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ABSTRACT

The effects of density and other situational factors on perceptions of and responses to crowding in classroom learning environments were examined in three separate and concurrent investigations. The first experiment examined the effects of various demographic variables, learning environments and room design variables on crowding. In the second experiment, the effect of two levels of density on classroom achievement was examined in the laboratory. The third experiment examined achievement as a function of class size over a 24-year period in two community school districts. It was concluded from the three experiments that: (1) density is primarily a moderator of arousal; (2) high density can therefore have either positive or negative effects on performance, depending on whether the task contains learned or unlearned components, or both; (3) the same interpretation applies to psychological reactions (affect) to the situation; (4) if perceived violations of personal space accompany high density, the outcome is uniformly negative; and (5) the effects of high density (positive or negative) can be eliminated by diverting a person's attention away from the other people in the room, or by increasing the degree of cooperation between people. (Author/BP)

FACTORS AFFECTING PERCEPTION OF AND RESPONSES TO CROWDED CLASSROOM ENVIRONMENTS

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CROWDED CLASSROOM ENVIRONMENTS

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The primary purpose of the research program presented here was to examine and detail the factors which affect the perception of and responses to crowding in educational settings. The project was interdisciplinary and included architecture, education and urban studies as well as psychology. Thus, we attempted to focus a broad range of technical and conceptual knowledge and skills on a rather narrow topic --the effects of classroom density on perceptions of crowding and task performance.

Class size, or density, has long been considered to have a major impact on student achievement (Blake, 1954). Larger or more densely populated classrooms are assumed to be detrimental to academic performance for a variety of reasons. These include loss of opportunity for individualized instruction, increased stress on the teacher leading to a decrease in effective teaching and increased behavioral problems in students, and so on. Recently, increased concern for the quality of man's physical and social environment and especially concern for the effects of high population density or crowding suggests an additional reason for limiting class size.

Early animal research by Calhoun (1962) seemed to indicate the effects of high density were uniformly negative and could be devastating. However, parallel research on human populations by Schmitt (1963) and Winsborough (1965) substantially moderated those conclusions. It is now generally argued by Stokols (1972) and others that it is the feeling or perception of being crowded that produces the effects known as the crowding stress syndrome. That is, high density is a necessary, but not sufficient condition for perception of crowding. Situations producing the perception of being crowded in turn act as stressor situations, producing the <u>crowding stress syndrome</u>--a term coined by Stokols (1972) to describe the general breakdown and social disorganization first observed in dramatic detail by Calhoun (1962).

Using the theoretical framework proposed by Stokols, laboratory efforts aimed at delineating the effects of high density on human behavior can be grouped into two research areas; those oriented to establishing the variables which moderate the perception of crowding in high density environments (e.g., Cohen, Sladen & Bennett, 1975; Desor, 1972) and those oriented to determining the effects of crowding on human task performance (e.g., Freedman, Klevansky & Ehrlich, 1971; Griffit & Veitch, 1971; Paulus, <u>et al</u>., 1976). The first group of studies has demonstrated that the perception or feeling of crowding in a room under conditions of high density can be substantially reduced by increasing the number of room partitions, increasing the disparity of the room's linear dimensions, and decreasing the number of entrances (Desor, 1972); by maintaining a comfortable room temperature (Griffit & Veitch, 1971); and by increasing the degree of acquaintance and amount of mutual cooperation among the persons in the room (Cohen, <u>et al</u>., 1975). On the other hand, the findings of the second group of studies are much more equivocal. With the exception of the work of Paulus and his associates (e.g., Paulus, <u>et al</u>., 1976), immediate behavioral effects due to crowding have not been demonstrated

(Freedman, et al., 1971) although negative behavioral aftereffects and evidence for increased psychological stress such as anxiety, aggression, and/or asocial behavior have been noted (e.g., Griffit & Veitch, 1971; Sherrod, 1974; and for a comprehensive review, see Lawrence, 1974).

In summary, while our knowledge of the variables which can alter the perception of crowding is increasing, the effects of crowding on human behavior remains unclear. This is especially perplexing since the theory of social facilitation proposed by Zajonc (1965), and backed up by a considerable body of research, predicts clear effects on task performance as a function of density level. Only the work by Paulus and his associates (e.g., Paulus, et al., 1976) is consistent with the theory. These researchers have found a clear positive relation between level of density and number of errors on a learning task using a finger maze. This finding was especially relevant to the present research since learning constitutes the raison d'etre of educational settings.

Because prior research was not consistent enough to generate a single design to study the effects of classroom density, it was decided that a three-pronged effort would be the most productive in clarifying the density-performance relationship in the classroom. Accordingly, three separate and concurrent investigations were carried out. The first dealt with variables considered potentially relevant in moderating perceptions of crowding in classroom environments. The second study specifically examined the effects of density on a learning task in three typical educational settings. Lastly, the effects of class size on academic achievement was investigated in a longitudinal field study of three local school districts.

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EFFECTS OF GROUP AND SITUATIONAL VARIABLES ON PERCEPTIONS OF CROWDING

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The purpose of this study was to extend the work of Desor (1972) and Cohen, et al., (1975) concerning variables which moderate the perception of crowding; especially those factors prevalent in educational settings. Subjects placed model figures in model classrooms until each of the following levels of crowding was matched: (1) the density level was such that maximum learning could occur (that is, an _ideal_ learning environment); (2) the density level was such that the addition of one more figure would produce crowding (that is, a _crowded_ learning environment); and (3) the density level was such that the addition of one more figure would make learning impossible (that is, an _intolerable_ learning environment). This manipulation differs sharply from that used by Desor (1972) and Cohen, _et al_., (1975), who used only the second level of density instructions described above. Our purpose in this study was (1) to obtain a more explicit understanding of what the concept of "crowding" meant to our participants and (2) to establish a perceptual range rather than a single upper limit for this variable.

Six additional factors including sex and vocation of subject, noise level, type of educational activity, ceiling height and esthetic quality of the model classroom were manipulated in a completely crossed design with repeated measures on the last three factors and the level of crowding manipulation mentioned above.

Sex and vocation of subject were chosen because subjects' perceptions of crowding may well depend on their perspective. The four levels of vocation were high school students, teachers, school administrators and educator-theorists. Educator-theorists consisted of graduate students and professors in education. Noise level (high vs. low), ceiling height (8' vs. 15'), and esthetic quality (institutional beige with no wall decoration vs. a three-color, coordinated scheme with wall posters, maps, and potted plants) dealt with aspects of room design; a variable class shown by Desor (1972) to be extremely important in perceptions of crowding. The factors of ceiling height and esthetic quality were manipulated by constructing four model rooms. Each room represented an 18 x 24 ft. classroom constructed to a scale of 1½" per foot. The model figures were constructed to the same scale. Finally, educational activity was chosen because of its relevance and also because previous research by Cohen, et al. (1975) indicated a strong relation between activity type and perception of crowding. The four levels of educational activity were resource center or library, discussion group, lecture, and study hall.

The seven-factor design described above contained a total of 768 cells. The repeated measures portion of the design required that each subject complete 48 cells or conditions (4 levels of activity x 3 levels of crowding x 2 levels of ceiling height x 2 levels of esthetics). Standard precautions to reduce fatigue and order effects were employed, including running each subject over a two day period at the same time periods each day and using a revolving Latin square to develop 48 different orders of the 48 conditions. The participants consisted of 20 high school students, 20 teachers, 20 educator-theorists and 11 school administrators. Half of each vocational group were males and half were females. Finally, after placing the model figures in the model classrooms for a particular condition, each participant completed a 20-item questionnaire. This questionnaire tapped variables which we thought might influence model figure placement and also provided some necessary manipulation checks. Parenthetically we would like to acknowledge the help of the 71 anonymous participants for without their remarkable and persistent cooperation, this study would never have been possible.

Results

The dependent variable in this study was the number of model figures actually placed in each model room under each condition of the design. The analysis of variance on this variable indicated that all six person and situation factors influenced the participants' perception of crowding. The seventh factor, level of crowding, was also reliable ($F(2,110) = 252.96$, $p < .00001$). This was, of course, an expected result since it was directly manipulated by instruction. Its importance lies primarily in establishing the success of the manipulation and also in determining the perceptual ranges discussed above. Its implications are discussed in further detail below. The main effect for participant vocation was reliable ($F(3,55) = 4.55$, $p < .01$), but was embedded in a reliable vocation x level of crowding interaction ($F(6,110) = 5.80$, $p < .001$). This interaction is shown graphically in Figure 1. It is clear from Figure 1 that while the vocations did not differ in their perceptions of what constitutes an ideal learning environment, they differed substantially in their perceptions of crowded and intolerable environments. Specifically, students placed the fewest

