1979

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THE EFFECTS OF THREE LEVELS OF SOCIAL INTERACTION ON THE MAINTENANCE OF SIDMAN AVOIDANCE IN RATS

BY

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A THESIS
SUBMITTED TO THE GRADUATE FACULTY
OF THE UNIVERSITY OF RICHMOND
IN CANDIDACY
FOR THE DEGREE OF
MASTER OF ARTS
IN PSYCHOLOGY

AUGUST 1979

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ACKNOWLEDGMENTS

My acknowledgments are many as my indebtedness and gratitude run deep. First, I want to express my appreciation to the members of my thesis committee- Dr. Kozub (committee chairman), Dr. Blick, and Dr. Tromater. Their patience, concern, and willingness to share their time and resources proved invaluable while I was at the University of Richmond, and especially in the course of producing this thesis.

Secondly, I want to acknowledge the Psychology Department at Emory & Henry College, Emory, Virginia, for the gracious use of their facilities, and especially Professor Dan Weese for overseeing my research there. I also appreciate the efforts of my observers, David Johnson and Mike Sloan, who invested a great deal of time in the laboratory.

I also want to acknowledge Dr. James O. Benedict of James Madison University for his help of the past years, as well as the recent months, in this line of research.

Finally, and most importantly, I want to thank my parents, who's support and encouragement made my education at the University of Richmond possible.

TABLE OF CONTENTS

FIGURE LEGEND

TABLE LEGEND

ABSTRACT

In 1965 Zajonc theorized that the effect of the presence of others was to facilitate the maintenance of a behavior. However, opposite results have been found when rat subjects were tested with shock used as a reinforcer. It was hypothesized that shock elicited aggression interfered with responding, producing performance decrement, rather than facilitation. A wheel-turn Sidman avoidance procedure was used to study maintenance behavior in rats under three levels of social interaction: single subject, two subjects separated by a barrier to prevent shock elicited aggressions (the companion paradigm), and two subjects not separated in the test chamber (the physical paradigm).

The barrier in the companion paradigm successfully prevented shock elicited aggressions between subjects. However, in regard to response and shock data, no significant differences were found among the three groups, with the exception of a significant F-max with response data. Aposteriori analyses of the last eight days of testing failed to find any significant differences.

INTRODUCTION

The study of social interaction and behavior dates back to the findings of Triplett (1898), showing that the performance on a pacing and competition task is greater among pairs than with subjects performing alone. From this beginning research continued at a brisk pace, peaking in the decade from 1925-1935 (Genn & Gange, 1977).

However, the area of social interaction continually suffered from conflicting results. Response increment (Travis, 1925; Bergum & Lehr, 1963; Dashiell, 1930) was found about as often as response decrement (Pessin, 1933; Gates & Allee, 1933; Husband, 1931; Pessin & Husband, 1933). This problem, combined with an almost total lack of theory, was probably the cause of the sudden death of the field with the outbreak of World War II.

In 1965 the field was revived by Zajonc's theoretical formulations. Zajonc (1965) theorized that the presence of others serves as a general arousal mechanism. The resulting drive energizes dominant responses at the expense of subordinate responses, in line with the Hull-Spence equation of E=DxH. This formulation predicts that if a subject is socially influenced while learning a task (when errors are dominant and correct responses are subordinate) the dominant error response will be increased and the acquisition of the response will be impaired. On the other hand, once the task is mastered (correct responses are dominant, errors are subordinate) social interaction will serve to increase the dominant correct response, improving performance. Briefly, social interaction impairs acquisition, but improves performance. Zajonc's theory has been supported through animal research using such response reinforcers as water (Zentall & Levine, 1972; Levine & Zentall, 1974), food (Morrison & Hill, 1967; Tolman & Wilson, 1965; Treichler, Graham, & Schweikert, 1971; Wheeler & Davis, 1967; Scott & McCray, 1976), and light (cockroach escape behavior) (Zajonc, Heingartner, & Herman, 1969). In a major review of the literature since Zajonc's 1965 formulations, Geen and Gange (1977) view Zajonc's drive theory analysis as still the best overall theoretical framework for explaining social interaction.

