

**THE EFFECTS OF SURGICALLY-PRODUCED ANOSMIA
ON PERFORMANCE IN DIFFERENTIAL
CONDITIONING**

DISSERTATION

WILLIAM H. RESHA

THE EFFECTS OF SURGICALLY-PRODUCED ANOSMIA ON PERFORMANCE
IN DIFFERENTIAL CONDITIONING

An Abstract
Presented to
the Graduate Council of
Austin Peay State University

In Partial Fulfillment
of the Requirements for the Degree
Master of Arts

by
William H. Resha
April 1975

ABSTRACT

The behavioral effects of rendering rat subjects surgically anosmic were investigated in a differential conditioning situation. Twenty-seven anosmic rat subjects were randomly assigned to one of three groups (nine subjects in each group). Group 1L-1S and Group 11S-1S served as the differentially rewarded groups with Group 1S-1S serving as the control group. During Phase I (Acquisition) Group 1L-1S received one 500 mg. food pellet on S+ trials and one 45 mg. food pellet on S- trials; Group 11S-1S received eleven 45 mg. food pellets on S+ trials and one 45 mg. food pellet on S- trials; while Group 1S-1S received one 45 mg. food pellet on both S+ and S- trials. Phase I lasted 18 days (with four trials per day, 2 S+ and 2 S-) followed by Phase II (Extinction) which lasted 5 days. The results of Phase I failed to yield significant differential conditioning, let alone NCEs. During Phase II, the small reward control group (1S-1S) extinguished significantly faster in the start measure than the two differentially-rewarded groups. Further, the two differentially-rewarded groups (1L-1S and 11S-1S) extinguished significantly faster in the run measure to the former S- alternative which indicated that differential extinction occurred. This suggests that some limited differential incentive formation occurred for Groups 1L-1S and 11S-1S during Phase I. The data indicates that surgically rendering rat subjects anosmic has the effect of reducing their incentive motivation level (reduction in non-emotional processes).

THE EFFECTS OF SURGICALLY-PRODUCED ANOSMIA ON PERFORMANCE
IN DIFFERENTIAL CONDITIONING

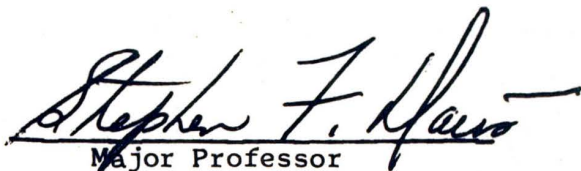
A Thesis
Presented To
the Graduate Council of
Austin Peay State University

In Partial Fulfillment
of the Requirements for the Degree
Master of Arts

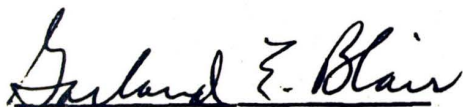
by
William H. Resha
April 1975

To the Graduate Council:

I am submitting herewith a Thesis written by William H. Resha entitled "The Effects of Surgically-Produced Anosmia on Performance in Differential Conditioning". I recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Arts with a major in Psychology.

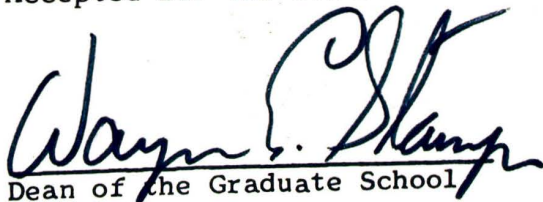

Major Professor

We have read this thesis and
recommend its acceptance:


Minor Professor
or
Second Committee Member


Third Committee Member

Accepted for the Council:


Dean of the Graduate School

ACKNOWLEDGEMENTS

The author wishes to express gratitude and appreciation to Dr. Stephen F. Davis, Assistant Professor of Psychology, Austin Peay State University, who suggested the problem and who was a significant force in the completion of the study.

Appreciation is also extended to John D. Seago, Assistant Professor of Psychology, Concord College, Athens, West Virginia, for his aid in performing surgery on the anosmic rats.

A special thanks is expressed to the author's wife, Elaine, who spent many hours in preparing readers copies and assisting in the statistical tabulations.

