentiles (L_{90}, L_{75}, L_{50} and L_{10}), the arithmetic mean (μ), Leq, and Griffiths and Langdon's TNI. Disturbed and not disturbed categories were used to permit multiple regression analysis. The results indicated that the daytime L_{75}, L_{50} and μ were the best predictors of community response to transportation noise.

Many of the studies mentioned have contributed to the development of noise standards. For example all of the studies (with the exception of Hall and Taylor), which appear in this paper are considered by the Alberta Department of Highways and Transport to "provide a full background for the development of recommended practices " (1975:i).

In Ontario the Ministry of the Environment has sponsored studies in Toronto, London and Hamilton. According to the literature review constructed by Alberta's Department of Highways and Transport, the Ministry of the Environment for Ontario considers each of these Ontario studies as "a precursor to formulating community noise regulations for the province as a whole"(1975: 3-22).

The Central London study in 1961-62 and later in

1967 by Griffiths and Langdon have been used in England to establish the extent of environmental noise impacts. Specifically, Griffiths and Langdon's measure TNI was earlier considered as an acceptable noise descriptor but according to Behrans and Barry, the TNI later proved to be unacceptable (1975:644).

France has been conducting studies on the individual's reaction to traffic noise. The study mentioned in this paper is one such study. By 1972, national guidelines stated that traffic noise impacts could be assessed if the L_{50} noise level from a project was 65 to 68 dBA or greater.

The U.S. study by Bolt, Beranek and Newman has been cited throughout by the U.S. Environmental Protection Agency in a document prepared on "Information on Levels of Environmental Noise: Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety." Since some of the investigations contributing to this document are still underway, the document does not constitute a standard at this time, however it does represent the best information available.

To restate the focus, this paper deals with the reliability of standards based on summer months which do not use data on winter noise or response. The possible seasonal variation in subjective response to road noise is dealt with in this study. Summer data were obtained from the Hall and Taylor study mainly because of their availability and additional winter data were collected. The remainder of the paper is structured as follows: the next section covers the development of the hypotheses based on the summer study. This section is followed by a description of the winter data collection. The analysis section contains the methods used to test the hypotheses as well as the outcomes of these tests. Finally, the results are evaluated and the conclusions of the study are presented.

CHAPTER 2

DEVELOPMENT OF THE HYPOTHESES

The summer survey of Hall and Taylor in 1975 determined the kinds of hypotheses used to examine the summer - winter problem. The hypotheses were constructed to make use of the data available. In order to make any sense of summer versus winter response it was necessary to control for the noise levels. In other words, it was necessary to select from several available summer sites, those sites which most closely matched noise levels at the winter sites. This section first describes the physical data and the response data in Hall and Taylor's study, then develops hypotheses which are structured by the response data.

The physical measurements of noise were collected by recording devices at each particular site. Fourteen sites were monitored between June and August with an analog tape recorder set up to record 10 seconds of noise every 2½ minutes. The remaining 14 sites were monitored using equipment which recorded sound levels once every second. Hall and Taylor stressed that monitoring for the road oriented sites was completed by October before snow tires were used (1975:1). The noise measurements included five direct measures (L_{90},

L_{75}, L_{50}, L_{25}, L_{10}) as well as the equivalent sound level Leq. These measurements were calculated for three time periods: daytime - 7 a.m. to 7 p.m.; evening - 7 p.m to 11 p.m.; and night - 11 p.m. to 7 a.m.

The response data for the summer survey were collected by the means of household interviews with the use of a structured questionnaire. The item on the questionnaire which formed the basis of this research project was a 9 point rating scale used to elicit the subjective response to overall neighbourhood noise and to specific noise sources (1975: 2). For example, response was elicited for the question, "How would you rate the overall noise in this neighbourhood?" The respondent was asked to answer this question by using the following scale:

Extremely agreeable
Considerably agreeable
Moderately agreeable
Neutral
Slightly disturbing
Moderately disturbing
Considerably disturbing
Extremely disturbing

On the basis of this 9 point scale, two kinds of hypotheses arise related to whether disturbance is greater in winter, or greater in summer, or the same in both seasons. One kind focusses on the number of people disturbed in summer and winter. The following set of hypotheses is derived:

1.0 The proportion of people disturbed by overall neighbourhood noise is the same in summer and winter.

Multiple hypotheses are used to encompass the subject on all sides, therefore the null hypothesis has two alternatives which provide the researcher with a basis for inductive inference or strong inference as discussed by Platt (1964:7).

