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Reducing Noise in a College Library

Increasing reports of noise in the library prompted interest in reducing noise levels. Inspection of existing facilities showed that chairs, tables, and carrels were placed adjacent to each other and frequently arranged in clusters. Previous research has indicated that such an arrangement may serve to increase talking and thus noise levels. It was hypothesized that disassembling the clusters and separating the three types of furniture would reduce noise. A multiple baseline design was used with two measures of noise: an electromechanical (objective) system and subjective ratings of perceived noise. The results showed no difference due to the intervention on the objective measure, but significant reductions in subjective ratings of noise, $F(1,773) = 8.80$, $p < .005$. *The utility and validity of the two measures are compared and issues in noise control in a library were discussed.*

NOISE LEVELS are reported to be doubling every decade[1] and threaten to seriously degrade the quality of life.[2] Widespread concern about noise is seen in the passage by Congress of the Noise Control Act of 1972 and by recent national conferences concerning noise pollution.[3]

While it is known that high levels of noise (i.e., 90 + decibels [dbs]) can produce hearing loss,[4] even noise levels of less than 50 decibels can interfere with communication, the performance of complex tasks, relaxation, and sleep, and produce annoyance.[5,6,7,8]

Aircraft, railroad, traffic, and industry are major sources of noise and considerable effort has been directed toward reducing noise output from these sources.[9] However, "people noise" in classrooms, residence halls, libraries, offices, and homes is often a significant source of annoyance as well.[10] Effective methods are needed to reduce people noise in these areas. The project described below was concerned with reducing noise levels in a college library.

The study was initiated because the number of complaints about noise was reported to have increased in the campus library. Since it is known that only a small proportion of people who are annoyed usually complain,[11] an initial survey was conducted to assess the degree to which library users perceived noise to be a problem. The results showed that 44 percent of the respondents agreed that noise was a problem and should be reduced.

Several previous attempts to reduce people noise have been reported in the literature, including three in which contingent consequences were used. In one study, lower noise levels were achieved in an elementary school classroom when access to desirable group activities was made contingent on decreased noise levels.[12] A similar study in a junior high classroom found that reduced noise was achieved by playing music when students were quiet and turning off music when noise levels rose above criterion.[13] A more recent

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study used cash prizes and academic credit as rewards for reduced noise in college dormitories.[14]

However, while the above cited research indicated that the use of contingent consequences produced decreases in noise in classrooms and dormitories, it was not clear how such an approach could be used in a library. The primary difference is that there is no comparable, stable population of users to whom the consequences can be differentially applied; e.g., there is a very high turnover in users, and patterns of use both within and across individuals appear to vary considerably from time to time with changing work demands. In addition, we were unable to identify a readily available reinforcer that could be easily administered in this setting. Consequently, existing stimulus conditions in the library that might contribute to noise were considered. A previous study in a college dormitory used a similar approach and found that subdued corridor illumination produced decreases in noise levels.[15] Here it was hypothesized that variables associated with the design of library facilities may contribute to the noise problem.

The library on the campus of the State University of New York College at Cortland was designed to be as attractive as possible to potential users. A new building, all study and work areas are carpeted, rooms are color coordinated in soft colors, and the furniture is new and comfortable. Three distinct types of furniture are available: (1) rectangular and round tables, (2) study carrels, and (3) upholstered chairs and sofas. These types of furniture were selected on the premise that different types of furniture meet different study needs at different times. Furthermore, to make access to library materials convenient to all users, the three types of furniture were distributed throughout all major reading areas in the library; i.e., clusters of upholstered sofas and chairs were located adjacent to tables and carrels in all reading areas.

Unfortunately, while meeting the original goals for attractiveness and convenience, it became apparent that the existing furniture arrangement could be a major factor in promoting noise. It has been shown that the proximity and orientation of furniture are important variables in social interaction.[16,17,18,19,20] In general, chairs that are placed within five to eight feet of each other, and that are oriented such that users face each other, are conducive to conversation. Further, Proshansky, Ittelson, and Rivlin demonstrated that assembling furniture, which was previously distributed, into formal, intimate clusters, increased conversation in a hospital ward.[21] Here, the primary purpose was to test the hypothesis that *disassembling* existing clusters of upholstered chairs and sofas would produce decreases in noise levels.

