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SOCIAL DEPRIVATION AND STIMULUS SATIATION

IN THE RAT

DISSERTATION

Presented in Partial Fulfillment of the Requirements for the Degree Doctor of Philosophy in the Graduate School of the Ohio State University

by

Lloyd Reynolds Sloan, B.A., M.A.

* * * *

The Ohio State University

1972

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CHAPTER I

Introduction

When laboratory rats are deprived of social contact by being housed in isolation, they subsequently spend much more time affiliating than do rats who are socially housed (Latané, Cappell and Joy, 1970; Latané, Nesbitt, Eckman and Rodin, 1972; Cappell and Latané, 1969; Walton and Latané, 1972; Latané and Walton, 1972; Poor and Sloan, 1972; Latané, Schneider, Waring and Zweigenhaft, 1971). For example, Latané, Cappell and Joy (1970) found that rats housed in pairs maintained only 53% time in contact, while singly housed rats were in contact for 70% of their time in the open field. Another typical study found pair-housed animals in contact 33% of the time while socially isolated rats averaged 61% time in contact (Cappell and Latané, 1969). The present dissertation began as an attempt to explore two questions related to such social deprivation effects.

One question involves the specificity of the consequences of social deprivation. Is social deprivation specific in nature, caused solely by the absence of a rat housing mate, or is it a symptom of a more general deprivation? If isolation produces a general form of deprivation, then non-rat substitutes should serve to cure the loneliness of social deprivation. Two experiments provide some evidence relevant to these questions.

Latané, Poor and Sloan (1972) housed rats alone, in pairs or with
a tennis ball. The tennis ball is similar to the rat in color, texture, size, is easily played with and should provide a stimulating and activity rich environment. When rats from all three housing conditions were tested for social attraction to other rats, those housed with rats were much less affiliative (29%) than those housed in isolation (53%) but those housed with the tennis ball were as gregarious as those housed in normal isolation. The tennis ball had not mollified their social deprivation state. Similarly, rats housed with a tennis ball were less attracted to other tennis balls (5%) than those in other conditions (9%), but social housing did not reduce attraction to the tennis ball. The housing effects were object specific, reducing the need to interact with that type of object (rat or ball) but not the other type. Perhaps there is some meaningful distinction, therefore, between social and nonsocial interaction (Barnett, 1963) in terms of their general effects, but both types do seem to be guided by the same laws.

When rats, gerbils and hamsters were housed in various combinations however, Walton (1972) found, although the evidence was somewhat inconsistent, that cross species housing did seem to satisfy some same-species sociability needs. For example, rats housed with gerbils were less attracted to other rats (41%) than rats housed in isolation (50%) although they were no more attracted to gerbils. Rats, therefore, are not the only objects which can satisfy the deprivation state caused by a lack of rat companionship. Other rather dissimilar rodents also serve to reduce the need for conspecific contact. To this extent at least,
social deprivation may not be specific. It is not clear then, just how general the deprivation state is, nor what variety or quality of objects might satisfy that need.

A second question has to do with the character of social deprivation. One possibility is that isolated animals may be stimulus deprived. Various studies (e.g., Glanzer, 1953; Premack, Collier and Roberts, 1957) have shown that stimulus deprived rats explore more than stimulated animals. Thus isolated rats may have been seeking stimulation in their heightened desire for affiliation. That living organisms from insect, to rat, to man seek stimulation is a well accepted fact (Berlyne, 1950, 1960; Barnett, 1958). One of the things which rats receive in socializing is stimulation from its comrades. When rats interact, their crawlings over and under, wrestling and intense investigations of one another can only be described as invigorating and engrossing activities, and must certainly be stimulating. Latané and Cappell (1972) have shown that rats exhibit higher heart rates in presence of another rat than when alone in the open field. Since stimulation has just the "drive-like" qualities (Berlyne review, 1950) attributed to sociability in the above research, it is reasonable to suppose that stimulation may mediate sociability in the rat.

An alternative to stimulus deprivation is that social isolation leads to activity deprivation. Casual observation of environmentally adjusted rats reveals that they are very active creatures even when bodily needs have been satisfied. They like to engage in activity as evidenced by their propensity to run in activity wheels on and off for
hours. When deprived of all other activities, they will even press levers in the side of a box at considerable rates.

A final possibility, not explored here, is that rats have a need to engage in the give-and-take which characterizes rat social interaction, and that social isolation produces interaction deprivation. When such needs are satisfied in social housing, less interaction would be sought in the open field.

If rats were housed in the same cage but separated by wire screen, they could have visual stimulation but neither physical interaction nor the opportunity to be particularly active. Walton and Latané (1972) examined precisely this situation. Although the opportunity for physical interaction quickly and strongly decreased the need for subsequent gregariousness, visual stimulation became similarly effective over time. These results suggest that the housing effect is not due simply to activity or interaction deprivation since perceptual stimulation alone will reduce sociability needs.

Another variable interacts with, and thereby complicates the housing effect. Rats are more gregarious in familiar environments than in unfamiliar ones; thus, sociability increases over days of testing (Latané, 1969; Latané, Cappell and Joy, 1970; Latané, Nesbitt, Eckman, Rodin, 1972; Walton and Latané, 1972; Latané and Glass, 1968; Latané and Werner, 1971; Latané, Joy, Meltzer, Lubell and Cappell, 1972; Cappell and Latané, 1969; Joy and Latané, 1971; Latané, Poor and Sloan, 1972; Eckman, Meltzer and Latané, 1969; Latané and Walton, 1972; Latané, Schneider, Waring and Zweigenhaft, 1971). It appears that
higher gregariousness is revealed as competing responses of fear and exploration drop out (Eckman, Meltzer and Latané, 1969; Latané and Walton, 1972).

Typically, the differences between housing conditions are not apparent in the first few days of testing when fear and exploratory responses are prevalent. As they drop out, differences in gregariousness among housing conditions are revealed, leading to a housing by day of testing interaction (Cappell and Latané, 1969; Latané and Glass, 1968; Latané, Cappell and Joy, 1970; Latané, Poor and Sloan, 1972 and Walton and Latané, 1972). Thus, studies employing various housing conditions or manipulations proposed as functional equivalents of sociability should produce stronger effects on later days of testing. Because of the effects of increased familiarity with the repeated testing situation, any variable which affects sociability should also produce an interaction of that variable with days of testing. Consequently, the main effect and the interaction with days will both serve as indicators of the variables' effectiveness in affecting sociability.

The studies which follow manipulate the intensity of stimulation impinging on subjects in housing. Several experiments examine the interaction or activity need versus stimulation need arguments by comparing perceptually stimulated rats with those living in an enriched response environment. Sources of both general stimulation (strobes, radios, slides; handling, human activity) and specific stimulation (various sized rats and housing arrangements) are employed.
CHAPTER II

Experiment 1

Is the deprivation caused by social isolation of a general or of a specific nature? Is there a substitute for a rat cagemate? If the deprivation is a rather general one in its consequences, then a variety of things should satisfy that deprivation. Living in the presence of one of those things should lessen the need for gregariousness in subsequent testing.

If social deprivation is a generalized deprivation, is it primarily stimulus deprivation or activity deprivation? The question is really whether stimulation or activity opportunities would make the best substitute for a cagemate.

What a cagemate represents should be a cue to the nature of what is sought. The housing partner provides a highly changable and significant element in the rat's environment. It moves, smells, makes noises and behaves in an unpredictable manner. It acts on the subject as a stimulus. The housing partner also provides an object for activity. The subject can act on it.

The isolated rat may then be deprived either of the stimulation received from the other rat or of the opportunity to engage in activity directed at the cagemate. In the following experiment, conditions providing nonsocial stimulation or an enriched activity environment are compared to normal controls. This is therefore an attempt to identify nonsocial equivalents of sociability as well as to identify
the relative importance of stimulus deprivation and activity deprivation in motivating gregariousness.

Either activity or stimulation could be effective in reducing sociability. If either or both are actually responsible for the housing effect, then the reduction in gregariousness should be greater for socially deprived rats than for group living animals. Socially housed rats would presumably be socially satiated.

Method

Rats lived in normal unadorned empty cages, cages containing objects with which they could play or cages exposed to external stimulation. In each of these conditions, rats lived in pairs or in isolation. Rats were tested for evidence of social attraction.

 Subjects. One hundred forty-four, 80-day old male Sprague-Dawley albino rats were randomly assigned to each of the three Stimulation-Activity experimental conditions. Half of the 48 animals in each of the above conditions were housed in pairs and half in isolation in single cages. Animals were so housed for three weeks prior to and during the eight days of testing. Rats were maintained on ad lib. food and water while in the laboratory.

 Apparatus. The apparatus was a wooden circular open field 4 feet in diameter with an 18 inch wall. The field was painted flat white and the floor divided by painted black circles and radii into 49 numbered sections of equal area and approximately the same shape.

 Procedure. For three weeks prior to and during testing, subjects were maintained in one of the following conditions:
Stimulated rats were continuously exposed to radio music, alternating high intensity lamps, strobe lights, and a continuous slide show projecting modern art, campus scenes, adjective trait sets and nudes (both pornographic and "artistic"). Room odor was altered by the use of variously scented air fresheners. There were no formal checks on the stimulation manipulation other than the dependent variables reported here. Subjectively, stimulated rats were more insensitive to presence of the experimenters and maintenance personnel in their housing-stimulation room than were other housing groups. They were also more violent in their reactions to handling than were Activity and Normal rats.

In another room, Activity rats were housed in cages equipped with two wooden blocks, a plastic golf ball, and frequently renewed cardboard scraps which the rat could and did chew, rearrange in heaps and otherwise manipulate extensively. Cotton swatches were fixed on the front of each cage, providing more material for collecting, hoarding, and play.

Normal (control) rats were housed in empty cages for which no unusual stimulation was planned. All rats were tested with a pairmate (not their cagemate) from the same experimental condition for five minutes daily for eight consecutive days of trials.

Measures. Gregariousness was taken as the percentage of time rats maintained physical contact during the five minute testing periods. Contact was timed whenever the rats touched one another, including vibrissa, but excluding tail to tail contacts.
Results

Gregariousness increased over days of testing as is common in this paradigm ($F = 27.20; \text{df} = 6,66; p < .001$) and the effect was primarily linear ($F = 143.00; \text{df} = 1,66; p < .001$). This increase in sociability over trials is apparently due to the dropping out of explorations and fear responses which compete with social behavior (Eckman, Meltzer, and Latané, 1970).