In conflict with Zajonc's theory, Davis (1969) using Sidman avoidance in rats found performance impairment both when two pretrained subjects were paired and when a pretrained and naive subject were paired. Cunningham and Roberts (1973) tested both the acquisition and maintenance parts of Zajonc's theory and showed that social interaction produced impairment in both cases. However, in both the Davis and the Cunningham and Roberts studies the paired subjects were capable of coming in physical contact with each other in the operant chamber. Since the stimulus used in their avoidance procedures (electric shock) has been shown to produce aggression (cf. Ulrich & Azrin, 1962) there is the possibility that the effects of social interaction were masked by the effects of the disruptive aggressive behavior between subjects.

A better test of Zajonc's theory in a setting utilizing aversive reinforcement might be to examine social interaction while preventing physical contact between subjects. The purpose of this study was to examine the maintenance phase of Zajonc's theory in a Sidman avoidance (1953) setting, while preventing shock elicited aggression.

Zajonc's theory was not tested during acquisition because as a task is learned response decrement would be expected in both test groups relative to the control group. However, for the maintenance of a task it was hypothesized that performance facilitation would be found in the group where physical aggression was prevented between subjects (thus confirming Zajonc's theory), while performance decrement would be found in cases where physical aggression was not prevented between subjects (in line with previous research).

Both Davis (1969) and Cunningham and Roberts (1973) used the lever-press as the avoidance response. However, several researchers have found that rats do not easily learn the lever-press avoidance response (cf. Meyer, Cho, & Wesemann, 1960). Others have argued that the lever-press reaction to shock produces responding that is partially non-operant in nature (Davis & Hirschorn, 1973; Bolles & McGillis, 1968). They claim that a combination of freezing over the lever, and either a reflexive or current-induced muscular contraction at the onset of shock, produces responding that is not "purposeful", but an artifact of an innate species specific defense reaction (SSDR)(Bolles & McGillis, 1968). It was decided to use a wheel-turn manipulandum in this study. Weiss (1971) found high response rates using this device. It was also hoped that the wheel-turn would require a more "purposeful" response in that each "bar" on the wheel would swing out of the way when pressed, placing the subject underneath the next "bar". This would make it difficult to freeze over the manipulandum, compared to the lever-press.

METHOD

Subjects. Forty male Sprague-Dawley rats were obtained from Flow Laboratories, Dublin, Virginia. Prior to the start of the experiment, thirty animals were randomly selected to be subjects, the remaining served as alternates. Of the thirty subjects, eighteen were randomly selected for solo pretraining. The remaining twelve served to provide the social interaction during the testing phase of the experiment. All subjects were experimentally naive, and 3-4 months old at the start of experimentation. All animals were housed in individual cages and handled often prior to the start of the experiment. Food and water were given ad lib, except when the subjects were in the operant chamber where neither food nor water were available. Due to a death on the third day of pretraining, one subject was replaced from alternates undergoing the same pretraining.

Apparatus. Three BRS-Foringer dual lever operant chambers (Model 143-22) were used. The food tray, three cue lights, and both bar-type response levers were removed from each test chamber.

The manipulandum used was a 7.3 mm wide spinable wheel placed on the left side of the chamber. This wheel projected 1 mm from an opening in a 7.9 x 10.2 x 15.2 mm (length x width x height) aluminum box. The wheel itself had a diameter of approximately 6.4 mm. A downward pressure which rotated the wheel one eighth of a turn activated a microswitch within the unit and a response was recorded. Upward pressure could not turn the wheel more than one eighth of a turn, nor could it record a response. The inside of the aluminum box was lined with sound-attenuating material. The axis of the wheel was 7.6 mm off the grid floor. A plate from the ceiling to the wheel unit served to prevent the subjects from climbing on top of the wheel unit.

When two subjects were separated, or when a single subject was in the chamber, a chamber divider was used. This divider was made of metal screen (7.1 x 6.3 per cm mesh) sealed in a Plexiglass frame. The metal screen was not coupled to the shock apparatus. When the divider was used, a second plate was placed on the right side of the chamber to hold the divider firmly against a thin block of wood partially covered with conductive foil. This block of wood rested against the manipulandum, and along with the second plate served to stabilize the divider and make the right side of the chamber approximately equal in size to the left side.