A second purpose of the hospital ward study was to compare an electromechanical system for noise monitoring with subjective judgments of noise and annoyance. Previous studies have used electromechanical devices, including microphones, voice-operated relays, and event counters, to measure noise levels.[22,23,24,25] However, in addition to the hardware, Meyers et al. also obtained subjective ratings of noise under the various conditions.[26] The use of both measures, and the distinction between them, is important because while electromechanical systems provide an objective measure of the occurrence of sound, subjective measures reflect perceptions of noise levels. Since annoyance is a reaction to perceived sound, subjective ratings may be more valid indexes of the actual problem. The importance of subjective data has received increasing attention in the behavioral literature in recent years as researchers have attempted to solve problems that are essentially subjective.[27] Here, the problem was library users' reports that noise in the library was annoying and interfered with their work.

Method

Subjects and Setting

The second- and third-floor stack areas were selected for this study because they were reported to be noisy, were virtually identical in layout, and contained a mixture of the three types of furniture mentioned above. The subjects consisted of all persons using these areas during the spring semester, 1978.

The floors were similar in that they were rectangular and contained both stacks and reading areas in virtually identical arrangements. In addition, they were separated from other areas of the library by glass partitions. The central reading area on these two floors was entered through double glass doors, in the center of the glass partitions.

The central reading area on each floor consisted of four clusters of upholstered furniture arranged around the center. These clusters were flanked by tables and carrels on both sides. The central reading area was also partially divided by partitions. Stack areas were located beyond the tables on both sides of the central reading area. Additional study carrels were located along the sides of the stack area, while the ends of each floor, beyond the stack areas, contained additional tables, carrels, and upholstered furniture. Detailed diagrams showing the dimensions of each floor and the furniture arrangements are presented in figure 1.

Outside the double glass doors on each floor was a central staircase leading to floors above and below, an elevator, a water fountain, and rest rooms. An important difference was that the area outside the second-floor doors was a major traffic route leading to reference, periodical, and other study areas as well. A copy machine was located there also. (The central reading area on the second floor appeared to be an excellent social meeting place, as friends who were passing through the library could be easily seen through the glass partitions and doors. This "social" aspect was much less obvious on the third floor.)

Apparatus

Two sound-monitoring units were assembled. Each consisted of two Dukane Dynamic Cardio 10 Model 7A160 microphones suspended approximately nine feet above the floor in the central reading areas on each floor. They were located between and approximately one foot below two sets of flourescent lights. The microphones were connected by coaxial shielded cables to a Dukane Model 1B670 amplifier that contained two separate microphone inputs. The amplifier was connected to a Grason-Stadler Model E3700A-1 voice-operated relay (VOR), which was set to respond whenever noise level at the most sensitive of the two microphones was equal to or greater than 50 dbs. (Because the amplifier had only one gain control, only one microphone could be set to respond precisely at 50 dbs. In both units the second microphone responded between 62 and 64 dbs). The VOR was set to respond at its fastest attack and release times, which permitted measurement of sharp sounds as well as prolonged noise. In one unit, the VOR was connected to a Behavioral Research Systems Model RT-904 1412-01 running time meter. In the other set, the VOR was connected to a Behavioral Research Systems 1 Lehigh Valley Electronics Model PF-901 pulseformer, which activated a Foringer Model 390 event counter. The VOR was separately connected through a Foringer Model 1184 relay to a Hunter Model 120A Klockounter. Both units were powered by a 24-volt Lehigh Valley Electronics Model 1578 power supply.

The microphones and cables were semipermanently installed on each floor. During recording intervals, the units were placed in a storage area located adjacent to the stack areas. The equipment was enclosed in a box covered with sound-deadening ceiling tile. The microphone cables were plugged in during recording intervals and disconnected during nonrecording intervals.

The sensitivity of each system was calibrated weekly with a Grayson-Stadler Model 901B noise generator, which was set for speech frequencies. The output from the noise generator was channeled through an Altec Model 893B Corona speaker, which was placed directly below the microphone at a height of fifty feet above the floor. A general Radio Model 1551-C sound-level meter was used to set the loudness of the noise generated through the speaker at the appropriate level.

Materials

A questionnaire was developed to obtain library users' subjective ratings of noise on the second- and third-floor stack areas during each phase of the study. Two forms were developed that were identical except that the second form included additional items to assess users' reactions to the intervention procedures used. All questions concerned the three-week period immediately preceding the administration of the questionnaire. In both forms, users were asked to rate the general noise level on the floor during the afternoon or evening and the extent to which they were annoyed by the noise. Values on the scale ranged from 1 (i.e., extremely quiet) to 10 (i.e., extremely noisy) in a Likert-type