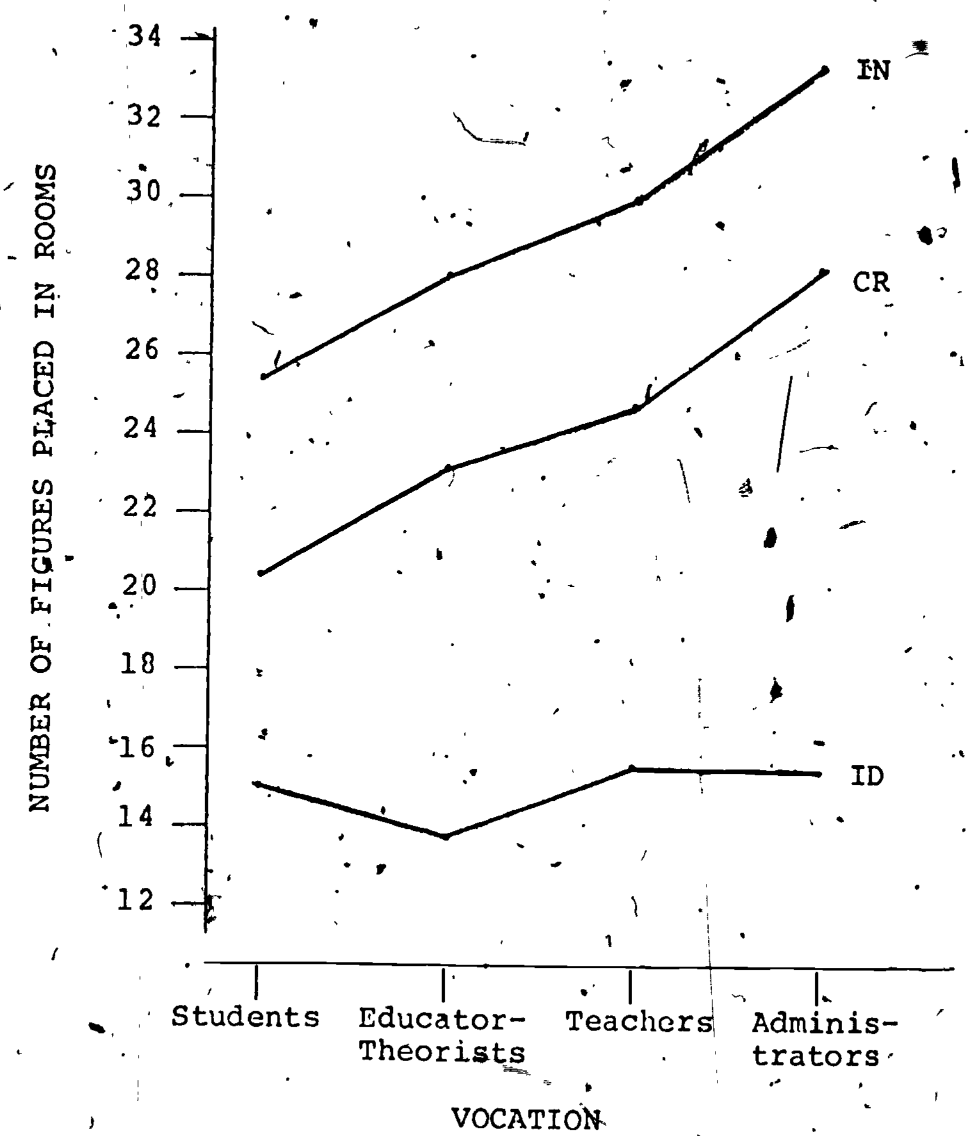

Figure 1. Graphic representation of the vocation by crowding interaction on the number of figures placed in the room (ID = ideal, CR = crowded, IN = intolerable).

figures in crowded and intolerable conditions while school administrators placed the most. Teachers and educator-theorists were intermediate in their placement of model figures (see Figure 1). The interaction strongly implies that as vocational perspective shifts from educational users to providers, economic factors play an increasing role in the judgment of crowded conditions. All can agree, however, on what constitutes an ideal environment. It is important to note that this interaction clearly establishes the need to assess multiple levels of crowding in research of this type. Had we chosen to measure only the second level of crowding as in previous research, we would have been lead to the erroneous conclusion that perception of crowding varies with vocational perspective; an implication only partially consistent with our data.

A main effect for activity type was also highly reliable ($F(3,165) = 69.58$, $p < .0001$). Again, however, this effect was embedded in a reliable activity type x level of crowding interaction ($F(6,330) = 10.83$, $p < .001$). This interaction is shown graphically in Figure 2 below. As before, the crowded and intolerable conditions are virtually parallel across activity type (see Figure 2). The source of the interaction therefore stems from the differential placement of figures in the ideal conditions as compared to crowded and intolerable conditions. As can be seen from Figure 2, there is a greater decline in number of figures from resource center to discussion activities and a slower rise from discussion to lecture hall and study hall activities for the ideal conditions as compared to the crowded and intolerable conditions. More importantly, however, the main effect for activity type is present in all three levels of crowding. As Figure 2 suggests, a clear distinction was made by all participants between resource centers

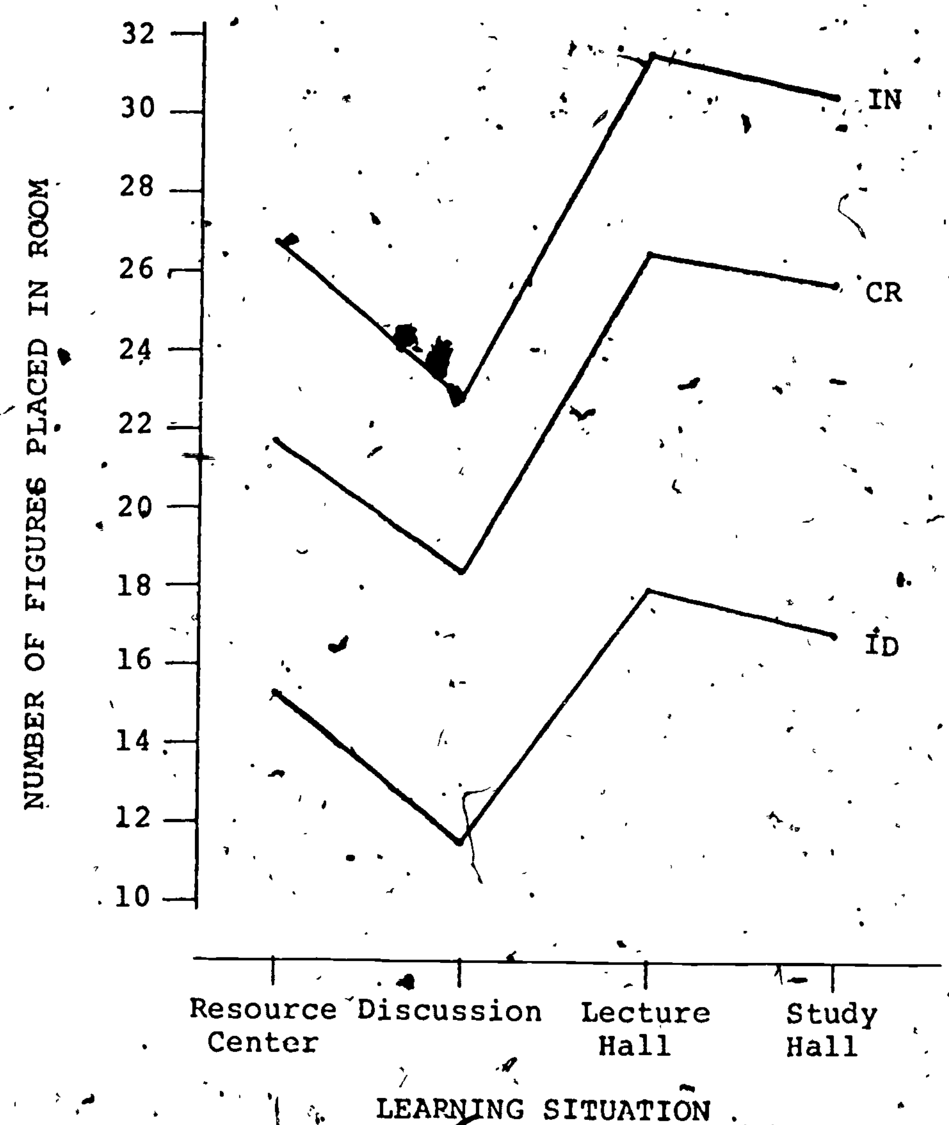

Figure 2. Graphic representation of the learning situation X crowding interaction on the number of figures placed in the room (ID = ideal, CR = crowded, IN = intolerable).

and discussion groups on the one hand and lecture and study halls on the other. Substantially more figures were placed in the latter two conditions than in the former. Analysis of the 20-item questionnaire indicated that resource centers and discussion groups were perceived as having a higher degree of personal contact, a lower amount of formality, a higher noise level, and a greater amount of interaction than were the lecture and study hall activities. In addition, [illegible] measures of interpersonal contact were considered more important in the participants' judgments of the former two activities than in the latter. That is, a perceived <u>decrease</u> in interaction level appeared to be responsible for the greater number of figures placed in the lecture and study hall activities; a finding in direct conflict with the findings of Cohen, <u>et al</u>. (1975), who found that more figures could be placed in rooms having a greater interaction levels. This contradiction between the two studies is resolvable if we assume that the type of interaction (cooperative vs. competitive) substantially moderates interaction level. In Cohen, <u>et al</u>. (1975), the figures were described as socializing or as engaged in mutually cooperative activities. School environments, as represented in the present study, may represent competition for teacher attention and/or time (especially in discussion groups) or other resources (especially in a resource center or library). That is, the present study suggests that if increased interaction implies increased competition for resources, then perception of crowding also increases; an outcome consistent with the model proposed by Stokols (1972). On the other hand, if increased interaction implies increased cooperation, then perception of crowding decreases as was demonstrated by Cohen, <u>et al</u>. (1975).

Main effects for the room design variables (ceiling height, esthetic quality, and noise level) were not reliable, but did interact with level of crowding or sex of subject. Ceiling height interacted with level of crowding ($F(2,110) = 4.84$, $p < .01$). This interaction is depicted graphically in Figure 3 below. As Figure 3 suggests, more figures were placed in the model rooms with high ceilings than those with low ceilings except in the intolerable learning environments where differential figure placement did not occur. Apparently, an intolerable learning situation is intolerable whether the ceiling is eight or fifteen feet high.