The entire modified operant chamber was housed in a ventilated sound-attenuating box through which a window was available for viewing and videotaping the subjects. Shock was delivered by a BRS-Foringer shock generator (Model SG-901), and scrambler (Model SC-901). Shock levels and duration were varied during the early part of the pretraining (though consistantly over all subjects). From Day 10 onward the apparatus was programmed to deliver a 200 msec, 1mA shock. Masking noise (80 dB) was continuously present.

Procedure. The eighteen subjects selected for pretraining were given 25 days (the last 14 of which were consecutive) on a Sidman avoidance schedule (Sidman, 1953) of S-S=5 and R-S=15 seconds. Each response briefly turned off the chamber lights. Shaping was necessary with a few subjects prior to Day 6. The first 15 daily sessions for each subject lasted one hour, while the remaining sessions throughout the experiment lasted one-half hour.

At the end of the pretraining phase, each third of these eighteen subjects were run under one of three different social interaction paradigms: physical paradigm (PP), companion paradigm (CP), and the single subject (SS) paradigm. Each paradigm placed the pretrained subject under a different level of social interaction. The highest level of social interaction was available in the physical paradigm (PP). There subjects were paired inside the test chamber and were capable of coming in physical contact with each other. Both subjects had access to the manipulandum. This level simulated the social interaction condition run by Davis (1969) and Cunningham and Roberts (1973).

In the companion paradigm (CP), subjects were paired and yoked to shock but physical contact was prevented by separating the subjects with a wire screen divider. This intermediate level of interaction was not tested by either Davis (1969) nor Cunningham and Roberts (1973). This procedure eliminated tactile cues between subjects, but visual, auditory, and olfactory cues were still available. Only the pretrained subject had access to the manipulandum; the other subject (the companion) provided the social influence. In the lowest, or zero level of interaction (the single subject (SS) paradigm), subjects were run in half of the operant chamber alone.

The testing phase of this experiment lasted for 15 days. (Response and shock data for the last two days were eliminated due to an equipment failure during testing on Day 14). The subjects were counterbalanced with respect to running order and test chambers, according to the design in Table 1. This design was randomly selected from all similarly counterbalanced designs, and was imposed upon the 6 x 3 matrix of testing order and chamber number. In other words, the eighteen pretrained subjects remained in the same testing order and chamber number in which they were pretrained. The social interaction condition they were assigned was determined by the counterbalanced design randomly selected.

The number of responses made and shocks received during each session of the testing phase was recorded for each subject. In addition, two observers were selected and trained to view videotapes of a random selection of

Table 1. Subject arrangement counterbalanced with respect to testing order and test chamber.

Table 1

Counterbalanced Design

Testing order	Chamber number 1	2	3
1	SS	CP	PP
2	CP	PP	SS
3	PP	SS	CP
4	PP	SS	CP
5	CP	PP	SS
6	SS	CP	PP

ten PP-CP pairs (a PP pair paired with the CP pair from the same testing chamber and the same half of the counterbalanced design. This procedure was used to facilitate videotaping). The observers recorded incidences of shock elicited aggression in the PP and CP conditions in order to test the effectiveness of the chamber divider in preventing shock elicited aggressions. The method of measuring aggression was taken in part from Ulrich and Azrin (1962) and Ulrich (1967). For the physical paradigm (PP) a single fighting response was recorded for any striking or biting movement of either or both animals towards the other. A new response was recorded for those striking or biting movements separated from previous striking or biting movements by approximately one second. The observers also recorded any incidences of the naive rat blocking the pretrained rat's access to the manipulandum. For the companion paradigm (CP) a single response was recorded for any lunging, striking, or hitting type movement of either or both animals towards the other through the screen. Again, a new response was recorded for those movements separated from previous movements by approximately one second. No measure of the naive rat blocking the pretrained rat's access to the manipulandum was taken in the CP condition, as the chamber divider prevented this from occurring. Observers were blind as to the nature of the experiment.

RESULTS

At the end of the pretraining phase analyses of the response and shock data showed the three groups to be statistically equivalent. For more information on the procedures used and results obtained see Appendix A.