As in many previous studies (Cappell and Latané, 1969; Latané, Poor and Sloan, 1972; Latané, Cappell and Joy, 1970; Latané, Nesbitt, Eckman and Rodin, 1971; Walton and Latané, 1972; Latané and Walton, 1972), animals housed in isolation were more sociable when tested in the open field than were pair housed rats ($F = 12.57; \text{df} = 1,66; p < .001$). The increase in gregariousness over days for single housed animals was greater than for socially housed rats (interaction $F = 2.53; \text{df} = 7,61; p < .03$).

The housing main effect was contributed almost entirely by Normal condition rats ($F = 14.40; \text{df} = 1,22; p < .001$). Differences between socially deprived and satiated rats were not significant in either the Perceptual Stimulation condition ($F = 2.00; \text{df} = 1,22; \text{n.s.}$) or the Enriched Activity condition ($F = 1.74; \text{df} = 1,22; \text{n.s.}$). These differences, however, were not sufficient to produce a Stimulation x Housing interaction ($F < 1, \text{n.s.}$).

The Stimulation-Activity manipulations had no overall effects on gregariousness in the open field ($F < 1, \text{n.s.}$). Rats exposed to perceptual stimulation spent no more of their time in the open field in
Figure 1
Percent time in contact as a function of housing, stimulation-activity conditions, and trials: Experiment 1.
PERCENT TIME IN CONTACT

SINGLE HOUSED

DOUBLE HOUSED

△ △ = STIMULATED

○ ○ = ACTIVITY

■ ■ = NORMAL

DAYS OF TESTING

1-2  3-4  5-6  7-8
Table 1
Experiment 1: Percent Time in Contact

<table>
<thead>
<tr>
<th>Housing</th>
<th>Stimulation Housing Condition</th>
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<tr>
<td></td>
<td>Perceptual Stimulation</td>
<td>Motor Responding</td>
<td>Normal</td>
<td>Average</td>
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<tr>
<td>Single</td>
<td>31.7%</td>
<td>31.1%</td>
<td>33.5%</td>
<td>32.1%</td>
<td></td>
</tr>
<tr>
<td>Double</td>
<td>28.0%</td>
<td>26.6%</td>
<td>24.3%</td>
<td>26.3%</td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>29.9%</td>
<td>28.9%</td>
<td>28.9%</td>
<td>29.2%</td>
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physical contact (30%) than did those with enriched activity environments (29%) or those housed in plain quiet cages (29%).

**Emotionality.** Overall, rat pairs in all conditions produced 2 boluses per testing session and remained immobile for 5.7 ten second periods. There were no differences in defecation or immobility between stimulation or housing conditions ($F$'s <1). Consistent with the suggestion that increasing familiarity with testing reduces fearfulness (Eckman, Meltzer and Latané, 1969), defecation decreased over days ($F = 56.04; df = 1,66; p < .001$).

**Discussion**

The results of this first study indicate that stimulation is not effective in reducing sociability needs in socially deprived animals, although it did trivially, reduce housing differences. The opportunity for additional non-social activity was no more effective than stimulation. This could well indicate the failures of the Stimulation and Activity Deprivation hypotheses, but there are other possible explanations.

An alternative is that the manipulation was simply not strong enough, that the type of stimulation provided here was not particularly well adapted to the simple and rather near-sighted rat's reception senses. Possibly the animals had simply habituated to the continuous massive doses of stimulation employed here. A similar argument might be made for the absence of Activity consequences. However, as noted above, the Activity objects were well chewed and rearranged, suggesting that those rats engaged in at least some additional activity.
It is noteworthy that overall time in contact in this experiment was reduced to only 29% while 40 – 75% has been typical in many previous studies. This overall decrement in gregariousness may have diminished the magnitude of any true stimulation-activity effects. It may also be a clue to the nature of the variables underlying the housing effect. This possibility will be further developed following Experiment 2.

Experiment 1 (Replication) used the same mechanical stimulation sources but eliminated the enriched activity condition (see Appendix A). Ninety-six rats received Stimulation or Normal conditions continuously while housed alone or in pairs. When observed for sociability in the open field, alone housed rats were more gregarious (45% time in contact) than those housed in pairs (36%). Stimulated rats (40%) were no more and no less gregarious than Normal condition animals (40%), replicating the results of Experiment 1.
CHAPTER III

The Effects of Exposure to Humans on Sociability

Experiment 2 (Pilot study) employed both the mechanical stimulation and 3 hours daily of exposure to human activity prior to testing (see Appendix B). Normal, Stimulation plus Human Exposure, and Activity single housed rats and Normal double housed animals were observed for evidence of social attraction in the open field. Once again, rats housed in social isolation were more gregarious (61%) than those socially housed (47%). Exposure to active humans served to reduce isolated rats’ sociability (52%), while the Enriched Activity Environment (57%) did not. The combination of Stimulation and Exposure to humans was almost, but not quite as successful as social housing in decreasing gregariousness.

If a state of general stimulus deprivation accounts for social isolates' increased gregariousness, then the various stimulation treatments (strobes, slides, radio, odors) should have satisfied the deprivation - they did not. A more specific stimulus, Human Exposure in combination with Stimulation, did lessen the deprivation state. In fact, Human Exposure may be largely responsible for the sociability changes produced in Experiment 2: Pilot. There is additional evidence to support this suggestion.

Human exposure effects on gregariousness. Experiment 2: Pilot produced much higher levels of overall sociability (57%) than either
of Experiments 1 (29%) or Replication 1 (39%). The reduction in
gregariousness for Experiment 1 and its replication is curious since
40 – 75% has been typical in previous smaller studies.

Another report of reduced overall gregariousness (Sloan and
Latané, 1971) suggested that it might have been caused by the stimulation
of high levels of human activity in the housing rooms. In that
study, human activity persisted for at least 12 hours per day and time
in contact dropped to only 30%. The effects of differential housing
and days of testing are normally quite robust. In Sloan and Latané,
these phenomena were weakened or washed out entirely, suggesting that
the stimulation of nearby human activity can inhibit or satisfy
affiliative desire. In Experiment 1, room activity due to maintenance,
neighboring experiments, and experimental testing itself typically
exceeded eight hours per day. In the replication, exposure to humans
occurred at least 6 hours each day. If this additional stimulation
prior and during the daily testing period accounted for the overall
decline in gregariousness, then it may also have minimized experimental
effects.

There are other explanations of course. The animals of Experiment
2: Pilot were considerably older than when they participated in
Experiment 1; they were also older than the subjects of Replication 1.
Age is not known to affect sociability however.

Perhaps a more likely explanation than subject age lies in the
fact that these animals had been tested before in the open field. Their
increased familiarity with the open field, compared to their own naive
performance and that of Replication 1 rats, could be expected to reveal a much higher level of gregariousness. This suggestion appears insufficient to account for all of the differences between experiments. If differential familiarity were solely responsible, then the level of gregariousness achieved at asymptote over days in Experiment 1 (37%) and the Replication (47%) should equal that displayed in Experiment 2: Pilot (57% overall), and it clearly does not. A more direct test of the human exposure level manipulation, confounded here with other conditions, is strongly suggested.

If the stimulation of human exposure serves to satisfy sociability needs, then rats tested late in the day may show less gregariousness than those tested early in the day's activity. The relationship between daily testing order and gregariousness was negligible in Experiment 1 \( (r = .01; \text{n.s.}) \) and Experiment 1: Replication \( (r = -.01; \text{n.s.}) \). It appears that the short term effects of stimulation are not great. Stimulation may find impact in terms of the longer term cumulative total absorbed by the subject rather than the level immediately preceding testing.

Thirty-one published experiments and theses were examined for a relationship between overall human activity level and overall gregariousness.\(^1\) The overall correlation between activity level and

\(^1\)The 31 experiments produced 58 separate entries or cells of about 14 rats or rat pairs per entry. Correlations were between distance apart or time out of contact and the number of testing observations per day per experiment. The number of testings per day was adjusted for experiments using tethered stimuli (which take longer to execute) and other special events (injections, lengthened observation periods, etc.). Within-cell correlations employed cells representing experimental factors; housing (single-double), measure (distance-time) and experimental length (6 days-less than 6 days). (See Appendix C for entry table.)
gregariousness was negative and significant ($r = -.42; v = 58; p < .01$). The more activity present daily, the lower the overall gregariousness observed in the experiment. As noted earlier, isolates should be more affected by stimulation and they were. Activity and gregariousness correlated $r = -.49 (v = 29; p < .01)$ for isolates and only $r = -.34 (v = 14; n.s.)$ for socially housed animals, but the two correlations did not differ reliably. Although the result is not significant due to the small sample, the magnitude of the housing effect was weaker in higher activity experiments ($r = -.32; v = 13; n.s.$).

Sociability is revealed as familiarity with the testing situation increases and competing responses of fear and exploration drop out. Consequently, sociability altering influences should be more observable in longer experiments. Experiments of 6 days revealed much stronger relationships between activity and gregariousness ($r = -.44; v = 39; p < .01$) than those of 4 or fewer days ($r = -.14; v = 19; n.s.$). These data strongly suggest that the stimulation of human presence in the housing area is an effective mediator of sociability needs.

**Stimulation effects: Inhibition or satiation of sociability?**

The true relationship between any form of stimulation and subsequent sociability remains unspecified, however. Stimulation could indeed be satiating some portion of the animal's needs for gregariousness or it could merely be inhibiting the expression of an otherwise unaffected desire for affiliation.

If stimulation in one form or another, does act directly upon social desires, then it should have little effect when social desires
are sated, as they are for double housed rats. On the other hand, single housed animals with deprivation-enhanced social desires should show the effects of stimulation readily. Thus, it is necessary to examine the effects of stimulation on a population of both isolated and multiple housed animals. If stimulation is effective then it should be more effective for single housed rats than for double housed rats. Supporting this position, the differences between single and multiple housed rats in both Experiments 1 and Replication 1 were trivially weaker for Stimulated animals relative to Normally housed controls.

If on the other hand, stimulation treatments serve to inhibit the expression of sociability, it should be equally strong for both single and double housed rats. Gregariousness might, if anything, be even more reduced by double housed animals since the continuous negative stimulation would be associated with the presence of another rat. This prediction of unchanged or increased magnitude of housing effect for Stimulation condition animals was not supported in either Experiment 1 or its replication.

