

THE EFFECT OF ELEVATED TRAIN NOISE ON READING ABILITY

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Early laboratory work (Kryter, 1950, 1970; Broadbent, 1957) had found no compelling support for direct effects of noise on mental and psychomotor performance, and it was concluded that people seem to adapt to noise (Kryter, 1970). However, Glass and Singer (1972a), through an extensive survey of previous noise research and their own studies on noise adaptation, found that, following exposure to unpredictable and uncontrollable high-intensity noise, the often reported after-effects were: degradation in quality of task performance, lowered frustration tolerance, and impaired ability to resolve cognitive conflict.

Most recently, in a study on the effect of noise in a natural environment, Cohen et al. (1973) found that elementary school children living on the lower floors of buildings, directly exposed to high-intensity expressway noise, showed greater impairment

of auditory discrimination and reading achievement than children living in higher-floor apartments.

In an attempt to explain their findings, Cohen et al. referred to the work of Deutsch (1964). Deutsch had speculated that a child reared in a noisy environment would eventually become inattentive to acoustic cues. The result would be impaired auditory discrimination or the child's inability, as he tunes out the noisy environment, to discriminate between relevant and irrelevant speech cues. This, in turn, might explain subsequent difficulty in learning how to read.

Correlational data obtained in both the Deutsch (1964) and Cohen et al. (1973) studies supported the hypothesized relationship between noise and reading deficits as mediated by impaired auditory discrimination. However, it is quite possible that a more direct association exists between noise and reading difficulties.

A National Resources Defense Council, Inc. report (1974) on the excessive noise created by the New York City subway system raised the possibility of exploring the effect of noise generated by passing elevated trains, on the reading skills of children in a nearby elementary school. The following study was undertaken to examine further the relationship between high-intensity, uncontrollable and unpredictable noise and reading deficits, as well as the experiential effect of such noise interference, in an actual environmental setting.

METHOD

SUBJECTS

Reading scores were obtained from 161 second-, fourth-, and sixth-grade elementary school children attending Public School 98 during the spring of 1974. Also examined were the mean reading scores of fourteen second-, third-, and fourth-grade classes attending the school between the 1971 and 1973 academic years. The exact number of children in each of the

1971-1973 classes was not available from school authorities, nor were the students' individual reading scores. A noise questionnaire was also administered to 212 students of the 1974 school year: the 161 children involved in the 1974 reading score comparisons plus an additional 51 children.

All classes at Public School 98 are intellectually and academically mixed with the exception of the one bilingual class and the one special high-ability class which appear at every grade level. Classes selected for comparison by the Assistant Principal from the east side of the building (parallel to the elevated train tracks) did not differ in terms of intelligence and achievement levels from those classes chosen from the west side of the building (the side farthest from the tracks). We were informed that rooms are occupied by the same class for the entire day and a child's yearly assignment to a classroom on a particular side of the building is entirely random. Public School 98 also reports a 25% annual mobility rate.

Matched classes were therefore set up on each grade level (excluding the bilingual and special high-ability classes for which possible matches did not exist) on the basis that their rooms be located on opposite sides of the building, be of comparable intelligence and achievement levels, on the same grade level, and under the same teaching method ("open classroom" or standard "closed classroom").

SETTING OF THE STUDY

Public School 98 is a five-story building in upper Manhattan which lies approximately 220 feet from an adjacent elevated subway track. According to the New York City Transit Authority, 80 trains pass along these tracks each weekday between the hours of 9:00 a.m. and 3:00 p.m.

NOISE MEASUREMENTS

Noise measurements were taken by the Department of Air Resources (Stempler, 1973) in room 505 on the east side of the

building which runs parallel to the tracks. The measures indicate the average noise level, while a sixth-grade class was in session, to be slightly higher than 59db (A). When a train passed, the noise level rose to 89db (A), a noise level which required the teacher to scream in order to be heard by a student sitting 16 feet away. It was determined that classes on this east side of the building were, on the average, disrupted every 4½ minutes for an interval of 30 seconds by the noise of the passing trains.