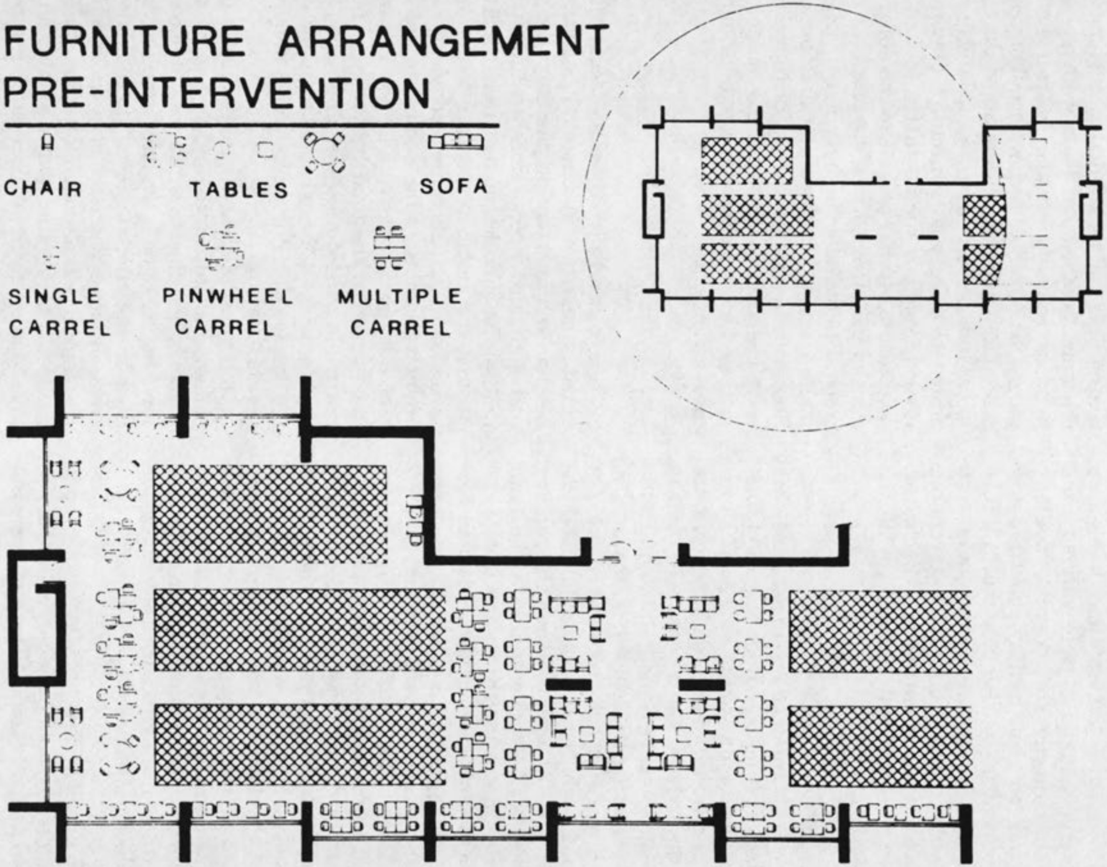

Fig. 1
Furniture Arrangement in the Central Reading Area Prior to the Intervention (Pretest)

format.[28] Users were also asked to estimate the number of hours each week they had studied on that floor and their usual location of study (e.g., center area, ends, or sides). On the second form they were also asked: (1) where they had worked before the intervention was initiated; (2) to rate noise levels since the intervention on a scale varying from "very much quieter" to "very much noisier"; (3) to indicate their feelings about the new arrangement (e.g., "like very much; dislike very much"); (4) to rate the amount of work they could complete since the intervention; and (5) to rate the extent to which the changes made influenced their decision to use the floor or the library.

Data Collection Procedures

Objective Data. Data were obtained after each half hour on both floors from 1–4 p.m. each afternoon on Mondays through Thursdays, and from 2–5 p.m. on Sundays. Data were similarly obtained from 7–10 p.m. in the evenings, from Sunday through Thursday. Measurements included: (1) the number of occurrences of noise over the criterion as recorded by the event counter; (2) the duration of noise (in seconds) from the running time meter of Klockounter; and (3) the number of persons using the center area of the floor at the time the readings were made. The latter measures were obtained to assess changes in usage patterns over the semester, since it seemed likely that noise levels are positively correlated with the amount of use.

Subjective Data. The first questionnaire was administered at the end of the baseline phase on each floor. Persons leaving the floor during the hours of data collection were asked to fill out the questionnaire. The second questionnaire was administered on both floors in a similar manner, after the intervention had been in effect for three weeks on each floor, respectively.

Experimental Design and Procedure

A multiple baseline design was used across the two floors.[29] Baseline measures were obtained on each floor prior to the intervention procedure. After four weeks in baseline, the intervention was implemented on the second floor and continued for seven weeks until the end of the semester. The intervention on the third floor was delayed until after the seventh week, and then continued for four weeks, until the end of the semester.