1.1. There are more people disturbed by overall noise in winter than in summer.

1.2. There are more people disturbed by overall noise in summer than in winter.

The second kind of hypothesis focusses on the degree of disturbance. Do those people who are disturbed show a greater degree of disturbance in winter or in summer? If they are more disturbed in one season than another then their responses along the upper 4 points of the 9 point scale will reveal this difference. The following hypotheses test whether or not there is a difference:

2.0 Those people disturbed are equally disturbed in summer and winter.

2.1 Those people disturbed are more disturbed in winter than in summer.

2.2 Those people disturbed are more disturbed in summer than in winter.

There are a number of reasons for constructing the first two sets of hypotheses. The null hypothesis can be explained on the grounds that people respond on a year round basis, therefore there is no difference between their summer and winter responses. Greater disturbance in winter could be due to the fact that people spend more time at home in winter during their leisure time, whereas in summer they are away from home at parks, beaches or other recreational areas. Alternatively, it is possible that disturbance increases in summer because the warm weather necessitates open windows and more time spent outside, whereas winter conditions cause more people to stay inside with their windows closed.

Information on disturbance from specific noises is also available from the summer survey. Additional sets of hypotheses can be constructed to investigate how disturbance due to noise from specific sources varies by season. The specific sources considered here are local traffic, freeway traffic, trucks and motorcycles. The sets of hypotheses are useful here because several of the options seem plausible. For example, a person's disturbance from local and freeway traffic could increase in the winter. Snow and ice on the roads cause traffic to flow less regularly, with numerous stops and starts. Noise is intermittent and from personal observation it seems as though the spinning snow tires generate a higher pitch of noise on wet and icy roads. The A - weighted noise measurements may not indicate any difference between summer and winter. It is possible, however, that a person's disturbance increases in winter. Similarly, disturbance from trucks could increase in the winter. Trucks do not change tires from summer to winter but icy road conditions could cause greater disturbance for the same reasons mentioned for increased disturbance from local and freeway traffic. However, disturbance from motorcycle noise is likely to increase in the summer because of a greater frequency of use.

The following hypotheses are developed to examine summer and winter response to specific noises(i.e., trucks, local traffic, freeway traffic and motorcycles).

3.0 The proportion of people disturbed by specific noises is the same in summer and winter.

3.1 There are more people disturbed by specific noises in winter.

3.2 There are more people disturbed by specific noises in summer.

and

4.0 Those people disturbed by specific noises are equally disturbed in summer and winter.

4.1 Those people disturbed by specific noises are more disturbed in winter than in summer.

4.2 Those people disturbed by specific noises are more disturbed in summer than in winter.

Information on the specific noise sources is used to develop another set of hypotheses to examine summer - winter differences in response. Based on the number of disturbing noises an individual mentions in summer and winter, the differences between the two can be observed.

5.0 The number of disturbing noises mentioned is the same in summer and winter.

5.1 There are more disturbing noises mentioned in winter than summer

5.2 There are more disturbing noises mentioned in summer than winter.

In summary, the purpose of the development of the hypotheses to this point is to determine whether or not differences exist between summer and winter response to noise. If testing of these hypotheses shows that differences exist then they must be explained. The summer study contains data to look at the explanations.

In summary, the summer survey generated the interest and provided a great deal of the data for this research paper. The hypotheses are in fact constrained by the information that is available in the summer survey. Winter data are needed for comparison and the winter data collection methods are presented in the next section.

CHAPTER 3

THE WINTER SURVEY

Ideal Sites

The purpose of the winter survey was to obtain response data and physical measurements to compare to the summer survey. Ideally, the physical measurements should be the same for any two sites being compared in terms of response.