During the testing phase, response, shock, and observation data were collected. For the observation data two observers recorded incidences of shock elicited aggression between a selection of subject pairs. Due to videotape malfunctions, data were collected from only eight of the ten selected pairs. Table 2 shows only two total incidences of shock elicited aggression for all eight CP cases. Informal observations support this in CP cases not selected for observation. Very few incidences of shock elicited aggression were observed in this social interaction condition. Inter-observer aggreement is shown to be very high; ranging from 99% to 100%.

In the PP groups, shock elicited aggression occurred at high rates with the exception of groups 72PP69 (subject number 72 (pretrained) paired with number 69 (naive)) and 68PP74 (Table 3). Inter-observer aggreement ranged from 71% to 100%. For the PP condition, the two observers were also asked to record incidences when the naive rat blocked the pretrained rat's access to the manipulandum. As Table 4 shows, very few incidences of this were observed. Inter-observer aggreement ranged from 98% to 100%.

Table 2. The occurrence of shock elicited aggression in the companion paradigm (CP). As can be seen, only two incidences of shock elicited aggression were recorded for all eight CP pairs.

Table 2

Shock Elicited Aggression

in the Companion Paradigm

Test Day	Subjects	Observer number 1	Observer number 2	Total disagg.	Percent aggree.
26	67CP75	0	1	1	99
27	67CP75	0	1	1	99
31	67CP75	0	0	0	100
34	67CP75	0	0	0	100
36	2CP76	0	0	0	100
37	2CP76	0	0	0	100
38	88CP90	0	0	0	100
39	63CP79	0	0	0	100

Table 3. The occurrence of shock elicited aggression in the physical paradigm (PP).

Table 3

Shock Elicited Aggression

in the Physical Paradigm

Test Day	Subjects	Observer number 1	Observer number 2	Total disagg.	Percent aggree.
26	84PP62	86	87	13	96
27	84PP62	49	85	44	88
31	84PP62	134	174	70	81
34	84PP62	155	82	106	71
36	72PP69	0	0	0	100
37	72PP69	1	1	2	99
38	66PP77	70	121	66	82
39	78PP61	0	0	0	100

Figure 4. The occurrence of incidences where the naive rat blocked the pretrained rat's access to the manipulanc As can be seen, only sixteen incidences of this were recorded.

Table 4

Manipulandum Blocking by Naive

Subject in the Physical Paradigm

Test Day	Subjects	Observer number 1	Observer number 2	Total disagg.	Percent aggree.
26	84PP62	0	7	7	98
27	84PP62	0	4	4	99
31	84PP62	1	0	1	99
34	84PP62	0	0	0	100
36	72PP69	0	0	0	100
37	72PP69	0	4	4	99
38	66PP77	0	0	0	100
39	78PP61	0	0	0	100

Figure 1. Graph of mean responses per subject for the three social interaction conditions over the thirteen test days (Day 26 to 38). The single subject (SS) paradigm, companion paradigm (CP), and physical paradigm (PP) each contained six subjects.