Intervention consisted of a furniture rearrangement condition in which the tables and upholstered chairs were removed from the central area and distributed throughout the other areas of the floor. These were replaced by carrels from those areas in an arrangement judged least likely to encourage talking. This procedure effectively disassembled the clusters of upholstered furniture and largely separated the three types of furniture. (The rearranged design is shown in figure 2. One qualification is that because of the design of some of the carrels, it was not possible to replace all of the tables in the center area. Two tables remained in the center area on each floor with one other remaining on the periphery.) The seating capacity of the center area increased by one chair on each floor due to the rearrangement.

RESULTS

Objective Data

Figures 3 and 4 represent the frequency of bursts of noise over 50 dbs obtained over the baseline and intervention phases on the second and third floors. Consistent with the multiple baseline design, data from the afternoons and evenings are compared separately across floors. Also, because there was considerable variability in the number of users of each floor across observation periods, a ratio is presented of the total frequency of noise bursts obtained during the observation period to the total "head count" obtained during the period, yielding a frequency of bursts/person index.

Inspection of these figures indicates that changing the furniture produced no reliable reductions in objective measures of noise on these floors. In fact, the data from the third floor in the afternoon even suggests an increase in noise after the intervention phase was introduced, although the effect was not replicated on the other floor or at other times. (The dashed lines in the figures represent days when the machines produced unreliable data, for reasons that are discussed later.) In the interest of space, the data on durations of noise bursts are not presented because they parallel the results for frequency exactly.

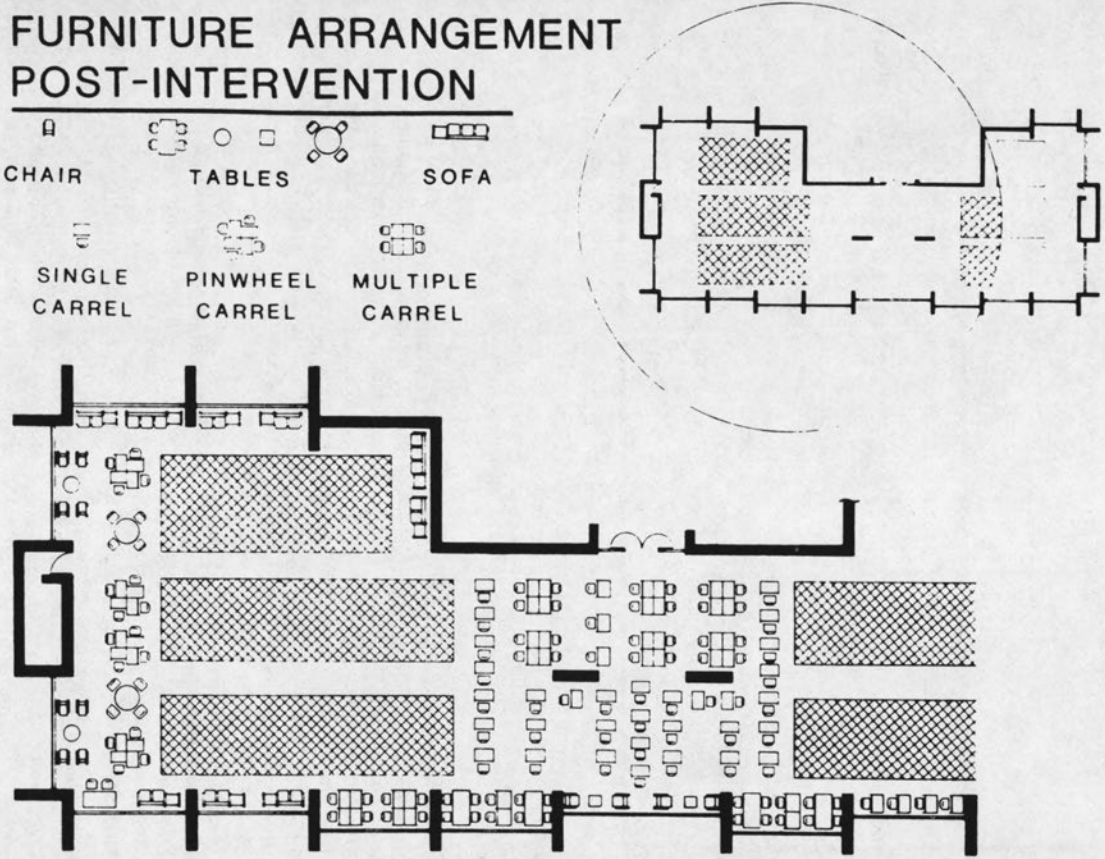

Fig. 2
Furniture Arrangement in the Central Reading Area
after the Intervention (Posttest)