However, the most striking aspect of Figure 3 was not the statistical reliability of the interaction, but rather the disappointingly small difference in number of figures placed in the two levels of ceiling height given the objective size of the ceiling height manipulation (8 vs. 15 feet). One possible explanation is that the participants failed to apprehend the objective difference in ceiling height or at least paid very little attention to it when placing model figures in the rooms. This explanation was directly disconfirmed by the relevant manipulation check in the questionnaire. That is, participants saw the high ceiling as much higher than the low ceiling across all conditions ($F(2,110) = 7.06$, $p < .001$). They also regarded ceiling height as moderately important in determining the number of figures placed. Furthermore, participants reported a reliable decrease in perceived interpersonal distance in the rooms with low ceilings as compared to rooms with high ceilings; a finding which supports and provides a potent explanation for the pattern in Figure 3. That is, more figures could be placed in rooms with high ceilings because equivalent per-

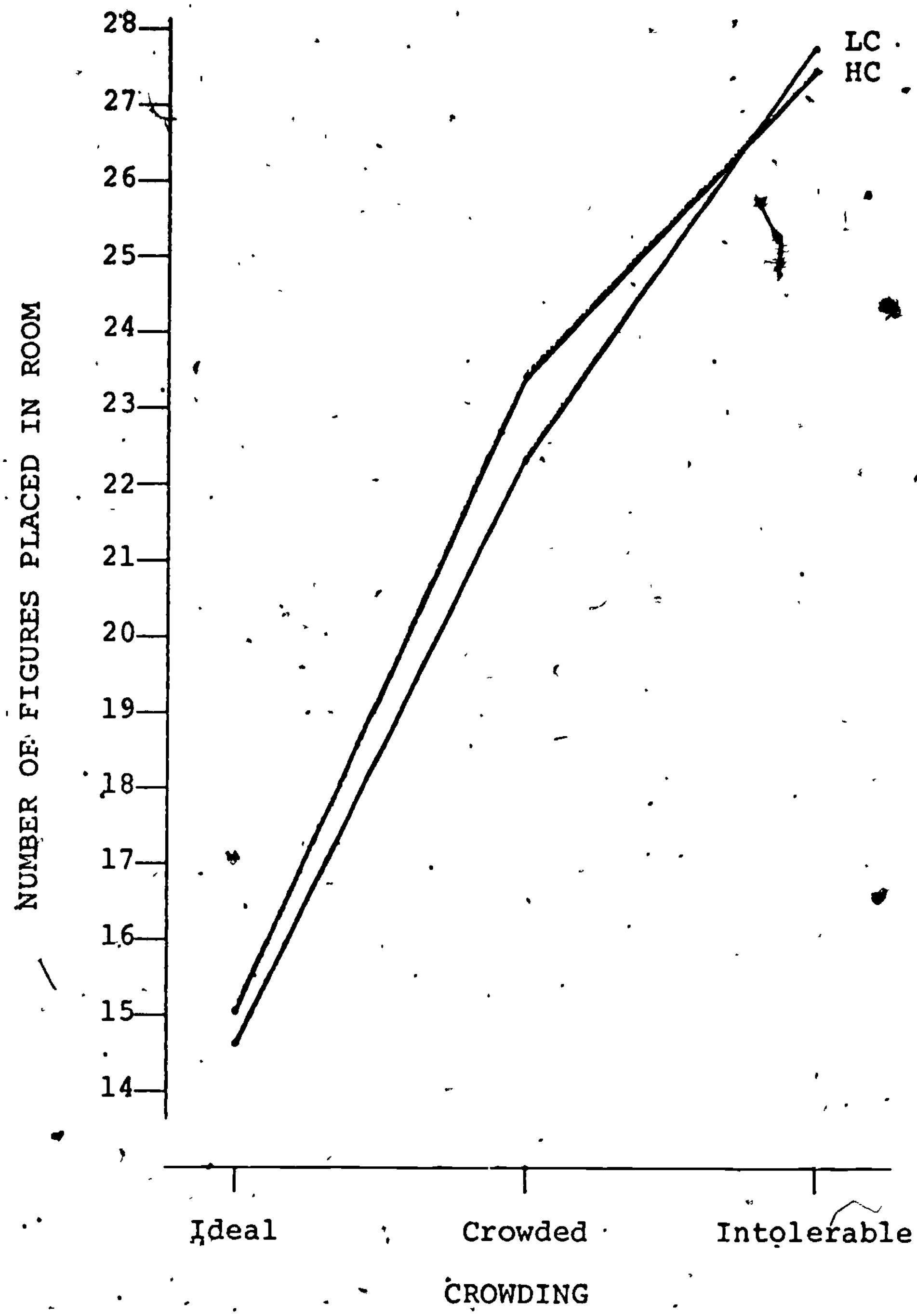

Figure 3. Graphic representation of the crowding X ceiling height interaction on the number of figures placed in the room (HC = high ceiling, LC = low ceiling).

ceptions of interpersonal distance in the two levels of ceiling height has the figures closer together physically in the high ceiling conditions.

The above interpretation coupled with the findings of Desor (1972) suggests an explanation for the relatively small differences in means graphed in Figure 3 that has important and far-reaching implications for room design. Desor found that the linear disparity of a room's dimensions substantially affects perception of crowding. Specifically, she found that more figures could be placed in a rectangular room (high linear disparity of dimensions) than in a square room (low linear disparity). Her manipulation involved only two dimensions--the length and width of the room. In our study, these dimensions were held constant and the third dimension (ceiling height) was varied. Thus, while our manipulation increased perceived interpersonal distance with increased height, it simultaneously affected perceived linear disparity. That is, the higher ceiling made the rooms look more cubical; in a sense, decreasing the perceived overall spaciousness of the room. This assertion has at least two implications. First of all, there is quite probably no simple relationship between ceiling height and perceptions of being crowded. Secondly, the above implies that any room design variable that will serve to enhance perceived linear disparity of room dimensions (spaciousness of the room) should permit greater density without increasing the perception of being crowded.

Both noise level and esthetic quality of the room interacted reliably with sex of the participants ($F(1,55) = 6.96$, $p < .05$ and $F(1,55) = 4.21$, $p < .05$; respectively). Figures 4 and 5 below depict the sex x noise level and sex x esthetic quality interactions, respectively.

The sex x noise level interaction (see Figure 4) was initially very perplexing since our original intent in manipulating this variable was to have it reflect the acoustical properties of the room. However, to avoid demand characteristics, this factor was manipulated as a between subject variable and no reference either to the source of the noise level or even to its presence was made in the instructions to the participants. Hence, attributions to its cause and interpretation of its effects were left up to the subject.

Surprisingly a rather straightforward explanation of the pattern in Figure 4 was provided by the participants' responses to the questionnaire. A reliable sex x noise level x level of crowding interaction ($F(2,110) = 4.47$, $p < .01$) occurred for a question tapping the degree of interpersonal contact between figures in the room. The means in this interaction indicated that males saw increased interpersonal contact as level of crowding increased under conditions of high noise level and decreased interpersonal contact as level of crowding increased under conditions of low noise level. Females showed no such pattern. This suggests that the males saw noise as a function of the number of people in the room and their degree of interpersonal contact. That is, the noisier the room, the more people that must be interacting. It follows that males were attributing noise level to the people in the room (a personal attribution) and under that assumption placed more people in the noisier rooms. While we have no direct evidence, it seems reasonable to assume that females, on the other hand, were attributing the noise level to room acoustics (an environmental attribution). Hence, the pattern of the female means (more figures placed in low noise conditions) is more consistent with the original intent of the noise level manipulation.

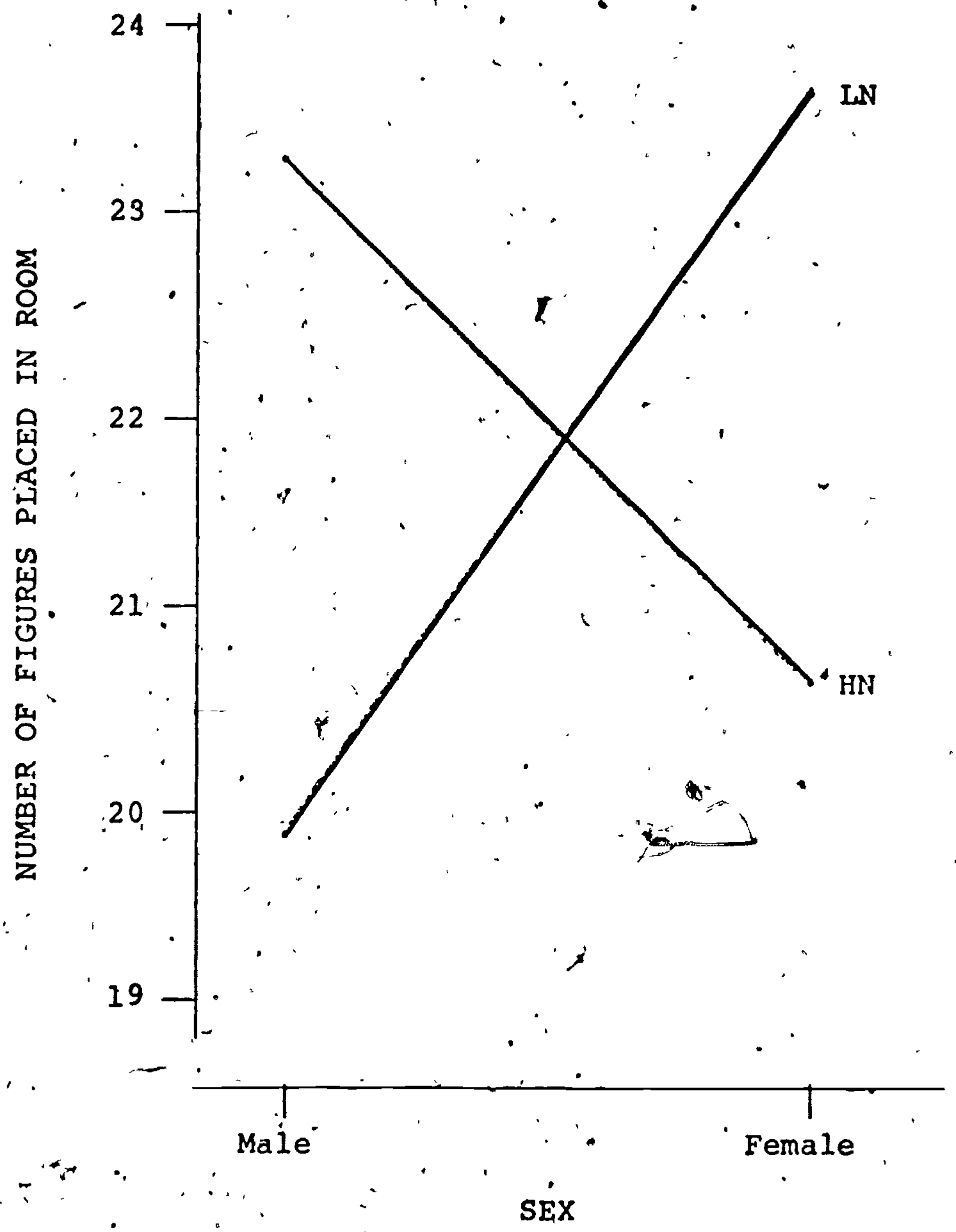

Figure 4. Graphic representation of the sex X noise level interaction on the number of figures placed in the room (HN = high noise, LN = low noise).