Figure 1

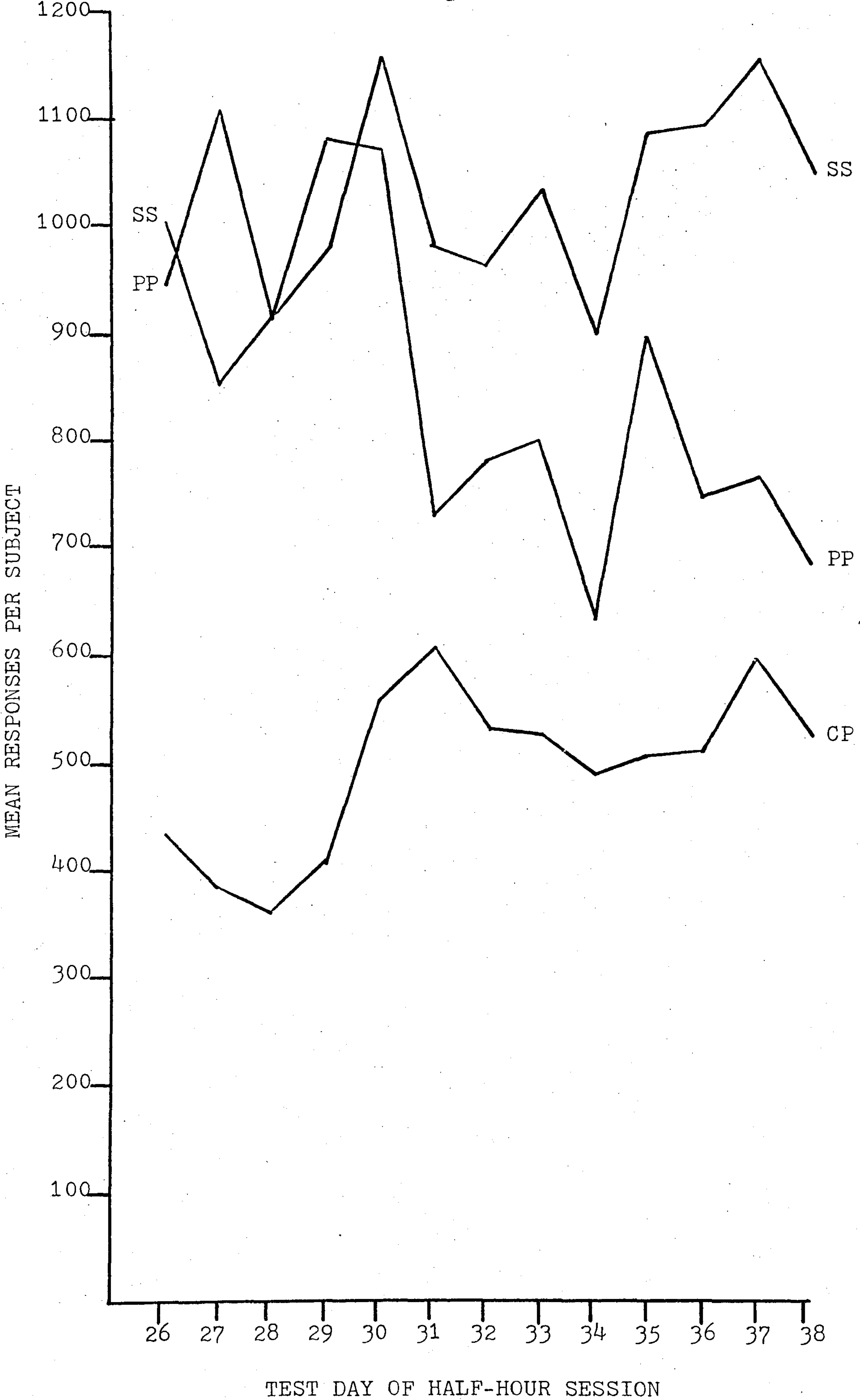
1200
1100
1000
900
800
700
600
500
400
300
200
100
MEAN RESPONSES PER SUBJECT
SS
PP
CP
26
27
28
29
30
31
32
33
34
35
36
37
38
TEST DAY OF HALF-HOUR SESSION

Figure 1 shows the mean response data for each day of the three social interaction paradigms. Due to a counter malfunction, data for Day 26 for subject pair 67CP75 were obtained by taking an average of their other twelve test days. Also, due to a timer malfunction, data for one subject in each of the three paradigms were interpolated from recorded data. While Figure 1 shows good group separation, a two-factor, repeated on one ANOVA (3 by 13) found no group, trial, or group by trial significant differences. Only the F-max value between paradigms was significant. Table 5 presents a summary of the analyses.

Mean shock data are presented in Figure 2. The same analyses used with the response data was performed on this data. The results are presented in Table 6. Again, no significant group, trial, or group by trial differences were found. The F-max was not significant.

The same analyses were performed aposteriori on the last eight days of both the response and shock data. The results of these 3 by 8 analyses are presented in Tables 7 and 8. No significant differences were found in any of the analyses.

Table 5. Thirteen day response data- aprior ANOVA and F-max statistics summary table. SS and MS values are presented in scientific notation. Note that only the F-max value is significant.

Table 5

Half-Hour Response Data

Over Thirteen Days

Source	d.f.	SS	MS	F	P
Treatments	2	1.11 E7	5.55 E6	.73	N.S.
Subjects within groups	15	1.13 E8	7.53 E6		
Trials	12	7.47 E5	6.22 E4	.83	N.S.
Treatments x Trials	24	2.10 E6	8.76 E4	1.17	N.S.
Trials x Subjects within groups	180	1.34 E7	7.48 E4		

	d.f.	K	F	P
F-max	5	3	13.00	.05

Figure 2. Graph of mean shocks per subject for the three social interaction conditions over the thirteen test days (Day 26 to 38). The single subject (SS) paradigm, companion paradigm (CP), and physical paradigm (PP) each contained six subjects.