The characteristics of each pair of sites should be similar. Sites should have the same number of respondents from the same type of dwelling (e.g., apartment sites should be compared to other apartment sites). The noise sources should be the same for the two sites being compared and for each household within each site. There should not be any intruding noises to confuse the respondents.

Practical Considerations

Time allowed 3 winter sites to be monitored. The monitoring was completed before snow tires were removed. It was not possible to monitor one site (St. Catharines) for the full 24 hour period and only the daytime noise measurements were collected.

Two of the sites (apartment buildings in Hamilton) were interviewed as part of a fourth year urban behavioural geography project at McMaster. At the time it was not certain which questions were needed for a summer comparison. It was necessary to use the same questionnaire for each group member's project and as a result, some questions were not asked which would have been asked otherwise. Questions on when people were most disturbed and the time spent at home on weekends were not asked at these two sites. There were at least three interviews that were unreliable and although efforts were made to delete them, it was not possible. Unfortunately, two of the interviewers confided that they had answered the questionnaires themselves in order to finish, and later it was learned that another interviewer conducted interviews on the opposite side of the apartment building away from the noise source. The interviewers were not certain which interviews were false.

People at the third site were interviewed by two experienced university graduates from the summer survey, and five other interviewers (2 McMaster geography students, my wife and I, and our neighbour) who were briefed by the two experienced ones. The questionnaire from the summer survey was used for interviewing at these sites. The site consisted of single - family residential dwellings in St. Catharines.

The sites themselves were chosen on the basis of personal knowledge, maps and visits to prospective areas. There was some difficulty in obtaining a site with enough households for an adequate sample. All the households within the site were to experience similar noise conditions, therefore it was necessary to find single - family residential dwellings or apartment buildings parallel to the road traffic. A site containing at least 60 single - family dwellings was needed to complete about 30 interviews.

Site Description and Comparison

The three sites used in the analyses were the two apartment buildings in Hamilton and the single - family residential site in St. Catharines (see Table 1). The noise level for comparison with the summer sites used was L_{50}. Hall and Taylor found the daytime L_{75} and L_{50} to be the best predictors of noise impact, however, monitoring equipment used in the winter did not measure L_{75},therefore L_{50} was relied upon.

The measurements for the two apartment buildings, Forest Drive and Mohawk West were 68 and 59 dBA respectively. The L_{50} in St. Catharines, the residential site, was 75dBA (see Appendix 1). It was necessary to select from the 28 summer sites, those sites which were most comparable in terms of noise measurement. Although L_{50} was the most important measure in terms of comparability it was necessary to look at all the percentage levels over the full 24 hour period as a

TABLE I - SITE DESCRIPTION

Site No.	Location and Noise Source for Summer Sites
* 11	Camelot Towers, W. Main Street, Hamilton Highway 403.
17	Oneida Drive, Burlington - QEW
13	Cloverleaf Drive, Marley Crescent, Burlington QEW (near Plains Rd.)
	Location and Noise Source for Winter Sites
* 1	Jolley Cut, Hamilton - Major arterial traffic from downtown to Hamilton - mountain
* 2	Mohawk West, Hamilton - Major arterial east - west traffic across Hamilton - mountain
3	Geneva and Fitzgerald Streets, St. Catharines QEW

* Sites 1 and 2 are apartment buildings. The other sites contain single family residential dwellings.

The pairs of sites being compared are 1 and 11, 2 and 17, and 3 and 13. To simplify matters, they are called Pair 1, Pair 2 and Pair 3 respectively.

further test (details appear in Appendix I). The summer sites chosen were Camelot Towers in Hamilton, and Oneida Drive and Cloverleaf Drive in Burlington. The winter and summer sites compared were the following: the Jolley Cut (daytime L_{50} = 68dBA) was compared to Camelot Towers (daytime L_{50} = 65 dBA); the Mohawk West site (daytime L_{50} = 59 dBA) was compared to the Oneida Drive site (daytime L_{50} = 62dBA); and the St. Catharines site (daytime L_{50} = 75dBA) was compared to Cloverleaf Drive (daytime L_{50} = 68dBA). The first two pair of sites were similar in noise measurements but in the last pair the St. Catharines site had a higher L_{50} than Cloverleaf Drive. Only 4 hours of noise measurements were taken at the St. Catharines site and two of these were peak or near peak hours 3:30 p.m. to 5:30 p.m., therefore accounting for the higher measurements. If the remaining 8 hours were included then the L_{50} would be expected to decrease.