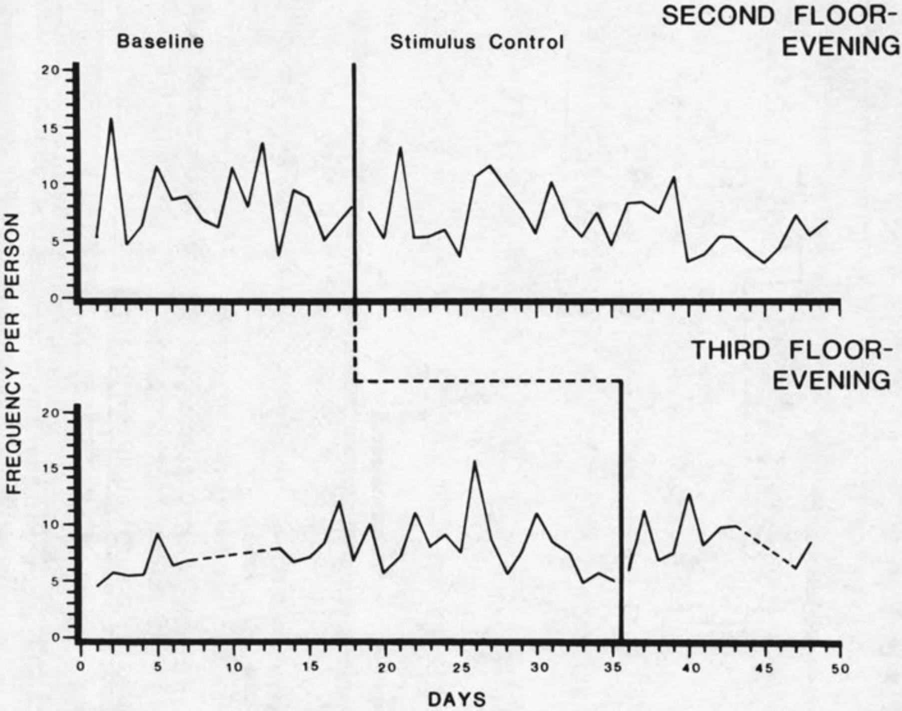

Fig. 3
The Number of Bursts of Noise/Person in the Afternoon across Floors Is Shown Over Baseline and Intervention Phases

These data did not support the hypothesis that disassembling the clusters of furniture would reduce noise levels.

Subjective Data

The subjective data were more encouraging. Figures 5 and 6 present the mean ratings of noise and of annoyance from preintervention to postintervention on both floors for both afternoons and evenings.

Inspection of these figures indicates that in six of eight comparisons there was a clear decrease in ratings of noise and annoyance from pre to post. In both figures the exception is on the third floor in the afternoon, where an increase in ratings of noise and annoyance were obtained. Furthermore, it should be noted that ratings of noise and annoyance were consistently higher during the evenings than in the afternoons, and were higher on the second floor than on the third floor.

These impressions from inspection were confirmed by statistical analyses. A 2 (pre- and post-intervention) x 2 (second and third floor) x 2 (afternoon and evening) analysis of variance was conducted for both noise and annoyance ratings.* For noise, the mean rating declined from 4.38 (SD = 2.00, n = 483) at the pretest to 3.90 (SD = 1.95, n = 347)

*Subjects who completed questionnaires were not asked to give identifying names or identification numbers in order to preserve their anonymity and obtain unbiased ratings. As a result, the assumption of independence of scores in ANOVA was violated to an unknown (but probably limited) degree. (Because the turnover of students on each floor was extremely high over a three-hour period, and because students' study schedules appear to be highly variable from day to day, it is unlikely that there was much overlap.) The use of ANOVA is justified since, assuming that dependent scores were positively correlated, the effect of this violation is to make the test more conservative. Thus, significant differences were obtained in spite of violations of the assumption of independence.