Figure 2

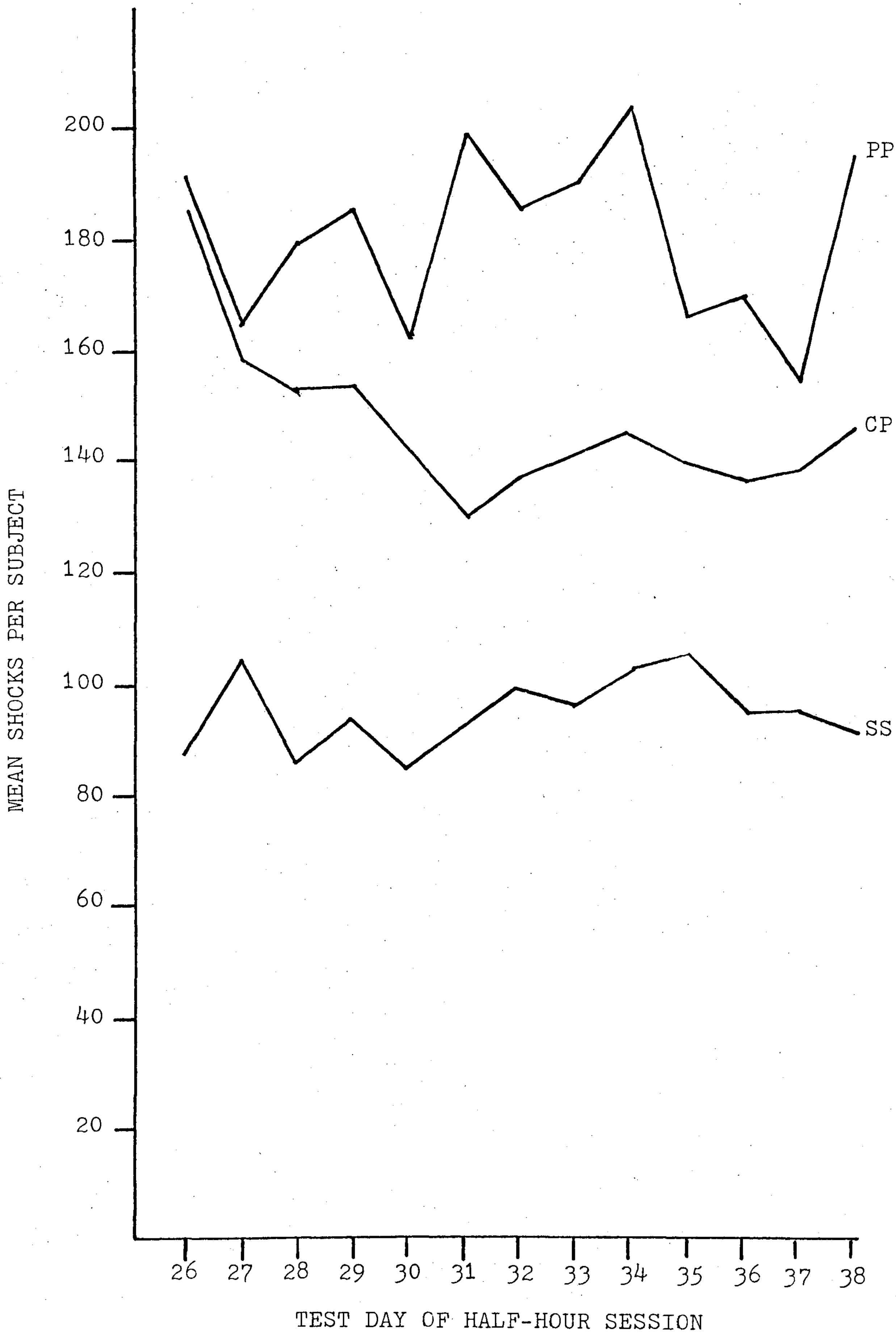
MEAN SHOCKS PER SUBJECT
200
180
160
140
120
100
80
60
40
20
PP
CP
SS
26
27
28
29
30
31
32
33
34
35
36
37
38
TEST DAY OF HALF-HOUR SESSION

Table 6. Thirteen day shock data- apriori ANOVA and F-max statistics summary table. SS and MS values are presented in scientific notation. Note that there are no significant F values.