In compounding stimulation and exposure to humans to enhance the experimental manipulation, Experiment 2: Pilot incorporated several undesirable procedures; unbalanced testing orders and the exclusion of some comparison double housed conditions. Experiment 2 employed improved procedures, control groups, and the apparently more effective treatment of exposure to human activity, to replicate and extend the results of Experiment 2: Pilot.
CHAPTER IV
Experiment 2

The results of Experiment 2: Pilot suggested that Human Exposure in the housing area may have functioned as effective stimulation in reducing the observing subjects' interaction with other rats. The present experiment sought to replicate that finding by extending and intensifying the amount of human activity in the housing area of the experimental groups. In addition, another intensive mode of interaction and stimulation, handling, was employed for comparison.

Handling is undeniably stimulating to the handled or "gentled" animal, though the exact nature of the stimulation is not clear. Some experimenters have observed handling to be a positive and apparently pleasant occurrence for their subjects (Welker, 1957; Boice, et al., 1967; etc.), while others have found avoidance of gentling in choice situations (Candland et al., 1960). In any case, handling seems to be a significant and stimulating event in the rat's daily life.

Pursuing this theme, Werner and Latané (1970) examined the attractiveness of a responsive human hand. Their results support the suggestion that handling could be a positively reinforcing event. A playful, responsive human hand was more attractive than a randomly moving or limp one and was nearly as attractive as a tethered animal. Rats interacted with the compassionate hand much as they would with a rat, sniffing it, crawling on and over it and allowing it to scratch,
prod and investigate them. Attraction to the responsive hand paralleled that to rats. Socially deprived rats were more attracted to the hand than were socially housed animals. Attraction to the hand increased over trials and did so to a greater extent for isolated rats, just as does attraction to other rats. In many respects, the interactive hand seems a functional equivalent for the rat as a stimulus. Experiment 2, employs this functional replacement in an attempt to reduce the social deprivation of isolated rats.

When rats were prehandled in the Werner and Latané studies, these animals were trivially less sociable with other rats. Prehandling did however, last only a few minutes once each day. More extensive handling might reveal greater effects upon subsequent gregariousness. Thus handling should be a very potent form of stimulation and if the stimulation-sociability hypothesis is correct, enough handling should reduce the handled subjects' need for gregariousness. It should be noted that higher levels of stimulation may also habituate fear of the testing situation and thereby enhance the expression of gregariousness in early trials (Eckman, Meltzer and Latané, 1969). This could diminish the possible gregariousness reducing effects of the stimulation received from handling.

Method

Subjects were housed in single cages alone or with another rat in either quiet undisturbed rooms or in the stimulation and handling room. Rats were again observed for sociability in the open field with a free roving partner.
Subjects. One hundred forty-four, 65 day-old Sprague-Dawley male albino rats were randomly assigned to the three stimulation conditions. One half of the 24 pairs in each stimulation condition were housed in pairs in single cages and the remaining half in isolation. Rats were housed in this fashion for the duration of the experiment beginning one week prior to the initiation of handling and stimulation and 12 days prior to the beginning of testing in the open field. Food and water were available ad lib. at all times in housing.

Procedure. The following experimental conditions were maintained for 5 days prior to and 6 days during testing:

Handled rats were removed from their cages by gloved handlers who rubbed, petted, stroked, scratched and playfully responded to the rat's movements on a holding table or on the handler's arm. Handling lasted approximately 60 seconds for each rat on each round of handling; all animals in this condition were handled on each round. Handling progressed continuously for about 8 hours each day. This amounted to about 14 sessions of handling per rat per day. When daily testing began the handling conditions were maintained, 4 hours immediately before the daily testing period began and 4 hours during observations.

After handling, many pairs were observed to engage in distinctive rough and tumble "play" or "dominance wrestling" in their home cages. As an indicator of the arousal generated by handling, the number of double housed pairs displaying such behavior was noted during each round.

An average of 19% of Handled pairs engaged in cage-rattling, rough
and tumble wrestling after being handled; such behavior occurred in only 3% of Exposed pairs. Disturbances decreased over rounds as the day progressed from 1st round, 44% to last round 4% and likewise decreased slightly over days of handling from 35% on day one to 17% on the last day of testing.

The function of these encounters and their detailed implications are difficult to assess at present. Here they are taken as simple indicators of the arousal produced by handling and thus as evidence for the intensity of the stimulation rats received from the handling experiences.

*Human exposure* rats were housed on alternating rows of the cage rack which also housed the Handled animals. Thus, they observed and heard intensive human activity for at least 8 hours each day as their peers from the same rack were removed from their cages, handled, and returned at intervals of about one minute. Opening and closing cages, moving to and fro in front of the housing rack, and so forth, is very similar to daily maintenance. It was precisely this type of activity which was hypothesized to account for differences in overall sociability reported in earlier work and in the present experiment.

*Normal* animals were housed in two isolated quiet rooms. By counterbalancing the testing fields' schedules, each room was entered only 6 times per day for testing and only once per day following testing for about ten minutes for testing. The levels of external activity and stimulation presented the Normal group was obviously very much less than that received by the Human Exposure or Handled condition.
animals. Beyond that, the conditions experienced by Normal rats were very much the same as those experienced by subjects in short daily duration, small population experiments. Conditions impinging upon the Exposed rats were very much like those influencing large duration, large population subjects.

Results

Gregariousness. Replicating the vast majority of findings in this paradigm, these open field naive rats become more gregarious over days of testing (linear $F = 4.05; \text{df} = 1,66; p < .05$). This days effect is however, much weaker than that usually produced, as is the overall level of gregariousness (37%) when compared to past experiment's average of 57% time in contact. The weak trials effect and low overall time in contact is reminiscent of the results of long daily duration, large population studies such as Experiment 1 reported here. If it is indeed the stimulation produced by room activity which reduces overall gregariousness and thereby diminishes the days effect, then the Human Exposure and Handled conditions should show much less influence of trials than the Normal animals. This was the case. The Handled-Exposed condition by trials (days) interaction was significant ($F = 6.58; \text{df} = 2,66; p < .01$). Independently analyzed, the Normal rats' increase in gregariousness over days was highly significant ($F = 19.19; \text{df} = 1,11; p < .001$). The effect fell well short of significance for both the Handled ($F < 1; \text{n.s.}$) and Human Exposure groups ($F < 1, \text{n.s.}$). Clearly the Normals behaved rather "normally" on this indicator, asymptoting in the range usually encountered (40-75% time in contact).
Figure 2
Percent time in contact as a function of housing, exposure-handling conditions, and trials: Experiment 2.
PERCENT TIME IN CONTACT

50

40

30

20

1-2 3-4 5-6

DAYS OF TESTING

PERCENT TIME IN CONTACT

60

50

40

30

20

1-2 3-4 5-6

DAYS OF TESTING

SINGLE HOUSED

STIMULATED

HANDLED

NORMAL

STIMULATED

HANDLED

NORMAL

DOUBLE HOUSED
The Handled and Human Exposure rats displayed the reduced day's effect associated with at least several long daily duration studies, asymptoting at only slightly more than 40%.

Rats housed in isolation were much more sociable (43% time in contact) than those housed in pairs (30%) ($F = 67.76; df = 1,66; p < .001$) and this differential sociability increased over days of testing (linear $F = 6.72; df = 1,66; p < .02$), replicating Experiment 1 and earlier work cited there.

Overall, the two Handled-Exposed conditions (36%) were only marginally less gregarious than the Normal rats (39%) ($F = 2.35; df = 1,66; p < .15$). The overall main effect was depressed by the fact that Normals were at least slightly less gregarious than the Exposed-Handled rats during the first two days of testing. This might well have been due to the Exposed-Handled condition's greater adaptation to and familiarity with the stress of human presence and handling (Montgomery and Monkman, 1955; Ehrlich, 1961).

As noted above, the marginal overall difference between Handled-Exposure conditions and Normals, became more reliable over days of testing ($F = 3.30; df = 1,66; p < .05$) (see Figure 3). Over the last three of the six days of testing, effects were pronounced: the Handled and Exposed animals were less sociable (36%) than the Normal condition rats (42%) ($F = 5.76; df = 1,66; p < .02$) and did not differ among themselves ($F < 1, n.s.$). It is apparent that the human exposure — handling manipulations produced the predicted effects upon gregariousness. The absence of differences in gregariousness between
Handled and Exposed animals is not too surprising. As noted above, handling may be a more stimulating event than merely observing human activity since it could alleviate response as well as stimulus deprivation. It should also provide greater familiarity and adaptation to the testing environment, thereby enhancing sociability.

Alternatively, it is probable that other factors are involved in animal's needs for gregariousness and that the consequences of these specific forms of stimulation can account for only a given portion of, for example, the variance in sociability needs between isolated and group living animals. Even after sociability levels began to asymptote here, the human exposure and handling manipulations reduced gregariousness by only about one-half the magnitude of the difference between Normal single and double housed rats.

The housing effect mentioned earlier has implications for the nature of the stimulation-sociability relationship. This housing phenomenon was also reduced by the exposure handling manipulations as it has been in several earlier long duration, large population studies and in stimulation Experiment 1 and its replication here. After performance asymptoted, the enhanced gregariousness of isolated rats over double housed animals was much greater for Normals than for Exposed-Handled rats ($F = 5.08; df = 1,66; p < .05$). Thus the handling-exposure manipulations produced both the predicted main effect and the interaction with housing condition.

This interaction between treatment and housing conditions was mainly a result of differences in influences upon isolated animals.
Single housed Exposed-Handled animals were less group (42%) than Normals (52%) ($F = 9.86; \textit{df} = 1.33; p < .01$), while double housed stimulation condition produced no differences ($F < 1, \text{n.s.}$). These results are precisely what one would expect if handling-exposure manipulations were affecting a need for sociability or whatever the desires are which are reduced by being housed with another rat. If social living provides the same satisfactions that these forms of stimulation do, then double housed rats should not be very affected by stimulation manipulations, whereas single housed rats would be. This interpretation describes the present results.

If stimulation acted not on the need for sociability in the rat but rather inhibited the expression of sociability through qualitatively unrelated variables (e.g. fear), then animals differing in sociability needs would be similarly affected by inhibitory processes. The fact that double housed animals do not display the same stimulation effects as do single housed rats casts doubt on the inhibition interpretation of stimulation effects.

**Emotionality.** Handled rats were less immobile (3.0 ten second periods) than Normal and Human Exposure animals (4.3) ($F = 8.37; \textit{df} = 1.66; p < .01$). However, Handled and Exposed animals defecated more (4.5 per session) than Normal rats (3.4) ($F = 4.41; \textit{df} = 1.66; p < .05$). Both immobility and defecation decreased over days of testing ($F = 29.94; \textit{df} = 1.66; p < .001; F = 9.48; \textit{df} = 1.66; p < .01$).