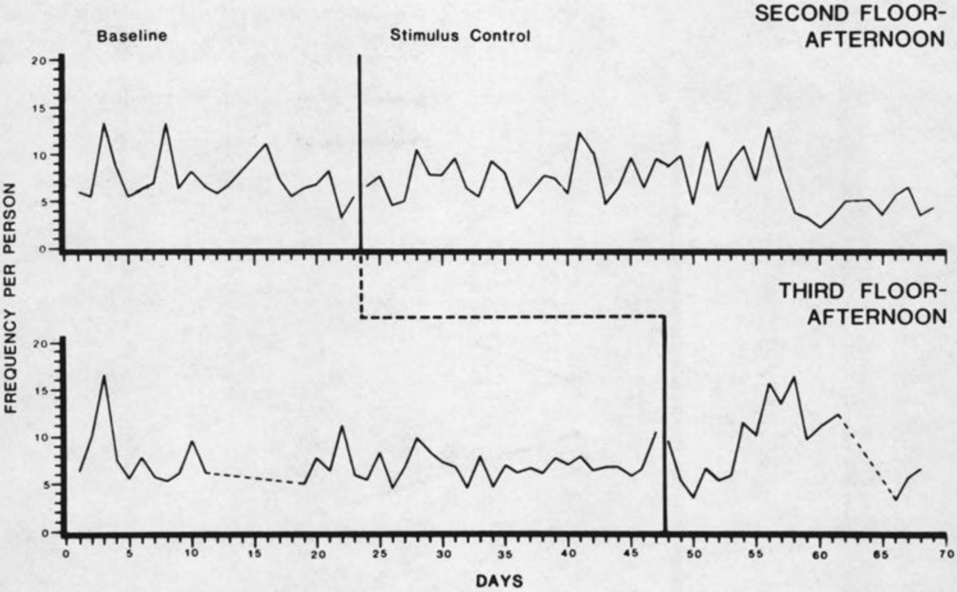

Fig. 4
The Number of Bursts of Noise/Person in the Evening across Floors Is Shown Over Baseline and Intervention Phases

after the intervention, F (1,773) = 8.80, p < .005. Annoyance ratings showed a similar decline, from 4.13 (SD = 2.48, n = 484) to 3.61 (SD = 2.38, n = 347), F (1,775) = 8/64, p < .005.

Ratings of noise were higher on the second floor (M = 4.47, SD = 1.96, n = 549) than on the third floor (M = 3.62, SD = 1.95, n = 281), F (1,773) = 12.39, p < .001. Similarly, annoyance ratings were higher on the second floor (M = 4.19, SD = 2.03, n = 550) than on the third floor (M = 3.38, SD = 2.29, n = 281), F (1,775) = 4.99, p < .025.

The evening was rated as noisier than was the afternoon with a mean rating of 4.74 (SD = 2.04, n = 465) versus 3.47 (SD = 1.70, n = 365), F (1,773) = 82.50, p < .001. Parallel data were obtained for annoyance ratings, with the annoyance rating higher in the evening (M = 4.51, SD = 2.52, n = 466) than the afternoon (M = 3.16, SD = 2.4, n = 365), F (1,775) = 62.87, p < .001.

For neither variable, noise or annoyance ratings, were significant differences found associated with the location of study on the floor or the amount of time spent in study. Nor, with one exception, were there any significant interactions. The exception was a pre-post x floor x time-day interaction for noise which was significant, F (1,773) = 4.69, p < .05. This interaction reflected the fact that ratings of noise increased on the third floor in the afternoon after the intervention, while decreasing in all other comparisons.

Responses to remaining questions on the questionnaire were analyzed using chi square, in which the obtained frequencies for each category were contrasted against frequencies expected if the respondents had answered randomly. In the interest of space, the five categories used for the first three questions were collapsed into three categories; positive, no difference, and negative ratings. For the remaining two questions, only two categories were used: influential or not influential.

To the question that asked for a judgment about the difference in noise from pre- to postintervention, 64 percent of the subjects said the floors were very much or somewhat quieter, while 24 percent said there was no difference and 4 percent said it was noisier (8 percent did not respond). The difference was