TABLE OF CONTENTS

Chapter	Page
I. INTRODUCTION.....	1
II. METHODS.....	11
Subjects.....	11
Apparatus.....	11
Procedure.....	12
III. RESULTS.....	14
IV. DISCUSSION.....	16
APPENDIX A: TABLES.....	20
APPENDIX B: FIGURES.....	27
BIBLIOGRAPHY.....	34

LIST OF TABLES

TABLE	PAGE
1. Analysis of Variance:	
Mean Start Speed - Acquisition Phase	21
2. Analysis of Variance:	
Mean Run Speed - Acquisition Phase	22
3. Analysis of Variance:	
Mean Goal Speed - Acquisition Phase	23
4. Analysis of Variance:	
Mean Start Speed - Extinction Phase	24
5. Analysis of Variance:	
Mean Run Speed - Extinction Phase	25
6. Analysis of Variance:	
Mean Goal Speed - Extinction Phase	26

LIST OF FIGURES

FIGURE	PAGE
1. Mean Start Speeds (Meters Per Sec.) For Groups 1L-1S, 11S-1S and 1S-1S During Acquisition and Extinction	29
2. Mean Run Speeds (Meters Per Sec.) For Groups 1L-1S, 11S-1S and 1S-1S During Acquisition and Extinction	31
3. Mean Goal Speeds (Meters Per Sec.) For Groups 1L-1S, 11S-1S, and 1S-1S During Acquisition and Extinction	33

Chapter I

INTRODUCTION

During the past 10 to 15 years there has been an increasing amount of interest shown in the effects of differential conditioning (i.e., concurrent reception of different reward magnitudes). An example of a differential conditioning situation might be to present the subject with a large reward (S+) in a black runway, and a small reward (S-) in a white runway. Findings from this area of research have been somewhat conflicting with at least one study (Goldstein and Spence, 1963) indicating that performance was determined solely by the magnitude of reward. On the other hand, other investigators have found performance to be dependent on the context in which the rewards are received (e.g., Bower, 1961).

The study by Bower (1961) found that the reinforcing effect of a given reward magnitude was not a static parameter; but rather that it depended upon the context in which that reward occurred. In this study, Bower (1961) employed three groups of rats that received concurrent reward in two distinct runways (i.e., black and white). One group of subjects received large reward (S+) in one runway and small reward (S-) in the second runway (i.e., a differential conditioning group). A second group received large reward in both runways, while the third group received small reward in both runways. The results indicated that the S- performance

of the first group was depressed below that of the group receiving only small reward in both runways. This finding was termed a "negative contrast effect" (NCE). Frustration theory (Amsel, 1958) was employed by Bower (1961) to interpret the NCE. Bower (1961) postulated that the lowered S- performance for the differential conditioning subjects resulted from a conflict between anticipation of reward (r_g) which had generalized from S+ and frustration (R_F) elicited by the S- goal.

Goldstein and Spence (1963) also reported a differential conditioning study in which black and white runways were used. However, their results conflicted with those reported by Bower (1961). Their findings indicated that asymptotic performance to a particular discriminandum was determined by the absolute magnitude of the reward received and was not a function of its relative magnitude (i.e., NCE's did not develop). For reasons to be discussed later, it should be noted that the two runways used by Goldstein and Spence (1963) were serviced by two individual gray start boxes.

In an attempt to resolve the differences in the findings reported by Bower (1961) and Goldstein and Spence (1963), Ludwigson and S.E. Gay (1966) used a three groups of rats which received either 19, 10, or 1 pellet of food reward in one (S+) of two runways of differential brightness, and one pellet in the second runway (S-), respectively. Their results indicated that S- speeds in the initial segments of the response chain were an inverse function of S- reward magnitude. In other words, NCE's

developed and were directly proportional to the magnitude of reward received in the S+. It was also found that response speeds to the S+ did not differ among the groups. In addition, their data indicated that the maximum NCE occurred in the start measure when the cue of the impending reward was presented, and further, that the strength of this NCE appeared to dissipate (i.e., less difference between S+ and S- speeds) as the subject approached the goal.