**Discussion**

Experiment 2 and the preceding pilot test strongly suggest that
there is some commonality between the consequences of exposure to humans and exposure to rats. Manipulations which increased various experimental conditions' exposure to humans produced reductions in subsequent gregariousness with other rats. Human exposure and handling produced three primary effects: (1) an overall reduction in the level of gregariousness, (2) a weakening of the magnitude of the effect of isolate versus social housing, and (3) a simultaneous diminishing of the trials effect which typically leads to increasing gregariousness.

The mechanical stimulation sources utilized in Experiments 1 and 2 did not lead to any changes in rat sociability. The apparent stimulus deprivation created by isolation housing is clearly not a general deprivation state. Instead, certain specific types of stimulation have been identified which apparently satisfy the needs created by social deprivation.

It should be noted that the animate versus inanimate dimension used here to discriminate between Experiments 1 and 2 is not the only plausible explanation. Experiment 1 and its replication provided continuous exposure with no rest periods from compounded stimulation sources. This schedule of exposure may well have allowed habituation to the mechanical stimulation. Experiment 2 on the other hand, employed human exposure intermittently. This schedule allowed quiet recovery periods which could have served to enhance the consequences of human exposure.

Although there are commonalities among the first and second
experiments (e.g., the reduction in the housing phenomenon for stimulated and for exposed animals) it is apparent that some forms of stimulation have much more impact on subsequent gregariousness than others. It would seem that the mechanical stimulation employed in Experiment 1 and its replication (slides, strobes, radio, etc.) was simply insufficient. This could have been a result of subject's adaptation to the continuous (24 hours per day) stimulation from mechanical sources. On the other hand, it should be recalled that Experiment 1 and Replication 1 had large populations and Normal condition subjects therefore received a great deal of perceptual stimulation. This intense and lengthy stimulation added to all factorial conditions may well have reduced differential independent stimulation results between experimental and control conditions.

In any case, the only experiments to produce positive stimulation influences on gregariousness employed some human exposure as a source of specific stimulation for the subjects. In both Experiment 2 and its pilot the exposure stimulation was not continuous and did immediately precede the daily testing period. In this way, adaptation to the situation was less likely to occur. Additional steps were also taken to insure solitude for Normal rats in order to sharpen the manipulations of exposure and handling. Despite these differences, the observer is subjectively inclined to believe that human movement is a much more potent specific source of stimulation for rats than slides, strobes and country music. Human activities, though routine to the experimenters, are highly complex and rich in variability
compared to the mechanical arrangements employed in Experiment 1. Human movements in the housing room pursuing maintenance or handling tasks must be more dynamic, unpredictable and therefore more stimulating.

The results of Experiment 2 also suggested explanations for differences in gregariousness between earlier experiments. Long daily duration and large population experiments can be reasonably construed to provide more environmental stimulation than small experiments due to the much greater amount of human activity in the housing rooms. Compared to relatively small studies, these long duration, high total activity studies produce results similar to those of stimulation conditions. Common to both situations are decreases in the effect of trials and the overall level of gregariousness. Clearly then, the amounts of stimulation received by subjects in social behavior investigations must be well considered and controlled if spurious conclusions are to be avoided. This is especially true in that the trials and housing effects are normally highly reliable and are used as markers of design and analytical sensitivity. Their absence in experiments with highly stimulating housing environments would reflect very meaningful phenomena related to social behavior rather than an artifact of methodology.

Experiments 1 and 2 investigated the effects of general and specific sources of stimulation on sociability, pursuing the hypothesis that seeking sociability is, in part at least, seeking stimulation. In the following series of studies, attempts are made to vary the amount of
social stimulation available from various partners in order to
genitalize and extend the stimulation-sociability hypothesis. If
varied amounts of social stimulation produce the same pattern of
results as different quantities of nonsocial stimulation, then common
underlying variables can be assumed to mediate sociability. This
relationship will have additional implications for the nature of the
stimulation (general or specific) which is functionally equivalent
to sociability.
CHAPTER V

Social Sources of Stimulation

As noted in the introduction, there seems little doubt that rats are attractive and stimulating to one another. In the presence of another rat their heart rates rise; even when continuously housed with other rats, their sociability desires are not completely sated and they remain much closer together than would be expected by chance. These facts are consistent with the hypothesis that the rat is a curiosity arousing stimulus for his conspecifics, and not quite what one would expect from a simple notion of a "need for sociability." If the novelty provided by the unpredictable and largely uncontrollable actions and responses of a cage-mate were stimulating, then they would tend to satisfy the stimulation needs of a stimulus deprived isolated rat. Since these behaviors were stimulating, they would continue to engender interest even after the stimulation deprivations were satisfied.

Just as rats are more attracted to novel and complex non-social objects in their environment, they seem to be more attracted to the more animated entities around them. A limp human hand is less attractive than a responsive playful one which in turn is somewhat less attractive than another rat. Tranquilized rats are less attractive than more responsive normal animals. Animals which could only see a cagemate through a screen were thus deprived of some of the stimulating aspects
of physical interaction. They were more gregarious in later testing than socially housed rats but were less gregarious than socially isolated rats.

If part of the novelty and stimulus value of another rat is its unpredictable and uncontrollable behavior in interaction with another rat, then different size (age) rats should provide differing amounts of stimulation. A larger cagemate should be less controllable and predictable than a smaller one. A large cagemate should be more stimulating if for no other reason than that he is a more significant stimulus in the environment than a less imposing smaller animal. If large cagemates do provide more stimulation than small cagemates, then their housing partners should be less sociable than those housed with smaller animals.

Experiment 3 (Pilot Test) housed the 26 eighty-day old subject rats with a cagemate either half or twice their own age. Subjects were observed for social attraction to an equal-age stimulus rat tethered in the open field. Rats housed with smaller cagemates were more sociable than those housed with large partners. These results are consistent with the notion that larger rats are more stimulating and that this stimulation satisfies sociability needs.

Experiment 3 was created for two purposes. First, to replicate and extend the present findings regarding cagemate size and sociability. Second, to test the assumption that larger stimulus rats are more attractive than smaller ones.
Experiment 3

One of the questions unanswered in Experiment 3: Pilot was the nature of the effect of differential housing on sociability. Does housing with a large animal reduce gregariousness relative to housing with an equal sized animal? Does housing with a smaller rat enhance sociability, or do both of the above occur. The symmetry of the effect is important to interpretations of the nature of the mediating variables involved. To resolve these "baseline" questions, isolated rats and rats housed with equal-sized cagemates were tested as well as those housed with larger or smaller rats.

In order to validate the assumption that larger animals are more stimulating, small, equal and large-sized animals were employed as stimuli for subjects from all housing conditions.

Method

Subjects. Seventy-two, 80-day old Sprague-Dawley male rats were randomly assigned to each of the four housing conditions, and maintained on ad lib. food and water while in the laboratory. All rats remained in these housing conditions for 10 days prior to the start of testing and during the 6 days of testing.

Stimuli. Stimulus rats for use in housing and testing manipulations fall in three classes. Small rats were 40 days of age and averaged 163 grams. Equal rats (equal in size and age to the subjects) were 80 days old and weighed 359 grams. Large rats were 300 - 400 days of age and averaged 634 grams.

Procedure. Prior to and during testing, subjects were housed in
four conditions. Groups of 18 subjects were housed either with Large, Equal, or Small stimulus animals, or alone in a single housing cage. The stimulus animals employed during testing were not the same as those used in the housing manipulation.

Rats were tested for five minutes daily for the 6 consecutive days of observation for social attraction to the stimulus animal. Rats from all conditions were observed for two days with each of the three types of stimulus animals encountered in counterbalanced order.

The primary measure employed was that of gregariousness or total time in physical contact.

Results

**Gregariousness.** Replicating earlier results, rats living in isolation were more gregarious in testing (52%) than double housed rats (45%) ($F = 5.29; df = 1,68; p < .03$).

The size of the housing partner was also important in affecting open field gregariousness. The larger the subject's housing partner, the lower the gregariousness displayed by the subject in subsequent testing ($F = 7.51; df = 1,68; p < .01$) (Table 2). This result is compatible with the social stimulation hypothesis prediction of housing partner size effects on gregariousness.

Once again, gregariousness increased over the two blocks of three days of testing from 42% to 52% time in contact ($F = 48.61; df = 1,68; p < .001$). This increase in gregariousness was lowest for subjects housed with larger partners and highest for those housed with smaller rats (Table 3) ($F = 8.14; df = 1,68; p < .01$). The rate of increase in
Table 2

Experiment 3: Percent Time in Contact

<table>
<thead>
<tr>
<th>Housed</th>
<th>Size of Testing Partner</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Small</td>
<td>Equal</td>
<td>Large</td>
<td>Average</td>
<td></td>
</tr>
<tr>
<td>Alone</td>
<td>47%</td>
<td>51%</td>
<td>57%</td>
<td>52%</td>
<td></td>
</tr>
<tr>
<td>with Smaller Rat</td>
<td>45%</td>
<td>50%</td>
<td>57%</td>
<td>50%</td>
<td></td>
</tr>
<tr>
<td>with Equal Rat</td>
<td>38%</td>
<td>44%</td>
<td>51%</td>
<td>45%</td>
<td></td>
</tr>
<tr>
<td>with Larger Rat</td>
<td>35%</td>
<td>43%</td>
<td>45%</td>
<td>41%</td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>41%</td>
<td>47%</td>
<td>53%</td>
<td>47%</td>
<td></td>
</tr>
</tbody>
</table>
Table 3

Experiment 3: Trials (Days) Effect
on Gregariousness (%Time in Contact)

<table>
<thead>
<tr>
<th>Housing</th>
<th>First 3 Days</th>
<th>Last 3 Days</th>
<th>Percent Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alone</td>
<td>44%</td>
<td>59%</td>
<td>34%</td>
</tr>
<tr>
<td>with Smaller Rat</td>
<td>43%</td>
<td>58%</td>
<td>36%</td>
</tr>
<tr>
<td>with Equal Rat</td>
<td>40%</td>
<td>49%</td>
<td>22%</td>
</tr>
<tr>
<td>with Larger Rat</td>
<td>39%</td>
<td>43%</td>
<td>8%</td>
</tr>
<tr>
<td>Average</td>
<td>42%</td>
<td>52%</td>
<td>25%</td>
</tr>
</tbody>
</table>
sociability for alone housed animals did not differ from that for rats housed with small partners \((F < 1)\).

This finding is very suggestive in light of the parallel it forms to the typically observed smaller increase in gregariousness for socially housed versus isolated rats. If that smaller increase in gregariousness reflects social satiation, then the above results indicate less satiation for rats housed with small cagemates and more for those with large cagemates.