Nevertheless, the differential source of attribution as a function of sex which produced the interaction is highly intriguing and deserves further investigation. For example, would male and female reactions to a noisy environment be different? Might not females simply withdraw from the environment assuming it was an environmental problem while males would attempt to reduce the noise by reducing the degree of interpersonal contact? It is an interesting problem that deserves further research.

The sex x esthetic quality interaction presents an entirely different problem (see Figure 5). Analysis of questionnaire responses indicated that participants perceived the high esthetic condition as more colorful and as having more furniture, posters, potted plants, etc., but they also reported being much less familiar with this condition than with the low esthetic condition. No other questionnaire responses showed reliable differences for this variable. Hence, we know the manipulation was successful, but we do not know why the pattern in Figure 5 appears as it does. One is tempted to argue that males placed more figures in high esthetic conditions because these rooms appeared to be warmer and more inviting. But if this is the case, why did the females reverse the pattern? Perhaps, they were responding to the arousal properties of the esthetic quality manipulation. Certainly, most people would agree that the high esthetic conditions are more arousing. Since participants were very unfamiliar with the high esthetic condition, it is plausible, but highly speculative, that males selected a different set of cues than the females did and consequently arrived at opposite conclusions. Clearly additional research is needed. One final point needs to be made. This study manipulated only two levels of esthetic

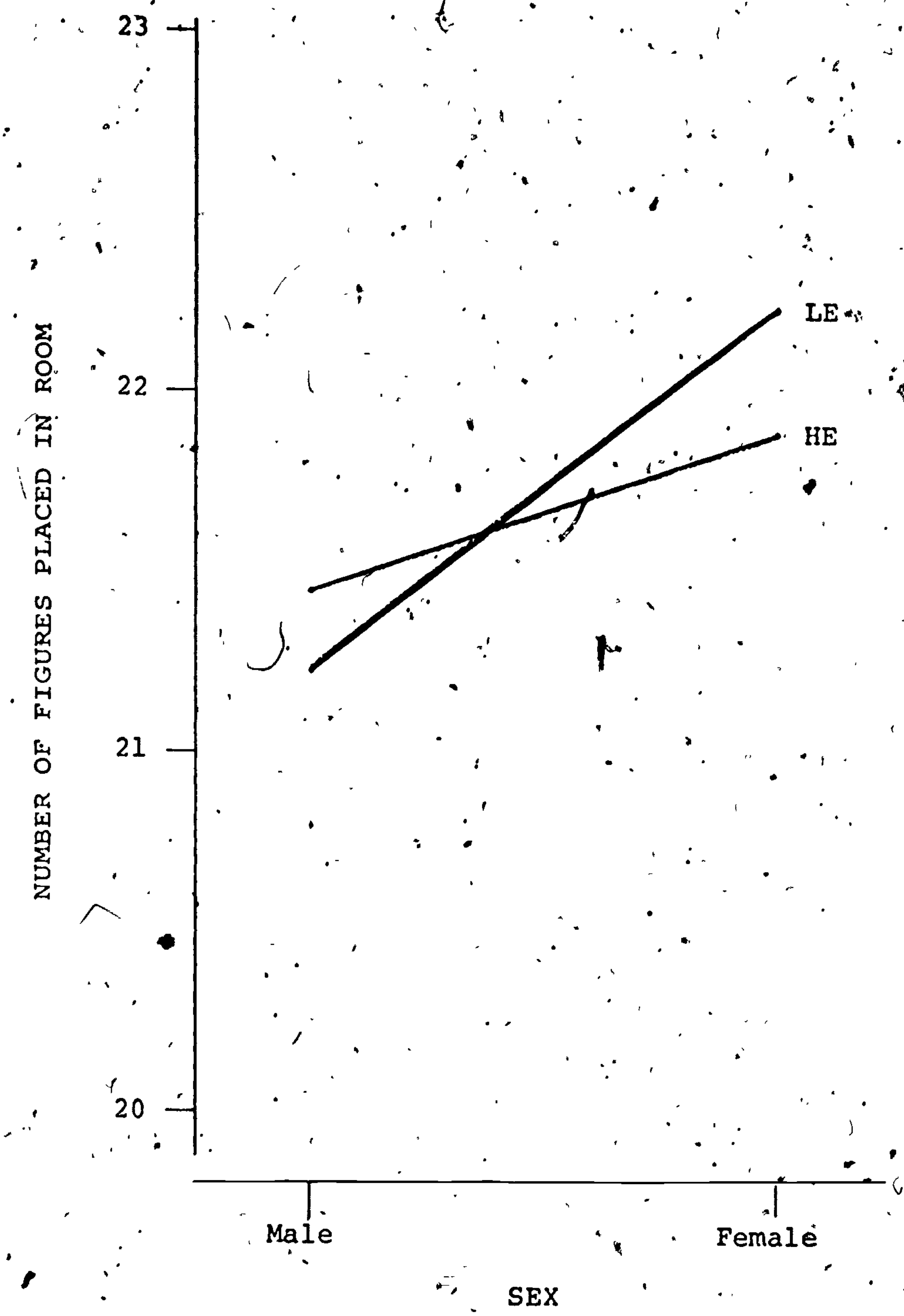

Figure 5. Graphic representation of the sex X esthetics interaction on the number of figures placed in the room (HE = high esthetics, LE = low esthetics).

quality. Obviously, many other variables contribute to a room's esthetic quality than the ones we chose. Esthetic quality of a room and its impact on perceptions of crowding remains a completely unknown quantity, desperately in need of additional research.

Finally, this study accomplished an extremely important goal that is especially relevant to the other two studies in this project. That is, a fairly clear set of perceptual ranges was developed from the level of crowding manipulation. As noted above, these ranges were, in part, a function of vocation. However, it seemed desirable to us to focus on the user-derived set of ranges (i.e., the student segment of our sample) for obvious reasons. The perceptual ranges derived from this study (holding the room design variables constant) are as follows:

(1) resource center or library (22-31 sq.ft./pupil)

(2) discussion group (25-43 sq.ft./pupil).

(3) lecture hall (17-27 sq.ft./pupil)

(4) study hall (18-29 sq.ft./pupil).

The above ranges are expressed in square feet per pupil in order to make them independent of the room size used in this study. It might be argued with some merit that the upper bound on these ranges is unnecessary since it is ridiculous to argue that there should be a minimum number of students in a classroom. In fact, this is exactly what we shall assert later. However, an adequate defense must await presentation of the remaining two studies.

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EFFECTS OF DENSITY, MOTIVATION, AND LEARNING SITUATION ON CLASSROOM ACHIEVEMENT

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As noted in the introduction, with the exception of the work of Paulus and his associates (e.g., Paulus, et al., 1976), attempts to document a relationship between density and immediate task performance have been markedly unsuccessful (e.g., Freedman, et al., 1971; Freedman, et al., 1972; Sherrod, 1974; see Lawrence, 1974, and Stokols, 1972 for systematic reviews of this issue). Hence, the present study was considered crucial to our investigation of the class size-achievement relation.

One effect of increased density may be an increase in arousal. Studies of the effects of group size (that is, density or crowding) may actually be studying the effects of arousal on the dependent variable of interest. Zajonc (1965), in his theory of social facilitation, argues that the mere presence of others increases arousal which in turn increases performance on simple or well-learned tasks. Conversely, arousal leads to a decrement in task performance if the task is complex or requires the acquisition of new skills. If the above is relevant to studies manipulating density, then high density should facilitate performance on well-learned tasks and inhibit successful performance on tasks requiring the acquisition of new responses.

In educational settings, however, the tasks presented to students can rarely be described as requiring the use of well-learned skills only or the acquisition of new responses only. Most tasks in these settings are quite complex and require that the student learn new responses and, in so doing, make use of previously-learned skills. For example, suppose an English teacher wishes to introduce her students to a classic piece of literature such as a short novel. The task as presented to the student is to read the novel, discuss its meaning in class, and take a test pertaining to the story. Clearly, this task requires previously-learned skills such as reading speed, reading comprehension, memorization techniques, etc. However, it also requires the acquisition of new knowledge and the integration of that knowledge in an organized, retrievable form.

In situations like the above, the relationship between arousal (as measured by density) and task performance (in this case, student achievement) may be quite complex and not at all easy to predict on an a priori basis. This may explain why previous research on crowding and performance has failed to show a consistent relationship (see, for example, Freedman, et al., 1971; Kutner, 1973; Sherrod, 1974; Stokols, et al., 1973; Paulus, et al., 1976). It is our position that for tasks requiring both usage of prior-learned skills and acquisition of new knowledge, the effect of density on performance is as follows: Under conditions of low arousal, acquisition of new material is facilitated, but the use of prior skills such as reading speed and comprehension is not and the individual's rate of acquisition is slower (though what is learned may be extremely well-learned). Under moderate levels of arousal, use of prior skills is facilitated (reading speed and comprehension may be vastly increased, for example) and the acquisition and organization of the new material may be only slightly impaired. Finally, under high levels of arousal, use of prior skills is maximally facilitated, but the acquisition and organization of the new material (responses) may be totally blocked, resulting in a corresponding decline in task performance. Although we cannot be sure this actually occurs, there is anecdotal evidence that something similar may be occurring. Furthermore, there is empirical support for the curvilinear relationship in research on test anxiety and achievement (Spielberger, 1966).