TESTING MEASURES

A questionnaire (similar to one used by Fitzroy and Reid, 1963) was designed to elicit information on students' attitudes toward the noise from passing trains and other possible sources of disturbance and interference to their school work. (To get a larger sample, 51 children from two other classes of the 1974 school year were given this questionnaire in addition to the 161 students.)

The Metropolitan Achievement Reading Test (Durost et al., 1971) is administered annually to New York City elementary school children. The test provides three scores in grade equivalent form: word knowledge, reading comprehension, and general reading which is the average of the two former scores. The reliability coefficients of these scores for the three grade level tests (Primary II: grades 2 and 3; Elementary: grade 4; Intermediate: grade 6) lie between .92 and .97.

PROCEDURE

Reading scores, obtained from school records of the 1971, 1972, 1973, and 1974 academic years, of classes on the east side (noisy side) of the building were compared with matched classes on the west side (quiet side) of the school. The only reading score available for comparisons of the 1971-73 classes was the mean class reading score which is the average of the general reading scores of the children within each class. Raw data (each child's word knowledge and reading comprehension scores) were available for the 1974 class comparisons.

TABLE 1
Analysis of Variance of Word Knowledge and
Reading Comprehension Scores of Matched Classes of
the 1974 Academic Year

Source	MS	df	F
Location (A)	44.230	1	7.270**
Sex (B)	.140	1	.023
Interaction (AXB)	12.967	1	2.131
Within Groups	6.083	157	
Test Measures (C)	1.568	1	3.782
A x C	.344	1	.830
B x C	.078	1	.188
A x B x C	.302	1	.729
Within Groups	.414	157	

**p < .01

RESULTS

A 2x2x2 analysis of variance performed on the word knowledge and reading comprehension scores of the children in the matched classes of the 1974 academic year yielded a significant main effect for location ($F = 7.270$, $df = 1,57$, $p < .01$). Students on the noisy side of the school building did more poorly on the achievement tests than those on the quiet side of the building (see Table 1). No significant differences for sex or test measures were obtained.

Due to the unavailability of raw data, statistical analysis of the reading score data of the matched classes of the 1971-1973 school years was not possible. However, a comparison of the mean reading scores of the matched classes (1971-1974) revealed that scores were lower for 9 of 10 classes located on the noisy side of the building (see Table 2). The mean reading scores of classes on the noisy side tended to lag three to four months (based on a 10-month school year) behind their quiet side matches. In one case the noisy side class was five months behind the comparable class on the quiet side and in another case as much as eleven months.

A questionnaire, reproduced in Appendix A was also presented to 212 children of the 1974 school year. Chi-square

TABLE 2
Mean Class Reading Scores* of Matched Classes
for the Academic Years 1971-1974

Year	Classes on East Side (Noisy) of the School Building	Mean Class Reading Score	Classes on West Side (Quiet) of the School Building	Mean Class Reading Score	Teaching Method
1971	2-301	1.8	2-304	2.2	Standard
1971	3-305	1.8	3-404	2.3	Standard
1971	4-405	4.3	4-512	3.6	Standard
1972	3-307	1.9	3-308	2.2	Open
1972	4-405	2.4	4-406	2.8	Standard
1973	3-307	3.0	3-306	3.3	Open
1973	4-403	2.5	4-406	2.8	Standard
1974	2-303	2.2	2-306	2.6	Open
1974	4-405	3.9	4-413	4.2	Open
1974	6-505	4.5	6-506	5.6	Standard

*Scores represent a 10-month school year.

analysis was performed on the responses to each of the questions.

Students on the noisy side, in contrast to those on the quiet side, felt it was not easy for their teacher to hear them (Question 2; $X^2 = 8.43$, $ldf, p < .01$), that there was too much noise in their classroom (Question 3; $X^2 = 22.26$, $ldf, p < .01$), that the noise made it hard for them to do their work (Question 4; $X^2 = 10.50$, $ldf, p < .01$), and that the subway trains bothered them or made it hard for them to think (Question 6; $X^2 = 18.78$, $ldf, p < .01$; see Table 3).