There were some limitations in the comparisons which are shown by a more detailed description of the sites. Mohawk West (an apartment) was compared to Oneida Drive (a residential area). In a paper on the residential implications of subjective response to noise Hall and Taylor found that multiple family dwellings reported lower disturbance generally although the authors admitted limitations in their data set (1975a: 78). Single - family residents were more disturbed. In the same paper Hall and Taylor stressed the value of shielding in significantly reducing response levels. Two of the summer sites (Oneida Drive and Cloverleaf Drive) contained slight tree shielding, however, the winter comparison sites did not have shielding present.

An overview of the data used for the analysis is presented in Table 2. Other characteristics of the sites appear not to affect subjective response to noise. Hall and Taylor found that length of residence was unimportant to response or in other words, people were unable to adapt to noise over time (1975a: 78). The authors studied the effect of age and income, but concluded that it was not possible to generalize about these characteristics. Sensitivity was randomly distributed, as it was in this study, therefore it was not used to explain response.

TABLE 2 - AN OVERVIEW OF THE DATA

	Daytime L60	No. of Interviews	No. Disturbed (Noise Source) Neighbourhood	Local	Freeway	Trucks	Motorcycles
Jolley Cut (w)*	68	31	18	0	22	22	24
Camelot Towers(s)*	65	30	14	0	19	13	6
Mohawk Rd.(w)	59	23	9	4	19	12	3
Oneida Dr.(s)	62	30	13	0	18	10	4
St. Catharines(w)	68≠	24	13	2	10	12	6
Cloverleaf Dr.(s)	75	30	17	1	8	20	2

*(w) Winter Site
*(s) Summer Site

≠ Measurement for 4 hrs. (1:15 p.m. - 5:25 p.m.) only.

CHAPTER 4

ANALYSES AND RESULTS

Analytical Techniques

The data available to test the hypotheses are counts of the numbers of people disturbed at each site and the distribution of ratings which are found on the upper half (slightly disturbing - extremely disturbing) of the 9 - point scale. Hypotheses 1,3 and 5 have nominal data (i.e., disturbed or not disturbed for hypotheses 1 and 3 and number of disturbing noises for hypotheses 5) by nominal data (site) which means that Chi - Square is the best test in these instances. Hypotheses 2 and 4 have ordinal data with the disturbance rating from 6 - 9 (slightly disturbing, moderately disturbing, considerably disturbing and extremely disturbing) by nominal data (site). The Mann - Whitney U test is appropriate by making use of the added information available on the ordinal scale. Siegel calls the Mann - Whitney U test the most powerful of the non-parametric tests (1956:116). For both the Mann - Whitney U test and the Chi-Square tests the null hypothesis will be rejected at the .05 significance level. The critical value for Chi - Square is 3.84 with 1 degree of freedom.

Results from Overall Neighbourhood Noise

The results from the Chi - Square test indicate that the null hypothesis cannot be rejected at the .05

significance level (Table 3). The samples are not significantly different at the 5% confidence level for any of the three pairs of sites.

Although the proportions of people disturbed are not significantly different it is possible that the degree of disturbance is greater. The results of the Mann - Whitney U test indicate that the null hypothesis cannot be rejected at the .05 significance level (Table 4). There does not appear to be any clear tendency for the degree of disturbance to be higher or lower in summer or winter. In fact, the significance levels of .92 and .93 at pairs 2 and 3 tend to give fairly strong support for the null hypotheses.

The results from both the Chi - Square and Mann - Whitney U tests indicate that there is no observable difference between summer and winter sites. The most obvious explanation for the results is that people respond to noise on a year round basis. When asked, in winter, to respond to noise, it was discovered that many of them thought back to the summer before they responded to the questions.

Results from Response to Specific Noises

The number of respondents for local traffic was not sufficient to perform Chi - Square or Mann - Whitney tests. Chi - Square test results from the three pairs of sites responding to freeway traffic showed that the null hypothesis could not be rejected at the .05 significance level (Table 5.)