The size of the testing stimulus partner also had a great effect on sociability. The larger the tethered stimulus rat, the more time subjects chose to spend in contact with it \((F = 27.80; df = 1, 68; p < .001)\). This suggests that larger rats are more stimulating and therefore more socially attractive and more capable of satiating sociability needs. Sloan and Latané (1971) found that large males were less attractive tethered stimuli than smaller females. The stimulus males in that study fought frequently and were very aggressive with the free-roving subject males. Thus, aggressiveness or some other situationally sex-related behavior may have overpowered the consequences of stimulus animal size for social attraction.

Finally, there was no interaction between the size of the housing partner and the size of the testing partner \((F < 1)\). The stimulation-sociability hypothesis, of course, predicts only main effects for size of cagemate and size of testing partner.
Emotionality. Replicating earlier findings (Sloan and Latané, 1971) socially isolated rats defecated more (3.2 boluses per session) than pair housed animals (2.4) ($F = 5.87; \text{df} = 1.68; p < .02$). The larger the testing stimulus animal, the fewer boluses were dropped ($F = 3.63; \text{df} = 1.68; p < .05$).

Discussion

The present results are compatible with the notion that the need for stimulation mediates sociability. That interpretation assumes that larger rats are more attractive, and this was amply reinforced by the influence of testing stimulus animal size. Since larger animals are more stimulating and attractive, they would satisfy more stimulation needs in housing, thereby reducing overall gregariousness in testing. Thus, the housing partner size main effect and the absence of an interaction between testing and housing stimulus rats are consistent with implications of the stimulation interpretation.

The housing condition by trials (days) interaction is the final piece of evidence to suggest that social needs have been manipulated here and that stimulation seeking may play a meaningful part in social attraction. Variations in the size of the housing partners affected not only the overall level of gregariousness but the rate of increase in gregariousness over days as well. The pattern of these effects paralleled those of the well known comparison between pair housed and isolated rats, suggesting that differences in housing partner size affect the same variables as does the complete absence versus presence of a similar housing partner.
One other thing which double housed animals may acquire from their housing mates besides stimulation is a reluctance to interact socially as a result of experiencing domination by their partner. This could result in a degree of learned submissive habits, fear or lack of confidence in social interactions.

LeBoeuf (1967) has shown that dominant animals socialize more freely than do submissive dogs. Similar relationships have been observed in chimps, rodents, and other animal forms (Hinde, 1970). In other studies, males housed with much smaller females were much more sociable (and domineering) with other males than were males housed with equal-sized males (Sloan and Latané, 1971). Similar results have been reported by Hudgens, Denenberg and Zarrow (1968) when they housed mice and rats in mixed litters. The suggestion that some form of learned fear or submission or lessened confidence could mediate sociability is further supported by findings dealing with adaptation to the testing conditions. Familiarity with the testing situation produced enhanced sociability in rodents, an effect interpreted as a dropping out of fear and escape responses which reveal prevalent social motives (Eckman, Meltzer and Latané, 1970) or learning functions (Harlow, 1972). If an animal is less fearful of social interaction as a result of learned confidence or fearfulness in housing, then he should be expected to be more sociable in subsequent interaction in the open field. Being housed with a much smaller rat should avail the subject of the opportunity to learn to be confident, dominant, less fearful and therefore more sociable than a similar rat housed with a
much larger partner. Alone housed rats might well be expected to be the most gregarious, as indeed they are. They have experienced no recent dominance from other rats and are therefore most confident and least fearful.

The dominance-learning thesis is consistent with the results of the size of housing partner manipulation. However, this dominance interpretation would not have suggested the greater attractiveness of larger rats. The positing of a "need to be dominated" or a "need to behave submissively" would account for all the present results nicely. It should be noted, however, that many other species appear to behave in quite the reverse manner, avoiding dominant (if not necessarily larger) animals (Hinde, 1970; LeBoeuf, 1967).

One other explanation for the results of Experiment 3 suggests the possibility of contrast influences on the stimulus value of the tethered test rat. Larger animals are more attractive stimuli and therefore probably more stimulating than are smaller rats. The present findings could therefore arise from the subjects' differential perception of the size of the stimulus test animal. A subject housed with a smaller rat would perceive the standard test rat as "larger than life" and thus as a more attractive stimulus than would the subject housed with a larger cagemate. The greater attractiveness of larger stimulus rats is an assumption of the contrast interpretation just as it is in the stimulation-sociability schema. The contrast interpretation finds support in other data as well. When rats were housed in groups of 1-6 (Latané, Cappell and Joy, 1970), the number of
cagemates (one to five) had little effect on gregariousness. Perhaps 5 cagemates would be more stimulating than one, but all being equal in size, would create none of the contrast phenomena suggested here. In defense of the stimulation interpretation, it should be noted that gregariousness decreased as group size increased although the effect was not significant.

It is apparent that the two explanations cannot be compared using the present data since they make the same assumptions and predictions for the outcomes. Further, both posit a phenomenal change in the subject animal as a result of his particular housing condition. The contrast hypothesis assumes that the subject adapts perceptually to the size of the cagemate. The stimulation hypothesis presumes that housing-mate size affects the level of stimulus deprivation-satiation for the subject. The resolution of this question is important to determining the source, internal or external, of the motive for sociability.
CHAPTER VI

Conclusions

The mechanical perceptual stimulation employed in Experiments 1 and its replication was ineffective in altering the sociability of the stimulated subjects. Although the reductions in overall gregariousness for stimulated animals was trivial, both experiments did produce suggestive reductions in the housing effect in groups receiving stimulation. Possibly, the stimulation was insufficiently intense or temporally arranged in a way that allowed habituation. It is likely, however, that these general forms of stimulation do not satisfy sociability needs. Although the timing and intensity of the stimulation may be important, some specific form is apparently required.

Exposure to human activity was suggested as a more effective form of social satiation. Animals tested early in the day should be less stimulated by human exposure and therefore should be more sociable than those tested later. Internal analyses of the effect of testing order in Experiments 1 and Replication 1 earlier studies indicated that the consequences of human exposure were probably cumulative rather than immediate (acting within a few hours). Results from published work in the paradigm further suggested cumulative exposure consequences by revealing that as human activity level increased across experiments, overall gregariousness decreased.
The more variable, intense and novel stimulus of human exposure or handling reduced gregariousness significantly in Experiment 2. Exposure caused isolated rats to become less gregarious but did not affect the sociability of socially housed animals. If human exposure acted to inhibit the expression of sociability, it should have done so to the same degree in isolated or pair housed rats. The data suggest that exposure acts to satiate sociability needs which are, of course, much greater for isolates than for socially housed rats. This is functionally observed as a decrease in the housing effect for exposed animals.

The ability to interact with and respond to another active animal has been shown necessary for maintaining social contact and sufficient to satisfy social needs following isolation. Free play does, however, confound responding, interaction and stimulation factors. One earlier study (Walton and Latané, 1972) had shown that merely observing another animal in housing was sufficient to satisfy sociability desires. In Experiments 1 and Experiment 2: Pilot, living in enriched response environments had no consequences for gregariousness. Experiments 2 and its pilot demonstrated that human exposure from the environment outside the cage could satisfy some of the need for social interaction. These results suggest that isolation produces stimulus rather than response deprivation in its victims.

The types of stimulation necessary to satisfy this deprivation is not specifically produced by conspecifics. Human exposure was sufficient to reduce the need for social interaction with other rats.
However, other more general sources of stimulation (strobes, slides, music, odors) did not mollify the consequences of social deprivation.

Larger rats are more attractive and presumably more stimulating partners than are smaller rats. When housed with standard sized subject animals, large rats satisfied more sociability needs that did small rats. If stimulation is indeed the variable which accounts for the differential attractiveness of variously sized rats, then it also should be assumed to account for their differential effectiveness in reducing subsequent sociability desires in their housing partners.

A final important aspect of the "size of cagemate" finding is its implication for interpreting the housing effect. It is now clear that the presence or absence of others is not the only factor which mediates satiation or deprivation. On some dimensions at least (size of cagemate) the underlying variable or variables are continuous in their effects on sociability. On others (number of cagemates) they may be more discrete in their influences. That continuous sociability must be a function of more than just a "social need" mediated by the length of isolation since when isolation time is equal, cagemate size alone has consequences for attraction to other rats.

Even though isolated rats are more gregarious than pair housed animals, the latter socially housed rats display greater than chance levels of attraction to one another. Social housing does not satisfy all of a rat's desires for affiliation. This suggests that the variable underlying the housing effect may not be the only variable involved in rat sociability. Although other mediators of gregariousness
in the rat probably exist, only those involved in causing the housing effect are directly investigated here.

Size of housing partner manipulation and human exposure procedures produced parallel results. Exposure or living with a larger animal served to reduce sociability needs. Both treatments led to greatly reduced trials or days effects, since there was less sociability to be revealed as competing responses of fear and exploration disappeared over time. These commonalities strongly suggest that exposure to humans affects the same processes as does the size of cagemate. Both manipulations produce the same effects as isolate versus social housing. Emotionality results which might have reinforced these observations by producing similar parallels did not. Immobility and defecation results were rarely significant and often contradictory among similar experiments.

Contrast or dominance interpretations may have considerable value in accounting for the size-of-cagemate results in Experiment 3 and its pilot test. Their utility in explaining the findings of Experiment 2 relating human exposure to sociability is however, rather dubious. When all of the data are considered, the implication is great that a common underlying variable, or set of variables, is mediating sociability. That variable appears to be a rather specific form of environmental stimulation which includes exposure to human activity, handling, and social interaction.
Appendix A

Experiment 1: Partial Replication
Appendix A

Experiment 1: Partial Replication

One other alternative interpretation of Experiment 1 has to do with an adjoining experiment. Normal animals and those in enriched Activity environments received most of the additional exposure to experimental activity. This kind of stimulation may have affected them in the same way as mechanical stimulation affected the Stimulation condition animals, leading to the appearance of a lack of differences between experimental conditions.

Experiment 1: Replication utilized the same sources of mechanical stimulation (strobes, radio, slides, odors) as used in Experiment 1. The enriched activity environment was eliminated to decrease the amount of experimental processing in testing and maintenance.

Stimulation's true role as a mediator of social desire is tested by observing both isolated and pair-housed rats within both the Stimulation and the Normal conditions. If isolated housing produces general stimulus deprivation, then perceptual stimulation should reduce affiliation needs more for isolates than for pair housed animals.