Table 6

Half-Hour Shock Data

Over Thirteen Days

Source	d.f.	SS	MS	F	P
Treatments	2	2.89 E5	1.44 E5	2.16	N.S.
Subjects within groups	15	1.00 E6	6.68 E4		
Trials	12	1.13 E4	9.49 E2	1.48	N.S.
Treatments x Trials	24	2.40 E4	1.00 E3	1.56	N.S.
Trials x Subjects within groups	180	1.15 E5	6.41 E2		

	d.f.	K	F	P
F-max	5	3	6.20	N.S.

Table 7. Eight day response data- aposteriori ANOVA and F-max statistics summary table. SS and MS values are presented in scientific notation. Note that there are no significant F values.

Table 7

Half-Hour Response Data

Over Eight Days

Source	d.f.	SS	MS	F	P
Treatments	2	6.00 E6	3.00 E6	.65	N.S.
Subjects within groups	15	6.87 E7	4.58 E6		
Trials	7	3.21 E5	4.59 E4	1.05	N.S.
Treatments x Trials	14	3.01 E5	2.15 E4	.49	N.S.
Trials x Subjects within groups	105	4.55 E6	4.34 E4		

	d.f.	K	F	P
F-max	5	3	7.36	N.S.

Table 8. Eight day shock data- aposteriori ANOVA and F-max statistics summary table. SS and MS values are presented in scientific notation. Note that there are no significant F values.

Table 8

Half-Hour Shock Data

Over Eight Days

Source	d.f.	SS	MS	F	P
Treatments	2	1.79 E5	8.79 E4	2.02	N.S.
Subjects within groups	15	6.50 E5	4.33 E4		
Trials	7	5.24 E3	7.48 E2	1.34	N.S.
Treatments x Trials	14	9.85 E3	7.03 E2	1.26	N.S.
Trials x Subjects within groups	105	5.83 E4	5.55 E2		

	d.f.	K	F	P
F-max	5	3	6.98	N.S.

DISCUSSION

Past research on Zajonc's (1965) social facilitation theory has produced results opposite to those predicted when paired rats were tested on their maintenance of Sidman avoidance. It was felt that past research (Davis, 1969; Cunningham and Roberts, 1973) used an inappropriate test group in that the paired subjects were capable of coming in physical contact with each other in a shock setting. The resulting shock elicited aggressions would interfere with responding and produce response decrement rather than the response increment Zajonc's theory would predict. This study attempted to examine social interaction while preventing shock elicited aggression by adding a companion paradigm where physical contact was prevented between paired subjects.

It was hypothesized that subjects in the companion paradigm would perform better than subjects responding alone; in line with Zajonc's theories. However, analyses on the results failed to show a significant difference between groups, with the exception of a significant F-max test of the manipulandum data. Therefore the hypothesis regarding Zajonc's social facilitation theory was not confirmed.

One item of speculation regarding the absence of significant ANOVA results with response and shock data can be found in the significant variability of the PP group relative to the CP group with manipulandum data.

The physical paradigm is a more dynamic condition than CP, in that more factors can affect the response and shock rates. In this study emphasis was placed on shock elicited aggression, and the blocking of the pretrained subject's access to the manipulandum by the naive subject. But other factors are involved, affecting responding by making shock elicited aggression not at all the automatic result in the physical paradigm that had been postulated, especially at the level of shock used in this experiment.

In the case of PP pair 72PP69 the disruptive effects of shock elicited aggressions were avoided. Subject number 72 learned the avoidance task so well during pretraining that when he was paired with number 69 he started avoiding before enough shocks were presented to elicit aggression. Had a few more shocks been received perhaps aggression would have occurred, which would have disruptive further responding. However, if any pretrained subject responds so well during pretraining that few shocks are received when paired with another subject, few incidences of shock elicited aggression will occur and therefore the high rate of responding can continue. This is especially noteworthy in view of the shock intensity in this experiment. Had the shock intensity been higher, more reliable shock elicited aggression might have been produced (cf. Ulrich and Azrin, 1962). A single shock might have been sufficient to produce aggression and disrupt further responding. However, the shock level in this experiment was set near those of Davis (1969) and Cunningham and Roberts (1973), and even at this relatively low level of shock aggression was generally elicited.