TABLE 3 - PEOPLE DISTURBED BY OVERALL NEIGHBOURHOOD NOISE

		Disturbed	Not Disturbed	X^2
Pair 1	Forest Drive(w)	18	13	.76
	Camelot Towers(s)	14	16	
Pair 2	Mohawk West(w)	9	14	.39
	Oneida Drive(s)	13	17	
Pair 3	St. Catharines(w)	13	11	.78
	Cloverleaf Drive(s)	17	13	

TABLE 4 - DISTURBANCE RATING FOR OVERALL NOISE

Disturbance Rating		6 slightly	7 moderately	8 considerably	9 extremely	U	Significance level
Pair 1	Forest Drive(w)	6	8	2	2	115	.48
	Camelot Towers(s)	5	7	2	0		
Pair 2	Mohawk West(w)	3	3	3	0	57	.92
	Oneida Drive(s)	5	3	4	1		
Pair 3	St. Catharines(w)	6	3	2	3	109	.93
	Cloverleaf Drive(s)	7	5	3	2		

There were no significant differences in the proportions of people disturbed. The Mann - Whitney U test (Table 6) indicated that for 2 of the 3 pair of sites there were also no significant differences in the levels of disturbance. The results for pair 1 indicated that the null hypothesis could be rejected with a probility of .05 that the differences between the two distrubutions occurred by chance.

The Chi - Square test for response to truck noise indicated that the null hypotheses could be rejected at pair 1 where there was a greater proportion of people disturbed in winter. Pairs 2 and 3 failed to indicate any differences and the null hypotheses were not rejected. The Mann - Whitney test results indicated that the null hypotheses could not be rejected (Table 6). There were no significant differences between the distributions at any of the pairs of sites.

For motorcycle noise, results from the Chi - Square test on pair 1 showed that a greater proportion of people were disturbed in winter. The results from the pairs 2 and 3 indicated that the null hypothesis could be rejected. The Mann - Whitney U test did not show any differences in the degree of disturbance and in all pairs of sites the null hypotheses could not be rejected.

At pair 1 there is a greater proportion of people disturbed by all three specific noise sources in winter and

TABLE 5 - PEOPLE DISTURBED FROM SPECIFIC NOISES

Freeway Traffic		Disturbed	Not Disturbed	X^2	
Pair 1	(w)	22	9	.30	
	(s)	19	11		
Pair 2	(w)	19	4	2.40	
	(s)	18	12		
Pair 3	(w)	10	14	1.35	
	(s)	8	22		
Trucks					
Pair 1	(w)	22	9	4.1	
	(s)	13	17		
Pair 2	(w)	12	11	1.2	
	(s)	10	20		
Pair 3	(w)	12	12	1.2	
	(s)	20	10		
Motorcycles					
Pair 1	(w)	24	7	21.3	.001 Significance Level
	(s)	6	24		
Pair 2	(w)	3	20	0	
	(s)	4	26		
Pair 3	(w)	6	18	2.35	
	(s)	2	28		

TABLE 6 - DISTURBANCE RATING FOR SPECIFIC NOISES

Disturbance Rating		6 Slightly	7 Moderately	8 Consid- erably	9 Extremely	U	Significance Level
Freeway Traffic							
Pair 1	(w)	2	10	6	4	138	.05
	(s)	8	5	5	1		
Pair 2	(w)	6	7	6	0	168	.91
	(s)	8	3	6	1		
Pair 3	(w)	3	3	2	3	27	.22
	(s)	3	5	0	0		
Trucks							
Pair 1	(w)	2	8	7	4	120	.40
	(s)	3	4	6	0		
Pair 2	(w)	1	4	4	3	56	.78
	(s)	2	2	4	2		
Pair 3	(w)	2	1	2	4	106	.57
	(s)	1	8	6	5		
Motorcycles							
Pair 1	(w)	3	7	8	5	61	.55
	(s)	1	3	1	1		
Pair 2	(w)	0	2	0	1	5	.57
	(s)	0	1	2	1		
Pair 3	(w)	3	1	2	1	4	.39
	(s)	1	1	0	0		

in addition, those people disturbed by freeway noise are more disturbed in winter. Pairs 2 and 3 do not show any significant differences in the proportion disturbed or the degree of their disturbance. The discrepency can be explained in part by the site characteristics. At the winter site (Jolley Cut) the apartment building is located on a hill and the traffic does not flow as smoothly as it does at the summer site (Camelot Towers) at which the road is level. The slope of the hill is quite pronounced thereby causing traffic (especially trucks and motorcycles) to continually shift gears. It is possible that the trucks and the continual gearing is not covered adequately by the A - weighting. For this reason the results from pairs 2 and 3 are considered more reliable.