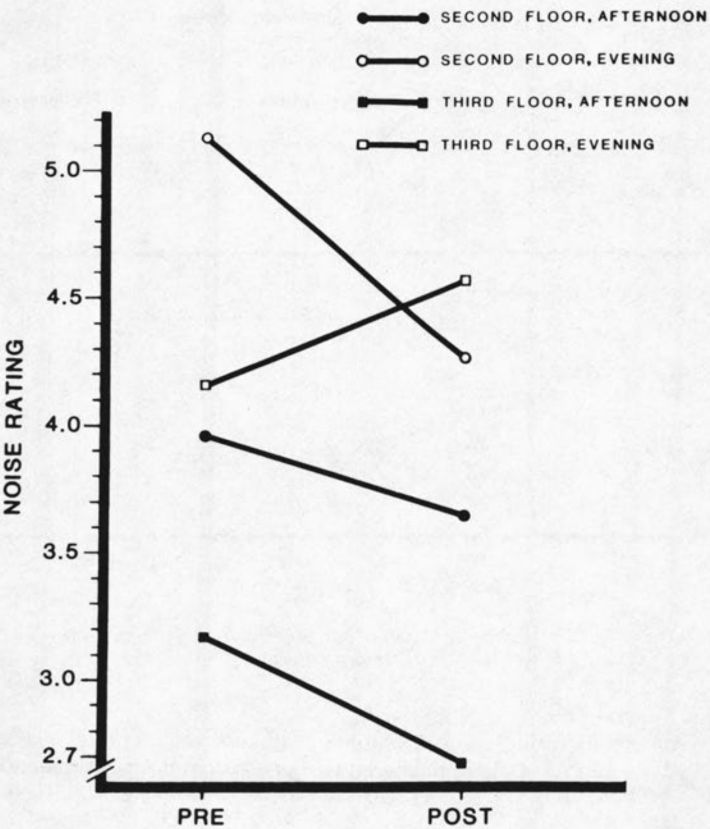

Fig. 5
Mean Ratings of Noise Levels from Pretest to Posttest during the Afternoons and Evenings on Both Second and Third Floors

significant, $X^2\,(2) = 202.79, p < .001$.

Asked how they felt about the new arrangement, 47 percent said they liked the change, while 25 percent were indifferent and 28 percent disliked it, $X^2\,(2) = 27.47$, $p < .001$.

Forty-four percent said they could accomplish more work, while 52 percent said there was no difference and 4 percent said they could do less, $X^2\,(2) = 130.92$, $p < .001$.

Sixty-five percent of the respondents indicated that the new arrangement was at least somewhat influential in their decision to use the floor. The difference from chance responding was significant, $X^2\,(1) = 32.38$, $p < .001$. About half indicated that the new arrangement was influential in their decision to work in the library, but the difference was not significantly different from frequencies expected by chance.

Discussion

The purpose of this study was to assess whether noise in the college library could be reduced by disassembling clusters of upholstered furniture and segregating types of furniture. A second purpose was to compare two methods to assess noise: subjective ratings versus an objective, electromechanical system.

The results provide conflicting evidence as to whether or not noise was reduced due to the intervention procedure. The objective assessment provided no reliable evidence of change, whereas the subjective assessment strongly indicated that library users per-

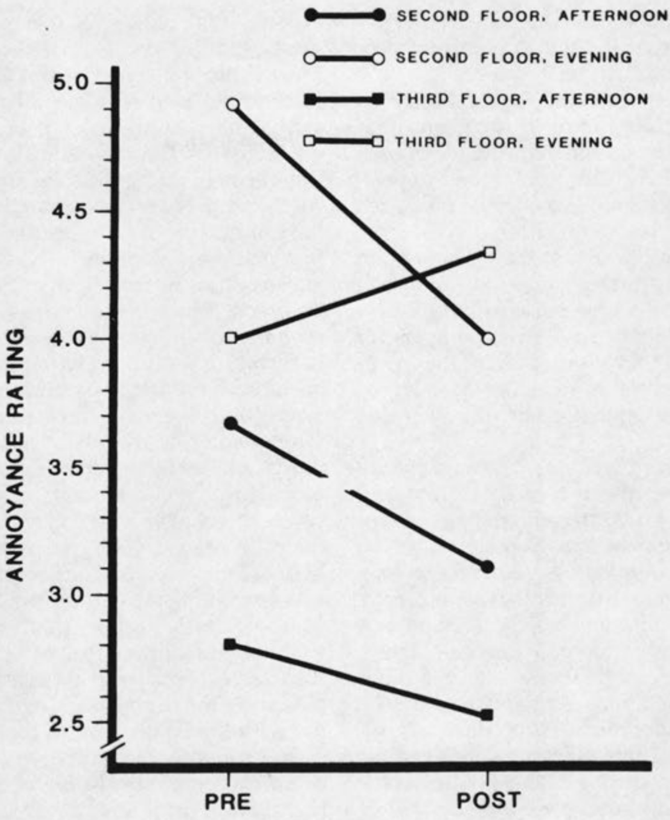

Fig. 6
Mean Ratings of Annoyance from Pretest
to Posttest during the Afternoons and Evenings
on Both Second and Third Floors

ceived a reduction in noise associated with the treatment. At issue is which of these two approaches best measures noise in the library and is the better indicator of an experimental effect. For the reasons given below, it is argued that the rating scale is the better measure of the two.