In the case of pair 66PP77, and to a much lesser extent with 78PP61, shock avoidance was obtained when the naive subject would lie on his back while the pretrained subject laid on top of him. The result was that the naive subject's fur insulated both subjects from the effect of footshock. It is important to note that this familar type of non-manipulandum avoidance of shock would be similar to shock elicited aggression in its effect on previous tests of Zajonc's theory. Like shock elicited aggression, it is limited to the PP group, leads to performance decrement, is caused by the ability of the paired subjects to come in physical contact with each other in a shock setting, and is prevented by the barrier. A replication of this study might emphasize that physical contact between subjects is not necessary for Zajonc's theory to predict performance facilitation, and that it is a class of behaviors, not just shock elicited aggression, which justify the study of a test paradigm preventing physical contact.

This non-manipulandum avoidance was partially the reason subject pair 78PP61 had no shock elicited aggressions, yet a fair amount of shocks received. The main reason appears to be due to subject number 78 responding to the shock rather than to avoid shock. One of the reasons a wheel-turn manipulandum was used was to avoid problems associated with the lever-press, in that responding may have been due to either reflexive or current-induced muscular contractions, followed by freezing over the lever until the next shock, followed by either reflexive or current-induced lever-pressing, etc.

It was hoped that the wheel-turn, by having each of the eight "bars" swing out of the way after being pressed, would prevent this. It did not. This subject would react to shock by jerking downward with enough force to spin the wheel and record several responses, then move to place itself back over the wheel until the next shock at the end of the R-S interval (15 seconds) repeated the process. Number 78's pair (number 61) received shocks, but apparently not enough within a short enough time span to elicit aggression. Future research might benefit from a manipulandum that avoids the problem that Bolles and McGillis (1968) term "the non-operant nature of the bar-press".

Other improvements can be suggested should this study be replicated. First, the measurement of shock elicited aggressions in this study suffered from a random selection which left two pairs untested in each of the CP and PP groups. In addition, the days selected for testing were not evenly distributed; the latter days were heavily tested. A preferred procedure might be to set up testing days prior to assigning pretrained subjects to conditions in order to produce a more meaningful and accurate picture of the occurrence of shock elicited aggression. Second, it would also be desirable to expand the classification and observation of behaviors uniquely disruptive to the PP condition, rather than just shock elicited aggression. This expanded list should include non-manipulandum avoidance. Incidences of the naive rat blocking the pretrained rat's access to the manipulandum should also be included on logical grounds, even though few incidences of this were recorded in this study.

APPENDIX A

At the end of pretraining each of the eighteen subjects were assigned to one of three conditions: single subject (SS), companion paradigm (CP), or physical paradigm (PP). Equivalence of these three groups was determined by summing each subject's response values over the last ten pretraining days, and then treating that value as one score in a single factor, independent groups design.

As can be seen in Table A, the ANOVA was not significant. An identical procedure was performed with shock data, and again a significant difference was not found (Table B). It was concluded that the groups were statistically equivalent at the end of pretraining.

Table A. Summary table on test of equivalence of groups with response data. SS and MS values are presented in scientific notation. Note that the single factor, independent groups ANOVA is not significant.

TABLE A

Test of Equivalence

of Groups- Response Data

Source	d.f.	SS	MS	F	P
Treatments	2	4.41 E7	2.20 E7	.93	N.S.
Error	15	3.56 E8	2.37 E7		

Table B. Summary table on test of equivalence of groups with shock data. SS and MS values are presented in scientific notation. Note that the single factor, independent groups ANOVA is not significant.

TABLE B

Test of Equivalence

of Groups- Shock Data

Source	d.f.	SS	MS	F	P
Treatments	2	4.74 E5	2.37 E5	1.49	N.S.
Error	15	2.38 E6	1.59 E5		

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VITAE

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