Method

Subjects. Ninety-six, 70-day old male Sprague-Dawley albino rats were randomly assigned, half to the Stimulation Condition and half to the Normal Condition. Within each condition, 24 rats were housed in isolation and 24 pairs in single cages. All rats were so housed for 15 days prior to and during the 9 days of testing. Food and water were available ad. lib.
Apparatus. The apparatus is as described in Experiment 1. Three testing arenas were employed simultaneously here.

Procedure. The procedure for the Stimulation manipulation and the quiet housing of Normal condition rats were the same as in Experiment 1. Housing rooms were chosen such that extraneous stimulation sources were eliminated equally effectively in both. Human activity was equated in both rooms, both during testing and maintenance. The testing order of all subjects and their housing conditions were counter-balanced.

Results

As is overwhelmingly typical of animals naive to the open field, rats became more gregarious over days of testing ($F = 12.44; df = 1,44; p < .001$).

Animals housed in isolation were more sociable ($45\%$ time in contact) than those housed in pairs ($36\%$) ($F = 23.61; df = 1,44; p < .001$) and became more so over days of testing (linear interaction $F = 8.52; df = 1,44; p < .006$). Of course, this replicates the result of Experiment 1 and the earlier work cited there.

Stimulated rats were no more and no less gregarious ($40\%$) than Normal condition rats ($40\%$) ($F < 1, n.s.$). This was true of Single-housed as well as of Double-housed rats (Housing x Stimulation interaction $F = 1.58; df = 1,44; n.s.$). This form of stimulation is clearly ineffective in reducing desires for sociability in socially isolated rats. The possibility that more intensive or qualitatively different forms of stimulation can mediate social desires is a question for further examination.
Table 4

Experiment 1: Replication: Percent Time in Contact

<table>
<thead>
<tr>
<th>Housing</th>
<th>Stimulation Housing</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Stimulated</td>
<td>Normal</td>
<td>Average</td>
</tr>
<tr>
<td>Single</td>
<td>43.9%</td>
<td>46.3%</td>
<td>45.1%</td>
</tr>
<tr>
<td>Double</td>
<td>36.8%</td>
<td>34.4%</td>
<td>35.6%</td>
</tr>
<tr>
<td>Average</td>
<td>40.4%</td>
<td>40.4%</td>
<td>40.4%</td>
</tr>
</tbody>
</table>
As in Experiment 1, the housing effect for Stimulation Condition rats was much weaker ($F = 6.11; \text{df} = 1,22; p < .022$) than for Normal rats ($F = 19.8; \text{df} = 1,22; p < .001$), but the interaction effect is not significant. Further, the difference is not where it should be, namely in reduced gregariousness for single-housed stimulated rats.

**Emotionality.** Neither stimulation nor housing had significant overall effects on immobility. Normal condition socially housed rats were more immobile (8.6 ten second periods) than isolates (5.8) ($F = 5.14; \text{df} = 1,22; p < .04$). Differential housing had no effect on stimulated rats ($F < 1; \text{n.s.}$).

Normal rats defecated more (2.8 per session) than stimulated groups (2.2 boluses) ($F = 4.27; \text{df} = 1,44; p < .05$). Taken together, the immobility and defecation results may suggest that stimulated rats are more adapted to the stress of stimulation of the testing situation.

**Discussion**

As in Experiment 1, the massive quantities of stimulation employed in Experiment 1; Replication had no effect on rat gregariousness. The great variety of mechanical sources of perceptual stimulation did not mollify the social deprivation created by housing in isolation.

The extent of the possible general nature of the deprivation caused by isolation housing is greatly limited by these results. That deprivation is not satisfied by a variety of general stimulation sources used here. It appears that some specific sources are indeed required to satisfy the needs aroused by social deprivation.
It must be recognized that the mechanical stimulation employed in Experiments 1 and its replication may have been ineffective due to lack of impact or simple habituation. For this reason, Experiment 2: Pilot presented both mechanical stimulation and human activity to the experimental subjects. By reducing the number of subjects, the level of experimental activity necessary for testing and maintenance was greatly decreased. On the other hand, intentionally increased human activity in the stimulation condition housing room may reinforce the stimulation manipulation, maximizing its possible influences on gregariousness.
Appendix B

Experiment 2: Pilot Study
Appendix B

Experiment 2: Pilot Study

This experiment separates and reduces the number of experimental groups in order to minimize movements in each housing room during testing. In addition, room arrangements were changed so that human activity in housing rooms was highest for the rats in the Perceptual Stimulation condition. Test schedules were arranged such that these animals were additionally exposed to considerable human presence in their housing rooms for 3 hours before testing. Exposure to humans was added to the basic stimulation treatment of Experiments 1 and 2 in order to intensify the overall manipulation of stimulus inputs.

In Experiment 2, the apparatus, method, subjects and testing procedure were the same as those in Experiment 1, with the following exceptions.

Subjects. In order to keep total operating activity low, only Stimulation and Activity isolation housed rats and Normal single and double housed controls were tested. These same animals had been housed and tested in the same conditions in Experiment 1 which concluded some 6 weeks before the beginning of testing in the present experiment. Each group (Stimulation, Activity and Normal) was isolated in a separate room which was entered only for testing and maintenance purposes.

Testing Procedure. Rats were again run in pairs with condition mates. To keep room activity to a controlled minimum, all rats in a given condition were tested in a continuous block. In this way, the 12 pairs in each condition could be tested in about one hour. Each day
the Normal singles were tested first, then the Activity singles, Normal doubles and finally the Stimulated single housed rats.

In order to intensify the treatments given the stimulated group, they were housed at the entrance to the testing area. Thus, each day they were exposed to intense human activities for at least 3 hours before they were observed for sociability. It should be noted that the additional exposure to human movements adds a "short-term" intense stimulation factor to the "long-term" perceptual stimulation condition. Although the two forms of stimulation are confounded here, they both might be thought to reflect the hypothesis in its general form. Thus, Stimulation treatment effects in the present experiment would not indicate precisely which kind or duration of stimulation is most effective.

Results

There was no overall change in gregariousness over days of testing (F <1, n.s.). As the subject animals had been familiarized with the field in earlier testing, this is consistent with previous results suggesting that the "days effect" is due to the dropping out of competing fear and exploratory responses as the rats gained familiarity with the field.

As in many previous studies and Experiments 1 and its replication, Normal single housed rats were more gregarious than Normal double housed animals (F = 8.38; df = 1,44; p < .006).

Housing objects were well chewed and ripped indicating that they received considerable attention from the Activity condition rats.
However, those rats were no more and no less gregarious (57%) than Normals living in isolation (61%) (F < 1, n.s.) and were more gregarious than Normal double housed rats (47%) (F = 4.76; df = 1,44; p < .035). Although other modes or more extensive opportunities for activity may satisfy social needs, the present variety of self-generated activities did not. Thus, neither Experiment 1 nor the present experiment provided any indication that the opportunity for exercise or activity (predominantly chewing) mediates social desires in rats. It must be noted however, that the difference in gregariousness between the Stimulation and Activity conditions was not significant (F = 1.71; df = 1,22; p < .20, n.s.), although the Stimulation condition animals were trivially less sociable.

Stimulated rats were significantly less gregarious (52% time in contact) than Normal singles (F = 7.68; df = 1,44; p < .01), and were no more gregarious than Normal double housed animals (47%) (F < 1, n.s.). Thus external stimulation treatments and social housing produced qualitatively similar reductions in gregariousness relative to single housed, unstimulated controls. There was no interaction between subject types and days of testing.

Emotionality. Although there was no overall effect of stimulation conditions on defecation rates, Stimulated rats produced more boluses (1.5) than all other groups (.7) (F = 6.87; df = 1,44; p < .02). Once again, defecation decreased over days of testing (F = 5.88; df = 1,44; p < .02). There were no differences among groups in immobility. The overall immobility average was 8.4 ten second periods in the same area.
Discussion

From these results and those of Experiment 1, the opportunity for motor responding cannot be unequivocally rejected as a possible mediator of social desire in rats. Experiment 2: Pilot does suggest that perceptual stimulation is the more effective variable in reducing gregariousness in the rat. Within the scope of the present study, the effects of isolation housing represents stimulus rather than response deprivation.

Stimulation as manipulated in Experiments 1 and its replication did not reduce the need for sociability. In Experiment 2: Pilot, stimulation and exposure to humans did mollify sociability desires. This combination was almost, but not quite as successful as social housing in decreasing gregariousness.
Appendix C

Table 5: Past Experiments Summary
### Table 5

Past experiments providing data for correlational tests of relationship between exposure to humans and later sociability with rats.