A fundamental difference in the two measures is that the electromechanical system responded indiscriminately to all sounds above the 50 dbs criterion regardless of source, and included noise bursts from dropped books, jacket zippers, chairs bumped into tables, and other random sounds, as well as people noise, such as coughing, sneezing, and talking. In contrast, the rating scale probably reflected only noise that was perceived as annoying, particularly meaningful noise such as loud talking or whispering. Other noise sources were probably "tuned out." (This would account for the striking parallels in users' ratings of noise and annoyance. In effect, these items were probably measuring the same thing.) Since the original complaints of noise were based on subjective perception, and not on measured sound levels, the rating scale we used was probably more closely attuned to the original "presenting problem" than was the objective system.

This view is supported by the finding we originally obtained in the survey in which talking (i.e., meaningful sound) was reported to be the most annoying source of noise. In addition, while the electromechanical system was sensitive to loud talking, it was not sensitive to whispering. However, whispering can be very annoying, and was probably reflected in the ratings.

Further support for the ratings derives from the fact that the results obtained were face-valid to library staff personnel. It was generally agreed that the second floor was much noisier than the third floor, and that the evening was noisier than the afternoon. The data entirely supported these impressions, bolstering confidence in the measure's validity.

Thus it seems clear that the rating system was superior to the electromechanical system as a measure of people noise in the library. Further, the data provide strong support for the hypothesis that disassembling the furniture was influential in reducing noise levels. However, several qualifiers to this conclusion are needed.

First, at present we do not know what are the normative patterns of noise ratings in a library across an entire semester in the absence of an intervention. Consequently, the decreases in noise ratings found here may only reflect general trends that would have occurred even without the experimental manipulation. There was no control floor that did not receive the treatment. On the other hand, our conclusions are supported by the fact that the experimental procedure was implemented (and the effect was obtained) at different times during the semester. As a result, the changes obtained probably reflect the treatment procedure rather than incidental variables in the environment that were inadvertently correlated with the experimental phases. In fact, it is argued that time-related effects over the semester would produce effects opposite to those obtained here. Previous research has shown that noise-sensitive college students become increasingly annoyed by noise over long periods of time.[30] Thus one would expect ratings of noise and annoyance to increase even if noise levels were constant. Here, contrary to that prediction, ratings decreased even though the objective data showed that absolute sound levels were relatively constant. Therefore, it is argued that the levels of annoying noise did diminish due to the treatment.

A second more serious problem arises from the fact that the "experimental groups" to which the treatment was applied were unconfined and mobile, which raises the possibility of migrations into and out of the experimental areas during or because of the experimental phases. It is conceivable that noise-sensitive people (i.e., quiet people) moved into the experimental areas once the furniture was rearranged. This would increase the proportion of people who were quiet and produce a decrease in annoying sound and in ratings of noise and annoyance. Also, people who were noisemakers may have moved off the floor to other areas, again producing a reduction in noise and annoyance ratings. In fact, both of these probably occurred. The questionnaire indicated that for a significant number of people the change in furniture was an important factor in their decision to use the floor, thus increasing the proportion of people who wanted a quiet environment. On the other hand, "reaction sheets" placed by the doors on both floors indicated that some students were very upset when the change was made on the second floor. They subsequently moved to the third floor. (They were furious when the change was later implemented on the third floor as well, evidently feeling that their personal study areas had been usurped by the library staff. The occasional absence of objective data from the third floor was due to tampering with the calibration of the VOR on one occasion and the fact that the plug was pulled on another, probably by one of these disgruntled users. Fortunately, the majority of the users seemed to approve the changes, while some were indifferent, and only a small fraction were displeased. It is possible that the perceived social aspect of these floors was also decreased.) As a result, it is not possible to know what the net effect of the procedures were on the library as a whole. It is likely that talking was actually reduced. However, it is also possible that "talkers" simply moved to a new location and that some of the noise was simply displaced. Additional research is needed to answer this question.

In summary, the present research provides evidence that the arrangement of furniture in a library is an important variable to consider in noise control. These data indicate that disassembling furniture so as to minimize face-to-face contact is an important consideration in reducing noise and annoyance. Unfortunately, it also appears likely that aesthetic values and the relative convenience of study facilities may have to take a secondary place in library design if noise control is to be effective. Fortunately, most students seemed pleased (or at least not displeased) with an arrangement that fostered reduced noise rather than aesthetics.

The present findings also indicate that, contrary to previously published procedures, an electromechanical noise monitoring system of the type used here was not sensitive to the kinds of sound that are annoying. It appears that subjective rating scales may be more useful in conducting research in this area.

Finally, because of the problems mentioned earlier, further research is needed to evaluate the sound levels in a library in a more comprehensive way, and thus to demonstrate that reductions in noise in one location represent actual decreases in sound in the library, and not simply a displacement of noise from one area to another.

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