Number of Disturbing Noises Mentioned

Since the number of disturbing noises mentioned is ordinal data and site represents nominal data a Mann - Whitney U test is appropriate. The test indicates whether there are significant differences between the two distributions of disturbing noises mentioned at the summer and winter sites. The null hypotheses were rejected at all pairs of sites at the .01 significance level (Table 7). The results showed that significant differences exist between the number of disturbing noises mentioned at winter and summer sites. The distribution of disturbing noises mentioned indicated that a greater number mentioned in winter. The results for pair 1 were consistent with previous tests which showed greater winter disturbance. Pairs 2 and 3 show a greater number of disturbing noises mentioned in winter which is contradictory to the results of the hypotheses testing on the proportion of people disturbed and the degree of their disturbance.

Since people were asked to mention all audible noises and only the disturbing noises were used for this test, it is possible that this measure is not as reliable a measure of disturbance as the tests which involve scaling. When given a scale to record responses to overall and specific noises, people are given the opportunity to think about the level of their response (i.e. disturbance or agreeability).

TABLE 7 - DISTURBING NOISES MENTIONED

Number Mentioned		1	2	3	4	5	6	7	8	U	Significance Level
Pair 1	(w)	4	4	14	6	1	0	1	0	40	.01
	(s)	8	9	5	0	0	0	0	0		
Pair 2	(w)	3	3	4	7	1	3	0	2	21	.01
	(s)	15	10	0	0	0	0	0	0		
Pair 3	(w)	8	6	4	0	1	1	0	0	31.5	.01
	(s)	13	9	0	1	0	0	0	0		

Summary

The evidence on the two measures of disturbance showed that there was no significant difference in the proportion of people disturbed and the level of their disturbance between summer and winter. This statement held true for hypotheses with respect to overall neighbourhood noise and the specific noise sources (i.e. freeway traffic, trucks and motorcycles). In 27 tests the null hypothesis was rejected only 5 times. The main rejections occured for pair 1 which showed a greater proportion of people disturbed in winter for freeway, truck and motorcycle noises. In addition, pair 1 showed a greater degree of disturbance to freeway noise in winter. A greater number of disturbing noises were mentioned in winter for pairs 1 and 2. The disparity of results between pair 1 and the other pairs of sites was considered as a problem in site comparability.

A general evaluation of these results is advanced in the next section. In it, site and personal characteristics are presented to explain the results.

CHAPTER 5

AN EVALUATION OF THE RESULTS

The least explicable result produced in the analysis is the rejection of the null hypotheses for pair 1, and it is this result which must be explained. Two possibilities are explored in this section: (i) the results at Pair 1 are unreliable because of problems with site characteristics, and (ii) alternatively, the results at pair 1 are reliable and the results at pairs 2 and 3 are unreliable because of differences in site characteristics. Consider possibility of (i) first.

The grade of the road for the two sites in pair 1 is not the same. The QEW is level on the section of highway at which Camelot Towers is located. The Jolley Cut offers access to and from the Hamilton mountain and the slope is relatively steep. The slope on the latter entails more shifting of gears in some types of traffic (trucks and other vehicles with standard transmissions), therefore, different noise frequency characteristics arise. From personal observation this type of noise is more distracting (i.e. disturbing) and it is plausible that it accounts, in part at least, for the increased disturbance at the winter site.

It is possible also that in the site selection, pair 1 matched a sample of highly noise - sensitive people at the winter site against people with an average sensitivity towards noise. However, results from the Mann - Whitney U test show that there is no significant differences in the two distributions, so it is not possible to explain greater disturbance at the winter site in pair 1 by a difference in sensitivity (Table 8).