In the present study, two manipulations of arousal were achieved. The major manipulation was classroom density which was achieved by varying group size in a classroom of fixed dimensions. Of three possible methods of varying density (group size or social density, room size or spatial density, and degree of interpersonal distance or proximity), group size appears to produce the most powerful effects (cf., Lawrence, 1974; Paulus, et al., 1976; Stokols, 1972). The classroom used for the experiment was square (12' x 12'), had three separate entrances, and was air-conditioned at a constant 72°. The room was deliberately chosen to enhance perceptions of crowding (cf., Desor, 1972) while avoiding possible confounds due to temperature fluctuation (cf., Griffit & Veitch, 1971). The high density conditions contained 16 subjects per group while the low density conditions contained eight subjects per group. This translates into 9 sq. ft. and 18 sq. ft. per subject, respectively. Given the findings of the first study regarding perceptual ranges, the levels of density used in this study present real problems with regard to the participants' perceptions of being crowded. The reader is reminded that the results of the perception study were unavailable at the time the present study was designed. More will be said concerning this problem when the results are presented below.

A second manipulation of arousal was achieved by motivational instructions to the participants. This was done for two reasons: (1) to study its effects and (2) to provide at least half the subjects with some incentive to do well on the task. The manipulation was achieved by informing half the subjects at the beginning of the experimental session that a test would be given at the end of the session and that they could earn extra money for doing well. The other half of the subjects were not informed of the test or bonus until just prior to its administration.

The research literature suggests that both the amount and type of interaction in a situation affect the perception of crowding (Desor, 1972; Cohen, et al., 1975; see also Elkin, 1977, as reported above). Thus it may be that task performance will vary with learning situations in complex ways. If perception of crowding produces high arousal and if it also varies with learning situation, then we should expect that the same density level will produce differential effects on task performance depending on the type of learning situation. The effect of learning situation was studied by including three very common educational activities: independent study groups, lecture groups and discussion groups.

In addition to the above manipulations, 17 demographic and personality variables were assessed for each participant. As suggested by Stokols (1972), personal and demographic attributes may interact with environmental variables to affect perceptions of crowding. If this is so, then we might expect differential task performance as a function of these variables. The personality variables assessed in the present study were as follows: (1) The first six subscales of Shostrom's Personal

Orientation Inventory (time competence, time incompetence, other-oriented values, inner-oriented values, self-actualized values, and existentiality), (2) the six subscales of Wrightsman's Philisophies of Human Nature Scale (trustworthiness, rationalism, altruism, independence, complexity, and variability), (3) Rotter's Internal-External Locus of Control Scale, and (4) the "trait" subscale of Spielberger's State-Trait Anxiety Scale. The demographic variables assessed were the participant's race, and socioeconomic status.

Finally, because successful manipulation of the density and motivation variables was considered so crucial to interpreting the results and because prior research has been so inconsistent, a subjective questionnaire was developed and given to all participants immediately prior to the exam to check on subjective responses to these two manipulations. The subjective questionnaire consisted of a set of semantic differential scales measuring arousal, anxiety, frustration, effectiveness of the educational activity engaged in (see above); feelings toward the group, feelings toward the situation, and feelings of preparedness for the exam (measure of task performance). In additions, the "state" subscale of Spielberger's Trait-State Anxiety Scale was given twice during the experimental session; immediately after the motivation manipulation and just prior to the exam.

The experimental procedure was as follows: (1) participants were given the personality and demographic questionnaire in a pre-experimental session conducted in the morning; (2) after a half-hour break for lunch, participants were seated in the experimental room and the appropriate experimental session was held; (3) in these sessions each participant read a short novella for 75 minutes, then participated in the assigned educational activity for 60 minutes, and finally filled out the questionnaire checking on manipulations and took the 45-minute, multiple-choice exam. Sixteen subjects participated in each of the eight cells of the design. All participants were paid \$2.20 per hour plus the bonus described above.

Results

Checks on success of manipulations. Concerning the density manipulation, participants in the low density condition can be described as more relaxed and at ease than the participants in the high density condition. This was indicated by several reliable F-tests for the dependent variables in the subjective questionnaire and the state anxiety measures. Specifically, participants in the low density cells had more positive attitudes toward other members of the group they were with ($F(1,166) = 6.73$, $p < .01$), felt much less crowded ($F(1,166) = 83.20$, $p < .0001$), and also experienced less anxiety immediately after exposure to the classroom situation as measured by the state anxiety scale ($F(1,166) = 5.47$, $p < .02$) than did participants in the high density cells. In addition, the former groups reported that they felt more prepared for the achievement test ($F(1,166) = 4.01$, $p < .05$) than participants in the latter groups. These results were taken as strong evidence for the success of the density manipulation.

With regard to the motivation manipulation, the F-tests on the subjective questionnaires indicate that the participants in the high motivation conditions were more self-assured just prior to taking the achievement test than the participants in the low motivation conditions. Specifically, participants in the high motivation cells felt more prepared for the achievement test ($F(1,166) = 4.12$, $p < .05$) and slightly less anxious and excited just before taking the test ($F(1,166) = 2.67$, $p < .10$ and $F(1,166) = 3.00$, $p < .08$; respectively) than participants in the low motivation cells.

While no manipulation checks were constructed to directly assess the learning situation manipulation, several reliable effects in the subjective questionnaire were observed. First of all, participants in the discussion cells had more positive attitudes both towards themselves and toward the situation ($F(1,166) = 4.64$, $p < .01$ and $F(1,166) = 3.69$, $p < .03$; respectively) than either the lecture or independent study cells. The latter two conditions did not differ from one another. The participants in the discussion groups also felt much more prepared for the test than the other groups ($F(1,166) = 4.66$, $p < .01$).

Finally, interesting differences occurred between learning conditions with regard to how stimulated the participants felt and how anxious they were immediately prior to taking the test. Specifically, participants in the discussion cells felt more stimulated than participants in the lecture cells, who, in turn, felt more stimulated than participants in the independent study cells ($F(2,166) = 4.33$, $p < .02$). Yet this did not translate into feelings of anxiety. For this latter variable, the participants in the discussion groups were least anxious before taking the test, while those in the lecture and independent study groups expressed much more anxiety. Again, these latter groups did not differ from one another. This pattern was confirmed by the statistical tests ($F(2,166) = 3.50$, $p < .03$). In summary, there was strong evidence that the participants in the discussion group were more stimulated, yet more at ease and confident than participants in the other two learning environments. Since participants in three of four cells in each of the learning situations were supposed to be at least moderately aroused by the density and motivation manipulations, the above findings suggest that arousal was interpreted differently depending on the learning situation the participants were in; a finding very much in line with Schachter's Theory of Emotion (Schachter and Singer, 1962).

Analysis of covariance on achievement scores. The set of 17 covariates (personality and demographic variables) was submitted to a Principal Components Factor Analysis procedure in order to reduce their number to a reasonable size for the planned analysis of covariance. The principal components procedure was applied to the matrix of correlations among the 17 covariates. Three principal components were extracted and rotated by the Varimax procedure (Harmon, 1968). The results are presented in Table 1 below. As can be seen from Table 1, the covariates were grouped by the above procedure into three readily interpretable factors. The first factor, labeled "Favorable attitudes toward people," consisted of the first four subscales of Wrightsman's Philosophies of Human Nature Scale, their sum (favorability), and Rotter's Internal-External Locus of Control Scale. The second factor, labeled "Flexible in applying one's own values," consisted of the six measured subscales of Shostrom's Personal Orientation Inventory, the "Trait" subscale of Spielberger's Trait-State Anxiety Scale, and the race of the participant. The last factor, labeled "Belief in individual differences," consisted of the last two subscales of Wrightsman's inventory, their sum, and the time incompetence subscale of Shostrom's inventory. Note that the first and third factors correspond very closely to those obtained in research by Wrightsman and his associates (e.g., Wrightsman, 1964). Note also that Socio-economic Status

Table 1: Factor Loadings[a], Eigenvalues, and Percent of Variance Accounted for by First Three Principal Components of the Covariates Correlation Matrix.

	Favorable Attitude Toward People	Flexible in Applying One's Own Values	Belief in Individual Differences
Favorability	.96[b]		
Independence	.78		
Altruism	.73		
Rationalism	.66		
Trustworthiness	.64		
Locus of control	-.51		
Inner-oriented values		.89	
Existentiality		.85	
Time competence		.77	.22
Self-actualized values		.60	-.34
Race		.41	.20
Trait Anxiety	-.38	-.46	
Other-oriented values		-.49	
Time incompetence	-.24	-.31	-.51
Individual differences			.93
Complexity			.79
Variability		.23	.66
Socio-economic status		-.14	-.14
Eigenvalue associated with original solution	3.90	3.35	2.03
Percent variance	22	19	11

Notes: [a]Factor loadings (coefficients) are those obtained after rotation by Varimax procedure.

[b]In order to enhance readability, factor coefficients less than .20 are not shown in this table.

appears to spread itself across all three factors and is only weakly related to any of them.

On the basis of the analysis reported in Table 1, three factor score variables were constructed by applying the appropriate factor score coefficients to the original set of covariates. These "composite" covariates were then combined with the design variables and a preliminary analysis of covariance was done. The results of this analysis indicated a violation of the regression parallelism assumption (Winer, 1971, pp. 764-775) that was traceable to the "Flexibility" covariate (factor 2). Accordingly, a median split was done on this covariate and it was treated as an <u>ex post facto</u> design variable. The "Favorability" and "Individual Differences" variables (factors 1 and 3) were retained as covariates and a final analysis of covariance was computed.