<table>
<thead>
<tr>
<th>Entry</th>
<th># of Housing Units</th>
<th>Free or Single</th>
<th>Distance (inches)</th>
<th>%Time in Contact</th>
<th>Observation Sessions/Day</th>
<th>Adjusted Sessions/Day*</th>
<th>Number of Testing Days</th>
<th>Sex</th>
<th>Age Days</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>Latané (1969) Exp. 1</td>
<td>24 pairs S F 12.1</td>
<td>24 pair runs 48 single runs</td>
<td>72</td>
<td>6</td>
<td>M</td>
<td>105</td>
<td></td>
<td></td>
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<tr>
<td>2</td>
<td>Latané (1969) Exp. 2</td>
<td>30 rats S F 13.2</td>
<td>1 run/day each 25</td>
<td>.6</td>
<td>M</td>
<td>30</td>
<td></td>
<td></td>
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<tr>
<td>3</td>
<td>Latané &amp; Glass (1968)</td>
<td>30 rats S F 11.6</td>
<td>30</td>
<td>6</td>
<td>M</td>
<td>30</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>4</td>
<td>Eckman, Meltzer &amp; Latané (1969) Exp. 1</td>
<td>80 rats S F 11.5</td>
<td>40</td>
<td>7</td>
<td>M</td>
<td>40</td>
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<tr>
<td>Entry</td>
<td>Number of Housing Units</td>
<td>Free Distance (inches)</td>
<td>% Time in Contact</td>
<td>Observation Sessions/Day</td>
<td>Adjusted Sessions/Day*</td>
<td>Number of Testing Days</td>
<td>Sex</td>
<td>Age Days</td>
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<tr>
<td>5</td>
<td>48 rats D F</td>
<td>12.0</td>
<td>42.6</td>
<td>24</td>
<td>8</td>
<td>M</td>
<td>60</td>
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<td>6</td>
<td>Latané, Cappell &amp; Joy (1970) 1st test</td>
<td>164 rats S F</td>
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<td>82</td>
<td>6</td>
<td>M</td>
<td>70</td>
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<td>Latané, Cappell &amp; Joy (1970) 2nd test</td>
<td>96 rats S F D</td>
<td>11.6 15.2 9.5 F</td>
<td>58.0 41.0 13.5</td>
<td>48 4 M 190</td>
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<td>8</td>
<td>Cappell &amp; Latané (1969) Exp. 1</td>
<td>56 rats S F (caffeine)</td>
<td>9.2 15.5 9.2 F</td>
<td>61.0 33.0 62.0</td>
<td>28 6 M 50</td>
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<tr>
<td></td>
<td>48 rats S F (alcohol)</td>
<td>14.8</td>
<td>17.2</td>
<td>24</td>
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<td>9</td>
<td>Latané, Schneider, Waring, Zweigenhalft (1971) Exp. 1</td>
<td>54 rats S F D</td>
<td>14.8 17.2</td>
<td>27 4 M 40</td>
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<td>10</td>
<td>Latané, Schneider, Waring, Zweigenhalft (1971) Exp. 2</td>
<td>36 rats D F</td>
<td>16.1</td>
<td>18 6 F 46</td>
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<td>Entry Number</td>
<td># of Housing Units</td>
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<td>Distance (inches)</td>
<td>% Time in Contact</td>
<td>Observation Sessions/Day</td>
<td>Adjusted Sessions/Day*</td>
<td>Number of Testing Days</td>
<td>Sex</td>
<td>Age</td>
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<tr>
<td>11</td>
<td>Latané &amp; Werner (1971)</td>
<td>S T</td>
<td>9.2</td>
<td>62.0</td>
<td>50</td>
<td>6</td>
<td>M 37</td>
<td></td>
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<tr>
<td>12</td>
<td>Joy &amp; Latané (1971)</td>
<td>S F (placebo) S F (drug)</td>
<td>9.6</td>
<td>24</td>
<td>6</td>
<td>M 30</td>
<td></td>
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<tr>
<td>13</td>
<td>Walton &amp; Latané (1972)</td>
<td>S F Wire D F</td>
<td>11.3</td>
<td></td>
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<td></td>
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<td>14</td>
<td>Latané, Poor, Sloan (1972)</td>
<td>S F Ball D F</td>
<td></td>
<td>45</td>
<td>10</td>
<td>M 80</td>
<td></td>
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<tr>
<td>15</td>
<td>Latané &amp; Walton (1972)</td>
<td>S F (preexposed) S F (nonpreexposed) D F (preexposed) D F (nonpreexposed)</td>
<td>52.0</td>
<td>34</td>
<td>8</td>
<td>M 240</td>
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Table 5 - continued

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<th>Entry Number</th>
<th>Number of Housing Units</th>
<th>Free or Single</th>
<th>Distance (inches)</th>
<th>Time in Contact</th>
<th>Observation Sessions/Day</th>
<th>Adjusted Sessions/Day*</th>
<th>Number of Testing Days</th>
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<th>Age</th>
<th>Sex</th>
<th>Age</th>
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<tr>
<td>16</td>
<td>Latané, Edwards, Steele, &amp; Walton</td>
<td>48 pairs S F (albino and hooded)</td>
<td>40.0</td>
<td>24</td>
<td>6</td>
<td>M &amp; F</td>
<td>70</td>
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<td></td>
<td></td>
<td>S F (albino)</td>
<td>43.0</td>
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<tr>
<td>17</td>
<td>Latané, Nesbitt, Eckman, Rodin (1972) Exp. 1</td>
<td>48 rats S F</td>
<td>39.0</td>
<td>96</td>
<td>8</td>
<td>M</td>
<td>44</td>
<td></td>
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<td></td>
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<td>D F</td>
<td>23.0</td>
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<td>18</td>
<td>Latané, Nesbitt, Eckman, Rodin (1972) Exp. 2</td>
<td>32 rats S F</td>
<td>55.0</td>
<td>16</td>
<td>4</td>
<td>M</td>
<td>40</td>
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<td></td>
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<td>D F</td>
<td>39.0</td>
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<tr>
<td>19</td>
<td>Latané, Nesbitt, Eckman, Rodin (1972) Exp. 3</td>
<td>40 rats S F</td>
<td>36.0</td>
<td>20</td>
<td>4</td>
<td>M &amp; F</td>
<td>45</td>
<td></td>
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<td></td>
<td></td>
<td>D F</td>
<td>25.0</td>
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<tr>
<td>20</td>
<td>Latané, Nesbitt, Eckman, Rodin (1972) Exp. 4</td>
<td>72 rats S F</td>
<td>58.0</td>
<td>36</td>
<td>2</td>
<td>M</td>
<td>40</td>
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<td></td>
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<tr>
<td></td>
<td></td>
<td>D F</td>
<td>49.0</td>
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<td>Entry</td>
<td># of Housing Units</td>
<td>Free Single or Tethered</td>
<td>Distance (inches)</td>
<td>% Time in Contact</td>
<td>Observation Sessions/Day</td>
<td>Adjusted Sessions/Day*</td>
<td>Number of Testing Days</td>
<td>Sex</td>
<td>Age Days</td>
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<tr>
<td>21</td>
<td>Latané, Ross &amp; Meltzer (1966) Exp. 1</td>
<td>26 rats S F (shock)</td>
<td>9.8</td>
<td></td>
<td>13</td>
<td>1</td>
<td>M 120</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>S F (no shock)</td>
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<tr>
<td>22</td>
<td>Latané, Ross &amp; Meltzer (1966) Exp. 2</td>
<td>48 rats S F (shock)</td>
<td>6.2</td>
<td>78.0</td>
<td></td>
<td>24</td>
<td>6 42</td>
<td></td>
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<td></td>
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<td>S F (no shock)</td>
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<tr>
<td>23</td>
<td>Latané, Meltzer, Joy, Lubell, Cappell (1972) Exp. 1</td>
<td>28 rats S F T</td>
<td>F=13.2</td>
<td>48.0</td>
<td></td>
<td>28</td>
<td>4 40</td>
<td></td>
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<td>D F T T=14.1</td>
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<tr>
<td>24</td>
<td>Latané, Meltzer, Joy, Lubell, Cappell (1972) Exp. 2</td>
<td>24 rats S T (normal)</td>
<td>18.3</td>
<td>17.0</td>
<td></td>
<td>24</td>
<td>4 40</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>S T (blind)</td>
<td>15.0</td>
<td>25.0</td>
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<tr>
<td>25</td>
<td>Latané, Meltzer, Joy, Lubell, Cappell (1972) Exp. 3</td>
<td>36 rats S T (normal)</td>
<td>37.0</td>
<td></td>
<td></td>
<td>36</td>
<td>4 40</td>
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<td>S T (hairless)</td>
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<tr>
<td>Entry</td>
<td># of Housing Units</td>
<td>Free or Tethered</td>
<td>Distance (inches)</td>
<td>%Time in Contact</td>
<td>Observation Sessions/Day</td>
<td>Adjusted Sessions/Day*</td>
<td>Number of Testing Days</td>
<td>Sex</td>
<td>Age Days</td>
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<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>12 rats D T (perfumed) D T (normal)</td>
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<td>27</td>
<td>Latané, Meltzer, Joy, Lubell, Cappell (1972) Exp. 5</td>
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<tr>
<td></td>
<td>32 rats S F S T S anesthesized partner S stuffed partner</td>
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<td>28</td>
<td>Werner &amp; Latané (1970) Exp. 2</td>
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<td></td>
<td>48 rats S T</td>
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<td>Sloan &amp; Latané (1972) Exp. 1</td>
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<tr>
<td></td>
<td>80 rats S F (consex) S F (cross sex)</td>
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<td>30</td>
<td>Sloan &amp; Latané (1972) Exp. 2</td>
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<td>48 rats S T</td>
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<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>31</td>
<td>Sloan &amp; Latané (1972) Exp. 3</td>
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</tr>
<tr>
<td></td>
<td>36 rats S T D T (male) D T (female)</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

* see footnote 1
Appendix D

Experiment 3: Pilot Study
Appendix D

Experiment 3: Pilot Study

In this experiment, rats were housed with another mail albino rat either half or twice their own age for 3 weeks. They were then observed for five minutes on each of 6 successive days for evidence of social attraction to a same aged tethered male rat. Subject and testing stimulus rats were all of the same age in order to avoid any interactive effects of age with gregariousness (Latané, Sloan and Walton, 1972).

Method

Subjects. Subjects were 26 eighty-day old male Sprague-Dawley albino rats, which had been maintained on ad lib. food and water schedules in single cages since their arrival in the lab at 30 days of age. At 40 days all subjects had had 6 days of exposure to the open field in the presence of tethered animals (the same stimuli for all subjects). At 60 days these subjects were randomly assigned to one of the two experimental housing conditions: 13 were housed with males one-half the subject's age (40 days) and 13 rats with males twice the subject's age (160 days). Rats were so housed for 20 days prior to and continuously during the experimental observation period of 6 days. Subjects averaged about 270 grams while small housing mates averaged 136 grams and large housing mates 411 grams.

Procedure and Design. Rats were observed in the open field with a tethered stimulus male on each of 6 days. Stimulus males were tethered next to the field wall by a 3-4 inch harness of string. The
experiment used a 2 x 6 multivariate ANOVA in which the housing condition was the between subjects factor and the day of testing was the within subjects factor.

Results

Gregariousness. There was no change in gregariousness over trials ($F < 1, n.s.$). These animals had been run in the open field 3 weeks earlier and therefore would not display the usual traits effect thought to be a function of increasing familiarity of the testing situation (Eckman, Meltzer, and Latané, 1970). There was no interaction between subject housing partner and testing trials ($F < 1, n.s.$) indicating that the subjects were not differentially affected by their testing partners over days.

Rats housed with smaller pairmates were more gregarious during testing than those housed with larger partners ($F = 5.05; df = 1.24; p < .01$). This finding supports that of Sloan and Latané (1971) showing increased consexual gregariousness for subjects housed with rats much smaller than themselves.

Emotionality. Subjects which had lived with smaller animals spent more consecutive 10 second periods in the same section of the field (5.9 compared to 4.0) ($F = 4.30; df = 1.24; p < .05$). For both groups, immobility decreased (linear $F = 18.33; df = 1.24; p < .001$) over days of testing. There were no differences between groups in defecation rates.