No significant differences existed between the two groups as to whether they liked their classroom (Question 7) or whether they found it easy to hear their teacher in their room (Question 1; see Table 3). The latter result would be expected as teachers on the noisy side of the building usually stop teaching when a train passes.

Question 4 attempted to get at different sources of noise disturbance (see Table 4). Noise from passing subway trains was reported by 77% of the children on the noisy side of the school and by 34% of the children on the quiet side ($X^2 = 38.37$, $ldf, p < .01$). Twenty-three percent of the children on the noisy side of the building also chose "noise from rooms next door" while 11% of the children on the quiet side chose this noise source

TABLE 3
Chi Square Analyses of Students' Responses to
Questions 1, 2, 3, 5, 6, and 7 of the Questionnaire

Questions	% of Children Who Noisy Side	Responded Affirmatively Quiet Side	χ^2
1. Easy to hear teacher in room	82.5	90.8	2.64
2. Easy for teacher to hear you in room	46.2	67.5	8.43**
3. Too much noise in classroom	79.0	48.0	22.26**
5. Does noise make it hard to do work	83.3	63.6	10.50**
6. Subway trains bother or make it hard to think	74.0	38.0	18.78**
7. Do you like this classroom	83.3	79.5	.53

** $p < .01$.

($\chi^2 = 4.73$, ldf , $p < .05$). This difference may be explained in terms of the location of one of the noisy classes. Nineteen of the 28 children who complained of "next door" noise were in a classroom situated next to the school gymnasium. The teacher of this class did not feel that this was a major source of noise disturbance to his class, but did feel that it became annoying on very warm days when it was necessary to leave the classroom door open.

The only other noise source in Question 4 for which the choices of the two groups differed significantly was "noise from the hallway." Thirty-eight percent of the children on the noisy side picked this choice while 55% of the children on the quiet side chose it ($\chi^2 = 6.54$, ldf , $p < .05$). This difference might be due to a contrast effect in which noise from the hallway was more salient to children on the quiet side than it was to children on the noisy side who had the train noise to contend with. This hypothesis might be tested by examining the responses of

TABLE 4
Chi Square Analyses of Students' Responses to
Question 4 of the Questionnaire

% of Total Children Who Chose Source			
Noise Sources	Noisy Side	Quiet Side	χ^2
Rooms next door	23 (28)	11 (10)	4.73*
Traffic in the street	10 (12)	3 (3)	2.68
Passing subway trains	77 (93)	34 (31)	44.61**
School yard	6 (7)	10 (9)	2.58
Hallway	38 (46)	55 (50)	6.54*
Other children in class	50 (60)	47 (43)	.31
Other	Recoded into categories above		

Note: Percentages do not equal 100 because of non-responses by children to some questions.

** $p < .01$

* $p < .05$

children who in earlier years had experienced the other side of the school building.

Question 8 was also designed to get at other possible sources of disturbance and interference between the two groups (see Table 5). No significant differences existed between the two groups and their choices in Question 8.

Seventy-five percent of the children on the noisy side rated their classroom as either "noisy" or "very noisy" in Question 9 while 83% of the children on the quiet side rated their classroom as either "not very noisy" or "not noisy at all" (see Table 6).

DISCUSSION

Finding a significant relationship between train noise and depressed reading scores tends to support the Deutsch (1964) and Cohen et al. (1973) hypothesis which states that low reading achievement may be related to exposure to noise interference through the mediation of impaired auditory dis-

TABLE 5
Chi Square Analyses of Students' Responses to
Question 8 of the Questionnaire

Source of Disturbance	% of Total Children Who Chose Source		p .05
	Noisy Side	Quiet Side	
Not enough light	2 (3)	4 (4)	---
Too cold or too warm	12 (15)	9 (8)	---
Too much noise	26 (31)	26 (24)	---
Too quiet	2 (3)	1 (1)	---
Too crowded	4 (5)	7 (6)	---
Other	Recoded into categories above		

Note: Percentages do not equal 100 because of non-responses by children to some questions.

crimination. Their speculation that difficulty in learning how to read may be related to the tendency of a child reared (or in this case, taught) in a noisy environment to block out indiscriminately all sound, whether relevant speech cues or not, is one plausible explanation of the present finding.