The results of the analysis of covariance are presented in Table 2. As Table 2 indicates, participants with negative attitudes towards others or strong beliefs in individual differences had higher achievement scores than did participants with more positive attitudes towards others or who believed that most people are alike. However, only the latter relationship reached conventional levels of significance. Why these variables are related to achievement is difficult to explain. Perhaps people with more negative attitudes toward others feel they have to be self-reliant and therefore develop coping strategies which enable them to perform better in this experiment. Or perhaps they were more task-oriented than those participants with more favorable feelings toward others. While similar kinds of interpretation can be applied to the individual differences covariate, such inferences may well be in error and therefore inappropriate at this time.

Table 2

Analysis of Covariance Summary Table

Source	d.f.	F-ratio	% of variance accounted for	Beta Weight
Favorable attitude toward others	1	3.70	2.20	-.12*
Belief in individual differences	1	7.27	4.15	.20***

Analysis of Variance on Adjusted Means

Source	d.f.	Means Squared	F-ratio
Density (A)	1	848.73	5.59**
Motivation (B)	1	7.36	.05
Learning Situation (C)	2	2130.58	17.97***
Flexibility (D)	1	3311.39	21.80***
A x B	1	198.52	1.31
A x C	2	115.61	.76
B x C	2	140.45	.92
A x D	1	161.32	1.06
B x D	1	53.08	.35
C x D	2	204.27	1.34
A x B x C	2	457.21	3.01**
A x B x D	1	23.25	.15
A x C x D	2	48.75	.32
B x C x D	2	28.27	.19
A x B x C x D	2	145.41	.96
S's within groups	164	151.83	

*p < .10
**p < .05
***p < .01

The analysis of variance on the adjusted means is also shown in Table 2. A strong main effect for flexibility emerged indicating that more flexible participants scored higher in achievement than did the less flexible participants. Again, perhaps this outcome is due to the greater adaptability of the more flexible participants, but this is difficult to substantiate.

Main effects for density and learning situation were also reliable, but both were embedded in a density x motivation x learning situation interaction (see Table 2). The interaction is graphed in Figure 1 below. As Figure 1 indicates, there were two major sources to the interaction. First, as Figure 1a shows, there was a decrement in achievement in the independent study condition for the high density-high motivation condition. This was confirmed by simple effects tests. It was found that within the independent study condition, there was a reliable simple main effect for density ($F(1,164) = 9.50$, $p < .01$) and a marginally reliable simple density x motivation interaction ($F(1,164) = 3.35$, $p < .10$). This outcome coupled with the clear pattern of means in Figure 1a, indicates that the differential effects of density and motivation within the independent study groups was due to the mean for the high density-high motivation condition. The second source of the three-way interaction was the differential achievement in the discussion groups for the high density-high motivation and low density-low motivation conditions as compared to the low density-high motivation and the high density-low motivation conditions. This was confirmed by simple effects tests which indicated a reliable simple density x motivation interaction only ($F(1,164) = 9.62$, $p < .01$). The pattern of the means in these two conditions (see Figures 1a and 1c)

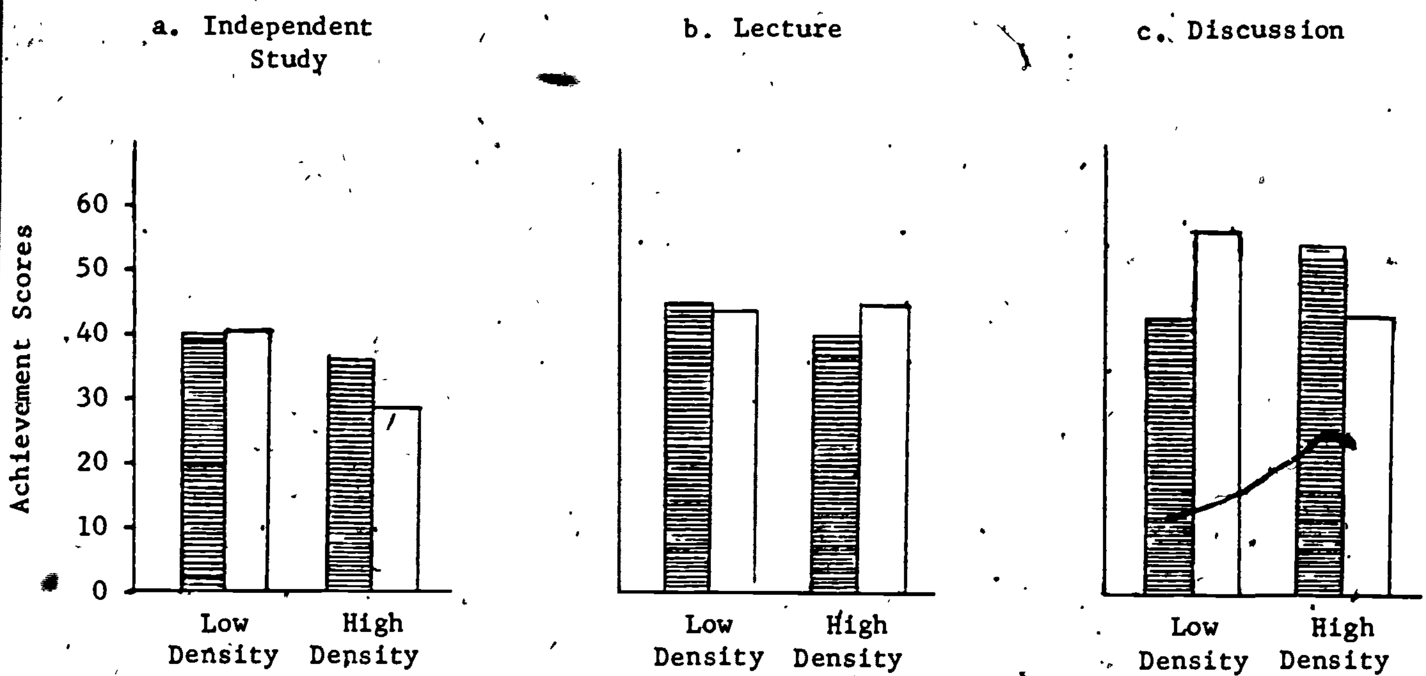

Figure 1. Graphic representation of the density x motivation x learning situation interaction with achievement scores as the dependent variable. Levels of learning situation are graphed separately (▤ = low motivation, □ = high motivation).

is consistent with the modified form of Zajonc's theory of social facilitation presented in the introduction. That is, if we assume that both density and motivation directly affect arousal, then low density-low motivation conditions should produce lower arousal than high density-low motivation or low density-high motivation conditions while high density-high motivation should maximize arousal. The predicted curvilinear effect on task performance is clearly achieved in the discussion group activity (Figure 1c).

While the pattern for the independent study activity is consistent with the above, it still differs sufficiently from the discussion activity to merit special comment. Given the perceptual ranges established in the perception study reported above, it is clear that the density levels in the independent study conditions did not produce the same perceptions of crowding that the same levels produced in the discussion activity. Specifically, the low density cells may be interpreted as marginally ideal in the independent study groups while they were well within the crowded range for the discussion groups. High density in both activities was well into the intolerable range. This implies that the density manipulation was more powerful in the independent study activity (marginally ideal vs. intolerable) than in the discussion activity (crowded vs. intolerable). This interpretation also explains the main effect for density in the independent study conditions.

Given this interpretation, the absence of effects for motivation or density in the lecture activity is striking (While the pattern of means in Figure 1b reverses the predicted pattern, the differences are not reliable). On the basis of the perceptual ranges established in the perception study, the pattern of means should look very similar to the independent study activity. Furthermore, both independent study and lecture activities involve co-actors, so the main source of arousal for both acitivites should stem from violations of personal space (either actual or anticipated). The one single difference between the two activities is that the attention of the co-actors in the lecture activity is focused on an instructor. This focusing of the participant's attention on a single point in the room may enable them to block the effects the density and motivational manipulations would ordinarily have had on their arousal levels. This interpretation is, of course, consistent with some ancilliary assumptions regarding moderator variables in the density-task performance model proposed by Stokols (1972).

In conclusion, this study clearly demonstrates that density affects immediate task performance. However, contrary to previous assumptions arguing that its effects are uniformly negative, we have shown that its effects can be either positive or negative depending on the environmental context and on task parameters. In view of this, we assert that density acts primarily as a moderator of arousal. Finally, the magnitude of the arousal produced by a manipulation of density appears to be a complex function of task parameters, room design, type of activity, amount and type of interaction in the activity, personal and social attributes of the individuals in the situation, and where the individual's attention is focused.

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A LONGITUDINAL INVESTIGATION OF THE CLASS

SIZE-STUDENT ACHIEVEMENT RELATIONSHIP

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Even a cursory glance at the literature on the relation between class size and student achievement clearly indicates that the evidence for a relation--positive or negative--is spotty at best. Major reviews of the literature (e.g., Blake, 1954; Holland & Galfo, 1964; Grajewsky, 1973) report a few studies showing a negative effect of large classes on student achievement, a few studies actually showing a positive effect, and the vast majority showing no effect at all. Most of the studies have glaring methodological shortcomings (for cogent criticisms of these studies, see Blake, 1954; Grajewsky, 1973; Holland & Galfo, 1964). Perhaps the most critical shortcoming from the point of view of the present study is that while class sizes are reported, room sizes used in the research are not. Thus the degree of density in these studies is impossible to assess. Another major criticism leveled by many reviewers is that the studies are primarily cross-sectional and that the presumed negative effect of large classes may surface only after extended exposure.