If it were stressful to live with a larger rat clearly capable of dominating all interactions, then it may be that those subjects were
Table 6

Experiment 3: Pilot Test: Sociability and Emotionality Measures

<table>
<thead>
<tr>
<th>Housing</th>
<th>Percent Time in Contact</th>
<th>Immobility</th>
<th>Boluses</th>
</tr>
</thead>
<tbody>
<tr>
<td>with Small Rat</td>
<td>48%</td>
<td>5.9</td>
<td>2.4</td>
</tr>
<tr>
<td>with Large Rat</td>
<td>39%</td>
<td>4.0</td>
<td>2.0</td>
</tr>
</tbody>
</table>
better adapted to stress, much in the same manner as are prehandled rats. Such an adaptation to stressful events is thought to reduce reactivity to testing and may serve to account for the decreased immobility of animals hypothesized to be stimulation-satiated.

**Dominance time in contact.** Although time spent in dominance activities increased over trials \((p < .001)\), there were no differences in dominance behavior between the two subject rat housing conditions. Thus the mediation of gregariousness by the overt expression of dominance activity (as rated here) seems unnecessary.

**Discussion**

It is clear that the size of housing partner did have a very real effect upon subsequent sociability. The specific cause of this effect remains somewhat elusive.

These results appear to be consistent with the thesis that rats seek and receive stimulation in social interaction and that small cagemates provide less stimulation than larger ones. Larger cagemates, behaving much at their own perogative, would present a more uncontrollable, unpredictable, and therefore more novel stimulus than would smaller cagemates.

An interesting remaining question deals with the boundaries of the housing partner size variable. How do the effects of living with a larger or smaller rat compare to living alone or with an equal sized animal? It could be that much smaller animals are nearly insignificant, creating de facto social deprivation from living with such partners. Similarly, the above results may arise solely from the influence of
having a larger cagemate. In order to investigate the stimulation hypothesis derivation that housing partner size is continuously related to subsequent sociability, additional sizes of cagemates should be employed.
Appendix E

Analyses of Variance-Experiments 1 through 3

including Pilot Studies and Replications
### Table 7
Experiment 1
ANOVA Time in Contact

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Between Subjects</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Housing</td>
<td>351,956.3</td>
<td>1</td>
<td>351,956.3</td>
<td>12.57***</td>
</tr>
<tr>
<td>Stimulation</td>
<td>8,591.2</td>
<td>2</td>
<td>4,295.6</td>
<td>&lt;1</td>
</tr>
<tr>
<td>H x S</td>
<td>62,870.3</td>
<td>2</td>
<td>31,435.2</td>
<td>1.12</td>
</tr>
<tr>
<td><strong>Subjects w/in</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Groups</td>
<td>1,847,685.0</td>
<td>66</td>
<td>27,995.2</td>
<td></td>
</tr>
<tr>
<td><strong>Within Subjects</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Days</td>
<td>6,61</td>
<td></td>
<td>R=.853a</td>
<td>27.20***</td>
</tr>
<tr>
<td>H x D</td>
<td>6,61</td>
<td></td>
<td>R=.446</td>
<td>2.53*</td>
</tr>
<tr>
<td>S x D</td>
<td>12,122</td>
<td></td>
<td>R=.373</td>
<td>1.05</td>
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<tr>
<td>S x H x D</td>
<td>12,122</td>
<td></td>
<td>R=.300</td>
<td>&lt;1</td>
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</tbody>
</table>

* p < .05
** p < .01
*** p < .001

a. Note: In all tables, all within subjects tests having more than one degree of freedom for the treatment are multivariate tests employing within levels as variables in MANOVA, modified, Ohio State University.
<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
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<tr>
<td><strong>Between Subjects</strong></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Housing</td>
<td>27,475.4</td>
<td>1</td>
<td>27,475.4</td>
<td>67.76***</td>
</tr>
<tr>
<td>Handled-Exposed vs Normal</td>
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<td></td>
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</tr>
<tr>
<td>(Last 3 days only)</td>
<td>953.2</td>
<td>1</td>
<td>953.2</td>
<td>2.35</td>
</tr>
<tr>
<td>H x HE - N</td>
<td>340.7</td>
<td>1</td>
<td>340.7</td>
<td>1</td>
</tr>
<tr>
<td>(Last 3 days only)</td>
<td>2,735.9</td>
<td>1</td>
<td>2,735.9</td>
<td>4.16*</td>
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<td>Subjects within Groups</td>
<td>26,767.2</td>
<td>66</td>
<td>405.6</td>
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<tr>
<td>(Last 3 days)</td>
<td>43,361.6</td>
<td>66</td>
<td>657.0</td>
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<td><strong>Within Subjects</strong></td>
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<td></td>
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<tr>
<td>Days (All tests Linear)</td>
<td>4,914.9</td>
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<td>4,914.9</td>
<td>4.05*</td>
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<td>H x D</td>
<td>8,144.8</td>
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<td>6.72**</td>
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<td>HE-N x D</td>
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<td>1</td>
<td>7,976.8</td>
<td>6.58*</td>
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<tr>
<td>H x HE-N x D</td>
<td>6,158.6</td>
<td>1</td>
<td>6,158.6</td>
<td>5.08*</td>
</tr>
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<td>D x Subjects within Groups</td>
<td>80,010.5</td>
<td>66</td>
<td>1,212.3</td>
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</table>

*p < .05  
**p < .01  
***p < .001
### Table 9

**Experiment 3**

**ANOVA Time in Contact**

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<tr>
<td><strong>Between Subjects</strong></td>
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<tr>
<td>Housing</td>
<td></td>
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<tr>
<td>Alone vs Double Housed</td>
<td>29,708.3</td>
<td>1</td>
<td>29,708.3</td>
<td>5.29*</td>
</tr>
<tr>
<td>(H) Small, Equal Large (Linear)</td>
<td>42,111.4</td>
<td>1</td>
<td>42,111.4</td>
<td>7.51**</td>
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<td>Subjects within Groups</td>
<td>381,457.8</td>
<td>68</td>
<td>5,609.7</td>
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<tr>
<td><strong>Within Subjects</strong></td>
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<tr>
<td>Stimuli (Linear)</td>
<td>80,333.4</td>
<td>1</td>
<td>80,333.4</td>
<td>27.80***</td>
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<td>Blocks</td>
<td>110,815.6</td>
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<td>48.61***</td>
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<tr>
<td>H x B</td>
<td>18,555.5</td>
<td>1</td>
<td>18,555.5</td>
<td>8.14**</td>
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<td>S x B</td>
<td>4,640.0</td>
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<td>1.2</td>
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<td>H x S</td>
<td>289.0</td>
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<td>289.0</td>
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<td>H x S x B</td>
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<td>B x Subjects within Groups</td>
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<td>68</td>
<td>2,279.6</td>
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<tr>
<td>S x Subjects within Groups</td>
<td>196,504.8</td>
<td>68</td>
<td>2,889.8</td>
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<tr>
<td>SB x S within Groups</td>
<td>262,394.6</td>
<td>68</td>
<td>3,858.7</td>
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*p < .05  
**p < .01  
***p < .001
Table 10

Experiment 1: Partial Replication

ANOVA Time in Contact

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<td><strong>Between Subjects</strong></td>
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</tr>
<tr>
<td>Housing</td>
<td>9,725.0</td>
<td>1</td>
<td>9,725.0</td>
<td>23.61***</td>
</tr>
<tr>
<td>Stimulation</td>
<td>58.0</td>
<td>1</td>
<td>58.0</td>
<td>&lt;1</td>
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<td>H x S</td>
<td>650.8</td>
<td>1</td>
<td>650.8</td>
<td>1.58</td>
</tr>
<tr>
<td>Subjects within Groups</td>
<td>18,123.0</td>
<td>44</td>
<td>411.9</td>
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</tr>
<tr>
<td><strong>Within Subjects</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Days (all tests linear)</td>
<td>29,889.4</td>
<td>1</td>
<td>29,889.4</td>
<td>12.44***</td>
</tr>
<tr>
<td>H x D</td>
<td>20,465.9</td>
<td>1</td>
<td>20,465.9</td>
<td>8.52**</td>
</tr>
<tr>
<td>S x D</td>
<td>26.8</td>
<td>1</td>
<td>20.8</td>
<td>&lt;1</td>
</tr>
<tr>
<td>H x S x D</td>
<td>670.9</td>
<td>1</td>
<td>670.9</td>
<td>&lt;1</td>
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<tr>
<td>D x Subjects within Groups</td>
<td>105,692.6</td>
<td>44</td>
<td>2,402.1</td>
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*p < .05

**p < .01

***p < .001
Table 11
Experiment 2; Pilot Study
ANOVA Time in Contact

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<tr>
<td><strong>Between Subjects</strong></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Contrasts:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Housing (normals)</td>
<td>10,360.2</td>
<td>1</td>
<td>10,360.2</td>
<td>8.38**</td>
</tr>
<tr>
<td>Activity vs. Normal Singles</td>
<td>426.5</td>
<td>1</td>
<td>426.5</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Activity vs. Normal Doubles</td>
<td>5,884.8</td>
<td>1</td>
<td>5,884.8</td>
<td>4.76*</td>
</tr>
<tr>
<td>Stimulation vs. Activity</td>
<td>2,114.1</td>
<td>1</td>
<td>2,114.1</td>
<td>1.71</td>
</tr>
<tr>
<td>Stimulation vs. Normal Singles</td>
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<td>1</td>
<td>9,494.9</td>
<td>7.68**</td>
</tr>
<tr>
<td>Stimulation vs. Normal Doubles</td>
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<td>1</td>
<td>1,088.0</td>
<td>&lt;1</td>
</tr>
<tr>
<td><strong>Subjects within Groups</strong></td>
<td>54,398.0</td>
<td>44</td>
<td>1,236.3</td>
<td></td>
</tr>
<tr>
<td><strong>Within Subjects</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Days (all tests linear)</td>
<td>5,40a</td>
<td></td>
<td>R=.263</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Treatments x Days</td>
<td>5,40</td>
<td></td>
<td>R=.224</td>
<td>&lt;1</td>
</tr>
</tbody>
</table>

*p < .05

**p < .01

***p < .001

a. Multivariate tests, see footnote a, Table 7.
### Table 12

Experiment 3: Pilot Study

ANOVA Time in Contact

<table>
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<tr>
<th>Source</th>
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<th>df</th>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>Between Subjects</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Size of Partner</td>
<td>4,869.8</td>
<td>1</td>
<td>4,869.8</td>
<td>5.05*</td>
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<td>Subjects within Groups</td>
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<tr>
<td>Days</td>
<td>5,20^a</td>
<td></td>
<td>R=.401</td>
<td>&lt;1</td>
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<tr>
<td>S x D</td>
<td>5,20</td>
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<td>R=.404</td>
<td>&lt;1</td>
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</table>

*p < .05

**p < .01

***p < .001

^n. See footnote a, Table 7.
BIBLIOGRAPHY