Now consider possibility (ii). There are problems with site comparability in pairs 2 and 3 which may have affected the results. Pair 2 has an apartment matched against a residential area. Hall and Taylor state that there is some evidence of lower disturbance in multi-family dwellings (1975:78). The results from the Chi - Square test indicate more disturbance in the multi-family dwelling. Shielding is present in the residential site (Oneida Drive) which may account for a lower number of disturbing noises mentioned in summer. Hall and Taylor place a great emphasis on the effect of shielding, saying that it can reduce disturbance by decreasing noise levels and shielding the view of the noise source.

At pair 3, time constraints enabled only four hours of noise monitoring. Perhaps there is much more difference in the daytime L_{50}'s than is indicated in Appendix I.

The problems of site comparability at pairs 2 and 3 are possible factors for being unable to reject the null hypothesis even if it is not true. Perhaps there are differences

TABLE 8 - SENSITIVITY

Sensitivity Rating	Not at all	A little	Moderately	Considerably	Extremely	U	Significance Level
Pair 1	8	2	9	7	6	411	.31
	5	5	13	7	0		
Pair 2	6	1	8	4	4	323	.67
	2	5	13	6	4		
Pair 3	6	6	7	2	1	109	.93
	7	9	8	5	1		

in the proportion of people disturbed between summer and winter but summer - winter site differences make it impossible to determine these differences. One very real possibility is the difference in noise levels at the sites. In the literature review it was frequently noted that noise levels are directly related to disturbance (Alberta Transportation, 1975). The necessity for having comparable noise levels when comparing responses is crucial but difficult to achieve.

Besides the problems in site comparability, it is possible also that although there are differences in summer and in winter disturbance, people respond on a year round basis. For example, more disturbance from motorcycle noise in winter indicates that people respond on an annual basis. Obviously, motorcycles are used primarily in the summer, therefore people must be thinking about the noise in summer before they give a winter response.

The guiding question of this study asked, "Are there differences between summer and winter response to noise?" It was expected intuitively that more disturbance would occur in either summer, or winter. However, very few of the results in this study supported this expectation. It is still possible that such differences do exist and are of critical importance in the understanding of subjective response to noise.

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APPENDIX I

Noise Level Comparisons

Pair 1

Noise Levels	Forest Drive (w) Daytime 7a.m.-7p.m.	Forest Drive (w) Evening 7p.m.-11p.m.	Forest Drive (w) Night 11p.m.-7a.m.	Camelot Towers (s) Daytime 7am.-7pm.	Camelot Towers (s) Evening 7pm.-11pm.	Camelot Towers (s) Night 11pm.-7am.
L_1	77	75	80	76	76	77
L_{10}	71	70	73	67	65	71
L_{20}	71	67	73	67	65	71
L_{50}	68	57	70	65	59	69
L_{90}	62	45	64	60	48	65
Leq	70	65	72	68	64	69

Pair 2

Noise Levels	Mohawk West (w) Daytime 7am.-7pm.	Mohawk West (w) Evening 7pm.-11pm.	Mohawk West (w) Night 11pm.-7am.	Oneida Drive (s) Daytime 7am.-7pm.	Oneida Drive (s) Evening 7pm.-11pm.	Oneida Drive (s) Night 11pm.-7am.
L_1	66	66	75	72	70	69
L_{10}	63	59	69	67	64	64
L_{20}	62	56	67	65	62	62
L_{50}	59	49	63	62	58	58
L_{90}	51	45	58	58	54	50
Leq	60	56	66	64	60	61

APPENDIX (cont'd)

Pair 3

Noise Levels	St. Catharines(w) Daytime 1;15-2:14pm.	2:15-3:15pm.	3:15-4:15pm.	4:25-5:25pm.	Cloverleaf Drive (s) Daytime 7am.-7pm.
L_1	84	83	83	83	82
L_{10}	80	79	79	80	77
L_{20}	78	77	77	78	74
L_{50}	75	75	75	75	68
L_{90}	70	70	71	71	57
Leq	74	74	74	74	72