One of the few longitudinal studies of class size was conducted by Furno and Collins (1965) in the Baltimore public school system. They measured third-grade student achievement over a five year period using a battery of standardized achievement tests. Among the predictor variables used by these researchers was class size; measured by the median class size for each student for the five consecutive years of the study. The results indicated that class size had a small, but reliable, inverse effect upon students of all intelligence levels and socio-economic groups. However, average room size was not reported, so no inference can be made concerning density levels or students' perceptions of crowding.

In another longitudinal study, Summers and Wolfe (1975) conducted a three year survey of the Philadelphia public schools and used a multiple regression procedure to measure the effect of 57 independent variables including class size upon achievement as measured by the Iowa Test of Basic Skills. These researchers concluded that students below grade level ability did better in classes of 28 or fewer students, while students performing at or above grade level ability could be placed in classrooms of up to 33 pupils without negative effects. In addition, they found that for any student, a class size of 34 or greater had an adverse effect on achievement. Again, however, room size was not reported and therefore the impact of density is hard to assess.

Nevertheless, the above two studies are at least consistent in demonstrating an inverse effect of class size on achievement. Given these findings from two longitudinal investigations, there is reason to believe that the long-term effects of high density may be more damaging than much of the cross-sectional studies seem to indicate (e.g., Blake, 1954; Holland & Galfo, 1964; Maddon, 1968; Grajewsky, 1973). However, as the other two studies reported in this monograph indicate, a clear understanding of the class size-achievement relation is not possible without knowledge of the density implied by a particular class size and thus, some indication of the students' perceptions of crowding.

Accordingly, the present study sought to achieve two goals: (1) to develop indices of classroom density that could be easily obtained from local school districts and that could be compared to the findings of the previous two studies such that indirect assessments of preceived crowding could be made, and (2) to obtain measures of student achievement from selected school districts so that direct assessment of the class density-achievement relation would be possible. Furthermore, it was decided the study would adopt a longitudinal approach using archival data. A 24-year period was chosen spanning the academic years from 1951-52 to 1973-74. This period was chosen because it included the post-war baby boom--a period of rapidly expanding enrollments, insuring the occurrence of several years of high density classrooms.

After careful consultation with the administrative personnel of the three cooperating school districts used in the study, two indices of density were chosen. The first was a teacher-pupil ratio which provided an index of the degree to which students were competing for the limited time of the teacher. The second index was the average square feet of classroom space per pupil (excluding gymnasiums, lunch rooms, and space set aside for extra-curricular activities). In addition, 41 other variables were obtained from each school district, including indices of teacher experience, teacher sex ratios, income sources, cost per pupil and voter activity. These indices were gathered by grade by year from school, county and state archives. For the index of achievement, national SAT scores, obtained from ETS, were used because none of the districts had complete summary data for a period of more than 10 years. This index was considered justifiable for two of the three districts since at least 70 percent of their students took the SAT's and the overall pattern of the available district SAT's were very similar to the national SAT's over the years examined. Constant mean differences were, of course, clearly evident, but irrelevant to the purpose of this study. Data from the third school district was discarded when it became clear that this district did not show the expected baby boom pattern.

Results

In a longitudinal study of this type, data is gathered for the same variable over a long period of time; in this case, 24 years. Each data point in the time series is considered a replication or observation. Data in this form is especially suited to a data analytic technique called time series analysis. One of the most useful aspects of time series analysis is that it automatically computes the relationship between two variables at various "lags." Whenever the data for a series of years for a variable is compared to itself or another variable at a later point in time, the computed relation is said to be lagged by the specified period of time. For example, since the students in a first-grade class would be expected to take the SAT's eleven years later, it would be appropriate to compute the relation between SAT's and variables derived from the first-grade data at a lag of eleven years. Furthermore, it would be expected that the relation would be maximum at this lag and be lower at all other lags.

Two statistics are derivable from lagged relations that are relevant to this study: the autocorrelation of each variable and the cross correlation of each variable and SAT scores. The autocorrelation was computed at various lags and indicates to what degree adjacent years are linearly dependent. The autocorrelation at lag zero is equivalent to a standardized variance (i.e., 1.0). The cross correlation at various lags indicates the degree to which two variables are related at each lag and also gives some key to the direction of causality. The cross correlation at zero lag is equivalent to a Pearson Product Moment Correlation Coefficient.

The SAT scores showed the much-discussed sharp decline beginning in 1962. Prior to that period, the SAT's show mild fluctuations including an initial 5-year decline from 1952 to 1956 followed by a 6-year increase to 1962. The autocorrelation for this was quite high for the one year lag trailing off rapidly to zero by lag 5 (5 years). This indicated strong linear dependence in the SAT data. In part this is due to the fact that some students take the SAT's twice; once as a junior and once as a senior. However, this can explain only part of the linear dependency. Whatever is causing SAT's to fluctuate, it is a long-term phenomenon.

The results for the analysis of the two density indices and their relation to SAT scores are presented in Tables 1 and 2, respectively. None of the other indices gathered were systematically related to SAT's and hence are not reported in this paper. Table 1 reports the means, standard deviations, ranges, and the trend codes by grade by district for the teacher/student ratio index and by district only for the square feet/pupil index (a by grade breakdown of this latter index was not possible since available archives did not indicate which rooms were used by each grade). The reader is reminded that the teacher/student ratio reported here is the reciprocal of the usually reported student/teacher ratio and thus a higher value in Table 1 on this index indicates a more favorable access to teacher time by each student. As Table 1 indicates, the smallest teacher/student ratio for district X was .0199 or, equivalently, approximately 50 students/teacher. The largest teacher/student ratio for district X was .0492 or, equivalently, 20 students/teacher. The equivalent values for district Y are .0222 teachers/student or 45 students/teacher and .0765 teachers/student or 13 students/teacher. The values in Table 1 for seventh and eighth graders cannot be taken at face value since seventh and eighth grade teachers in both school districts also teach high school and hence the numerator of the ratio for these grades was the number of certified high school teachers. Nevertheless, the pattern for these grades is still interpretable in terms of autocorrelation and cross correlation. Autocorrelation functions vary widely for the data in Table 1, but, in general show a high positive relation at lag 1 which tapers off slowly to zero four to eight lags later. Again we have strong evidence for a long-term phenomenon. Furthermore, both districts X and Y show the expected peaks during the baby boom period and we attribute the autocorrelation to the baby boom phenomenon.

The comparison of the sq. ft. per pupil index to the results of the previous two studies produced some striking conclusions. Classroom density over the 24-year period studied ranged from 25 to 72 sq. ft. per student. According to the criteria of the perception study, classroom density in the two districts never moved out of the ideal range. In fact, on this basis, class size could be substantially increased in these two districts and it would not produce perceptions of crowding. There are, of course, other potential reasons why class size should not be increased (as noted earlier), but high density does not appear to be one of them. Given the current and continuing decline in enrollments,

Table 1. Descriptive Statistics for Three School Districts on the Measures of Density Data (statistics include the mean, standard deviation, range, and the trend code which describes the data pattern over the 24 years from 1952 to 1975).

School Districts and Variable Labels	Mean	Standard Deviation	Range	Trend Code[a]
A. District X				
1. Teacher/Student Ratio				
a. First Grade	.0364	.006	.0243-.0448	D(5)A(3)N(10)D(6)
b. Second Grade	.0371	.004	.0232-.0415	D(5)A(8)N(5)D(6)
c. Third Grade	.0361	.005	.0240-.0455	D(5)A(5)N(14)
d. Fourth Grade	.0345	.004	.0243-.0462	A(14)D(10)
e. Fifth Grade	.0336	.005	.0199-.0395	D(5)A(5)D(14)
f. Sixth Grade	.0342	.003	.0273-.0411	D(5)A(12)D(7)
g. Seventh Grade	.1510	.029	.0900-.1934	D(4)A(17)NT(3)
h. Eighth Grade	.1555	.026	.0919-.1876	D(1)A(20)NT(3)
i. High School	.0379	.004	.0308-.0492	D(4)A(18)D(2)
2. Square Feet/Pupil	34.58	19.087	25.69-55.71	D(5)A(7)NT(8)A(4)
B. District Y				
1. Teacher/Student Ratio				
a. First Grade	.0428	.006	.0272-.0558	A(2)D(5)A(15)D(2)
b. Second Grade	.0424	.006	.0248-.0569	A(2)D(2)A(18)D(2)
c. Third Grade	.0419	.007	.0278-.0598	A(8)NT(11)A(3)D(2)
d. Fourth Grade	.0413	.007	.0280-.0571	A(15)D(1)NT(5)A(1)D(2)
e. Fifth Grade	.0393	.005	.0284-.0498	A(2)D(1)A(19)D(2)
f. Sixth Grade	.0412	.007	.0222-.0542	A(4)D(2)A(6)D(7)A(3)D(2)
g. Seventh Grade	.1323	.095	.0296-.2776	D(2)A(20)D(2)
h. Eighth Grade	.1299	.094	.0667-.2716	D(2)A(20)D(2)
i. High School	.0497	.016	.0[illegible]79-.0765	D(9)A(13)D(2)
2. Square Feet/Pupil	50.32	9.535	34.04-72.31	A(2)D(5)A(2)NT(7)A(8)

Notes: a. Symbols used in the trend code have the following interpretation:
A = ascending: the data points show a general increase in value over the period specified.
D = descending: the data points show a general decrease over the period specified.
NT = no trend: there was no discernible trend over the period specified.
(n) = the number in parentheses indic--es the length of the period, in years, over which the data is ascend. descending or no trend is discernible.

high density in classrooms is not likely to be a danger in the near future.

Table 2 reports the cross correlations between the two indices of density and verbal and math SAT scores. For teacher/pupil ratios reported by grade, the cross correlations at zero lag and at the positive lag where a maximum causal relation was predicted is reported. For first grade indices, this lag was 11 years, for second grade, 10 years, and so on. For teacher/pupil ratios not reported by grade (i.e., high school) and for the square feet/pupil index, zero lag and several other positive lags are reported. As Table 2 indicates, there is a very consistent and surprising relationship between the indices of classroom density and achievement scores as measured by SAT verbal and math scores. All of the indices of density, whether by grade or not show a negative and, in most cases, highly reliable relation to SAT's. That is, greater density was associated with higher achievement.