However, the Deutsch and Cohen speculation might better explain the low reading scores of Public School 98's student population in general,¹ whether they attend classes located near the noisy elevated tracks or not. Most of the children attending Public School 98, a Title One School, which means that more than 50% of the children come from families whose income is

TABLE 6
Chi Square Analyses of Students' Ratings of
Noisiness of Their Classroom (Question 9)

	% of Total Children Who Chose Rating		χ^2
	Noisy Side	Quiet Side	
Very noisy	39 (47)	10 (9)	22.28**
Noisy	36 (43)	15 (14)	9.83**
Not very noisy	17 (21)	62 (56)	44.04**
Not noisy at all	3 (3)	11 (10)	13.73**

Note: Percentages do not equal 100 because of non-responses by children to some questions.

**p < .01

below the poverty level, live near the school which is located in one of the poorer and noisier New York City neighborhoods.

Since Stempler (1973) reported that at least 11% of classroom teaching time is lost daily because of passing trains, it is possible that lower test scores on the noisy side of the school building may be the result of lost teaching time. (This alternative hypothesis might also explain the lower reading scores of the children in the Cohen et al. study who were exposed to high levels of expressway noise interference in their homes, e.g. lost homework time, lost speaking time, and so forth.) Since New York City's Title One schools have introduced enriched programs to raise reading levels, the children in Public School 98 can ill afford to lose classroom time.

Children who attended classes on the noisy side of the building all year long took their reading tests in these same rooms. It is possible, though unlikely, as interviews with teachers of these classes confirmed, that the reading scores were lower because of the noise in the classroom at the time the tests were taken. This hypothesis could be tested by having children who attend noisy classrooms during the year take their achievement tests in quieter rooms.

Whatever the explanation for the present findings, the fact remains that the grade equivalent scores of children on the noisy side of the school building were found to lag behind their peers on the quieter side from three months to as much as one year. This debilitating effect of noise on reading scores during the formative school years may prove irreversible even if these children attend quieter classrooms in the future. In addition, there are 54 other schools in the Metropolitan New York area that are also located within 150 yards of elevated train tracks, and it is possible that reading scores of children in these schools may also be adversely affected by noise from passing trains.

It is hoped that the results of the present investigation, together with those of Cohen et al. and those of the Natural Resources Defense Council, Inc., have provided enough evidence to encourage city administrators to implement existing plans for reducing noise in our cities.

NOTE

1. P.S. 98 placed 514 in the 1974 ranking of the reading test achievement scores of the 637 public elementary schools in the Bronx and Manhattan. Only 20.8% of the school's students were reading at or above grade level.

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APPENDIX A

1. Is it easy to hear your teacher in this room?
 - (a) Yes
 - (b) No

 2. Is it easy for your teacher to hear you in this room?
 - (a) Yes
 - (b) No

 3. Is there too much noise in this classroom?
 - (a) Yes
 - (b) No

 4. If you think there is too much noise in this room, what kind of noise is it?
 - (a) Noise from rooms next door
 - (b) Noise from traffic in the street
 - (c) Noise from the passing subway trains
 - (d) Noise from the school yard
 - (e) Noise from the hallway
 - (f) Noise from other children in the room
 - (g) If there is any other kind of noise, write it here _____

 5. If you think there is too much noise, does the noise make it hard for you to do your work?
 - (a) Yes
 - (b) No

 6. Do the subway trains bother you or make it hard for you to think?
 - (a) Yes
 - (b) No

 7. Do you like this classroom?
 - (a) Yes
 - (b) No

 8. If you don't like this classroom, what don't you like about it?
 - (a) Not enough light
 - (b) Too cold or too warm
 - (c) Too much noise
 - (d) Too quiet
 - (e) Too crowded
 - (f) If you have any other reason write it here _____

 9. How noisy is this classroom?
 - (a) Very noisy
 - (b) Noisy
 - (c) Not very noisy
 - (d) Not noisy at all
-