This finding contradicts to a significant degree much current educational wisdom concerning the relation of class size to achievement. Nevertheless, it is entirely consistent with the findings of the previous two studies within this project. As noted above, the square feet/pupil index indicates that for both districts X and Y, density never moved out of the ideal range, even during the peak years of the baby boom. Furthermore, the data from the second study confirmed a modified version of Zajonc's (1965) theory of social facilitation which predicts a curvilinear relation between density and task performance (in this case, achievement). Since density levels in the two districts were all in the ideal range, we can assume that arousal levels in students varied from low to moderately aroused. This places the students on the

Table 2. Relation of Verbal and Math SAT Averages by Year to Measures of Density for Three School Districts (for variables where data was gathered by grade by year, zero lag and the positive lag, where a maximum causal relation was predicted are reported; for all other variables, zero lag and several other positive lags are reported).

Variable Type	Verbal SAT Lag Zero	Verbal SAT Lag A[a]	Verbal SAT Lag B	Verbal SAT Lag C	Math SAT Lag Zero	Math SAT Lag A[a]	Math SAT Lag B	Math SAT Lag C
District X								
A. Teacher/Student Ratio								
1. 1st Grade	.52*	(11)[b]-.73**			.58**	(11)-.74**		
2. 2nd Grade	.09	(10)-.76**			.14	(10)-.73**		
3. 3rd Grade	-.48*	(9)-.45*			-.44*	(9)-.38*		
4. 4th Grade	.07	(8)-.59**			.10	(8)-.50*		
5. 5th Grade	.54*	(7)-.46*			.58**	(7)-.40*		
6. 6th Grade	.09	(6)-.58**			.17	(6)-.59**		
7. 7th Grade	-.71**	(5)-.65**			-.55*	(5)-.57*		
8. 8th Grade	-.65**	(4)-.65*			-.49*	(4)-.62**		
9. H.S.[c]	-.69**	(1)-.83**	(2)-.86**	(3)-.80**	-.59**	(1)-.80**	(2)-.89**	(3)-.76**
B. Square Feet/Pupil	-.55**	(3)-.56*	(7)-.78**	(11)-.88**	-.37*	(3)-.50*	(7)-.74**	(11)-.85**
District Y								
A. Teacher/Student Ratio								
1. 1st Grade	-.29	(11)-.63**			-.15	(11)-.66**		
2. 2nd Grade	-.31	(10)-.54**			-.16	(10)-.50*		
3. 3rd Grade	-.17	(9)-.67**			-.01	(9)-.61**		
4. 4th Grade	-.05	(8)-.71**			.09	(8)-.66**		
5. 5th Grade	-.08	(7)-.61**			.10	(7)-.55*		
6. 6th Grade	.32	(6)-.25			.42*	(6)-.31		
7. 7th Grade	-.71**	(5)-.77**			-.59**	(5)-.73**		
8. 8th Grade	-.67**	(4)-.79**			-.54*	(4)-.73**		
9. H.S.	-.18	(1)-.10	(2) .10	(3) .22	-.19	(1)-.09	(2) .07	(3) .16
B. Square Feet/Pupil	-.81**	(3)-.54**	(7)-.52*	(11)-.43	-.78**	(3)-.52*	(7)-.50*	(11)-.46

Notes: a. For variables in which data is reported by grade by year, this is the predicted lag. For all other variables, Lags A, B, and C are positive lags chosen to illustrate the pattern of the relation between SAT scores and that variable.

b. Numbers in parentheses indicate the number of years lagged. Associated correlations are to the right of these numbers

$*p<.05$

$**p<.01$

positive side of the curvilinear function. That is, increased density produced increased arousal which facilitated achievement. It is also clear from the first and second studies that the number of square feet per pupil would have to decline to a value of 18 square feet or less before detrimental effects due to density would be observed. This would require a 143% increase in density over the most dense year for district X and a 189% increase for district Y. One would be hard pressed to find any district in the United States that would have achieved that level of density in the 24-year period covered by the present study.

What is being implied here is that there is no evidence in this study that supports the contention that smaller classes facilitate achievement. In fact, if this study is taken at face value, class sizes up to 35 students for a standard 24 x 32 foot classroom should facilitate achievement. However, this conclusion must be tempered by other considerations. For example, Holland and Galfo (1964) report that both teachers and administrators have strong negative feelings toward class sizes over 30. Such attitudes may, in fact, have detrimental effects on the teacher's behavior toward the class and thus cancel any gains attained by the higher levels of arousal that would occur in class sizes over 30.

One note of caution must be asserted. There exists a potential confound in this data. Zajonc and Markus (1975) recently proposed a theory relating birth order to intelligence; arguing that, under certain conditions, later born children have lower potential for intellectual growth. Furthermore, our data was gathered over the period of the baby boom and hence the first 12-14 years of SAT scores may have come from a population dominated by first-born and only children while the latter years may have seen a corresponding increase in later-born children. Thus the possibility exists that the relation reported in this study may be confounded by a cohort variable. Nevertheless, it is very hard to believe that the relation would be completely reversed by controlling for birth order; eliminated perhaps, but not reversed.

Conclusions from the Project

The findings of the three studies reported here, when taken as an integrated whole, provide substantial insight into the density-perception of crowding-task performance sequence. These insights force some very important and perhaps controversial conclusions. Some of the more important ones are listed below. Some are more tentative than others and where this is the case, the need for further research is clearly indicated.

1. The clearest conclusion to be drawn from this project is that density is best construed as a moderator of non-specific arousal up to a certain point. This view agrees most closely with the theoretical position of Zajonc (1965) and implies that high density can have either positive or negative effects on task performance depending on the parameters of the task itself. Strong evidence for this interpretation is provided by both the laboratory and field studies reported above. The findings of Paulus, et al. (1976) are also consistent with this conclusion.

2. Beyond a certain point, high density is likely to produce frequent violations of personal space. These violations coupled with high arousal probably produce a lot of negative affect and may also inhibit task performance regardless of the task parameters. This conclusion received its strongest support from the independent study activity in the second study reported above. It is important to realize

that the negative effects are not produced by high density, per se, but rather by the concomitant violations of personal space. This implies that if frequent violations of personal space occur in a low density environment, the same negative effects would be expected. Or if violations of personal space can be minimized in a high density environment, we would predict an absence of the negative effects. Indirect support for these latter assertions is provided by the lecture and discussion activities of the second study and also by the differential perceptions of crowding as a function of activity type reported in the first study and by Cohen, et al. (1975). This interpretation is somewhat tentative and deserves further research. Perhaps an orthogonal manipulation of density, personal space violation, and task parameters such as performance on a well-learned vs. unlearned task would more fully document our assertion.

3. The above two conclusions suggest that perceptions of crowding may be more a function of personal space violation (actual or perceived) than of density, per se. We are not asserting that density is unimportant, for in natural environments personal space violations are much more likely in high density situations. What we are saying is that perceptions of crowding are produced as a function of the perceived or actual violations of a person's personal space, and variables which reduce perceptions of crowding are actually reducing the potential for personal space violation. Hence, increasing the partitions in a room will reduce interpersonal contact (Desor, 1972); reducing the number of doors will decrease traffic flow and the potential for personal space violation (Desor, 1972); focusing a room occupant's attention away from the other occupants will reduce his/her perceptions of potential

personal space violation (c.f., the first two studies in this project); etc.

4. The type of activity engaged in appears to have powerful effects on perceptions of crowding. If the activity involves competition for resources (c.f., Stokols, 1972, and the first study of this project), perceptions of crowding are enhanced. If, on the other hand, the activity involves mutual cooperation (e.g., Cohen, <u>et al</u>., 1975), perceptions of crowding are reduced. We are strongly tempted to argue that the cooperative-competitive dimension of activity type has its effect on perception of crowding primarily through perceived or actual personal space violation, but this assertion must be considered highly tentative and deserving of substantial additional research. Parenthetically, we would add that resource competition is a characteristic of many natural environments. Here, high population density may indeed be uniformly detrimental. Highrise, low income housing may well be a case in point.

5. Conclusions concerning room design must be considered the most tentative of all. Linear disparity of room dimensions appears to be extremely important in perceptions of crowding. If we make the tentative inference that this variable primarily affects perceived spaciousness of the room, then any room design variable that enhances perceived spaciousness of a room should reduce perceptions of crowding. This is, of course, an extremely vague conclusion. We do not yet have an adequate definition of spaciousness of a room and we have very little idea of the variables which affect it. Clearly additional research in this area is desperately needed. Parenthetically, we regard noise level as a variable affecting perceived or actual violations of personal space.

6. Understanding of task parameters appears to be essential to predicting the effects of arousal (high density) on task performance. This point was emphatically made by Zajonc (1965) years ago, but we apparently need continual reminders. Furthermore, the present project demonstrated that for tasks involving both well-learned skills and the acquisition of new responses, a curvilinear relation between density and performance is to be expected.

7. Finally, we conclude that the findings of the present project, especially the second study, do not support secondary drive explanations of social facilitation (Cottrell, 1972) or crowding (Geen, 1976). While Cottrell's notion of evaluation apprehension might account for the superior achievement of the discussion group over the other two groups since the discussion group reported less anxiety, it cannot explain why they were more excited (aroused) than the other two groups nor can it explain the reliable density x motivation interaction in the discussion activity. A similar argument can be lodged against the expectation of negative outcomes hypothesis of Geen (1976). Although this assertion is highly tentative and deserves considerable testing, we believe that a more parsimonious explanation for our findings and other research on social facilitation and crowding will stem from a hypothesis of generalized arousal as a function of density, task parameters such as those discussed above, and variables which affect anticipated or actual violations of personal space.

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