A study by Ludvigson and R.A. Gay (1967) supported and extended the Ludvigson and S.E. Gay (1966) findings. The Ludvigson and R.A. Gay (1967) article reported the results of two experiments. The first experiment undertook to replicate the Ludvigson and S.E. Gay (1966) study with one exception, the latency between the time that the subject consumed the reward and his removal from the goal box was kept to a minimum to ensure that no competing responses were made. This procedure was employed to ensure that frustration did not have an opportunity to develop in the goal box. The results of the first experiment reported by Ludvigson and R.A. Gay (1967) substantiated those of Ludvigson and S.E. Gay (1966) by showing that a strong NCE in S- speeds did develop and was again most pronounced in the initial segment of the response chain and dissipated as the goal was approached. The data indicated that immediate removal of the subject from the goal box did not prevent the occurrence of a NCE (i.e., frustration due to competing responses made at the goal was not the source of the NCE). The second experiment reported by Ludvigson and R.A. Gay (1967) tested the hypothesis that presenting the cues signaling the S- as the subject

entered the start box, as compared with the alley, would markedly influence performance in the alley. The research anticipated that a maximal NCE would occur at the point of initial presentation of S- cues and that this NCE would attenuate rather quickly. Subjects were randomly assigned to one of three groups of equal size with the study consisting of two phases, preshift and postshift. During the preshift phase, Group BW always started from two start boxes, black and white respectively, which corresponded in color to the alley each start box serviced. A second group, Group G, started from a single gray start box on each trial; while in a third group, Group C (control), one half of the subjects started from the gray start box and the other half from the black and white start boxes. Subjects in Groups BW and G received 12 pellets in S+ and one pellet in S-, while subjects in Group C received one pellet on all trials. During the postshift trials, Group BW's start boxes were reversed, with the white start box leading to the black alley and the black start box leading to the white alley. Group G was shifted from the gray start box to the black and white start box (i.e., the conditions that prevailed for Group BW during the first phase). Conditions for Group C remained unaltered during the postshift phase. The results indicated that Group BW showed a NCE in the "speed of orienting" to the start box door, and a greatly attenuated NCE in actual alley performance. On the other hand, Group G showed a strong NCE in the start measure (i.e., the initial presentation of the discriminative cues for that group). The results corroborated the Ludvigson and S.E. Gay

(1966) data by indicating that the initial presentation of the S- cue is an important variable in controlling the magnitude of the NCE and that the NCE is maximal just after the subject first receives the cue indicating that an S- trial is impending. Ludvigson and R.A. Gay (1967) speculated that the discrepancy between results reported by Bower (1961) and those reported by Goldstein and Spence (1963) could be attributed to the starting conditions used by the two studies. The Goldstein and Spence (1963) study employed two separate gray start boxes, one for each alley, which might have provided the subject with differential S+ and S- cues just prior to the measurement of the running response. Thus, a greatly attenuated, or possibly no NCE would be predicted on the basis of the Ludvigson and R.A. Gay (1967) data. Goldstein and Spence (1963), as already pointed out, did fail to obtain an NCE. On the other hand, Bower (1961) used only one gray start box, common to both runways. In this situation differential responding (i.e., an NCE) would be predicted, and, as already mentioned, did occur.

A study by Davis, Gilbert, and Seaver (1971) sought to determine the effects of presenting the discriminative cues at different points in the runway.

Forty rat subjects were randomly assigned to four equal groups. For subjects in Group SO, the discriminative cues were presented only in the start box; Group WA received discriminative cues in the start box and throughout the entire apparatus; Group RO received discriminative cues only in the run and goal sections;

Group NO (control Group) received non-discriminative cue presentation.

The results of the Davis et al. (1971) study supported the data reported by Bower (1961), Ludvigson and S.E. Gay (1966), and Ludvigson and R.A. Gay (1967), by indicating that the primary effects of differentially presenting the discriminative cues were on S- performance. Further, the most significant decrement in performance occurred when the onset of the S- cue coincided with the initiation of the response. It was also shown that the longer a subject was in the presence of the discriminative S- cue, the more the decrement in S- performance dissipated.

A differential conditioning study reported by McHose and Ludvigson (1966), interestingly enough, found that a nondiscrimination control group displayed differential responding, (i.e., fast to S+, slow to S-). To account for these surprising results, McHose and Ludvigson (1966) proposed that the discrimination displayed by these control subjects was based upon odors exuded by the discrimination subjects. These odors were subsequently attended to by the control subjects. Subsequent to the publication of this study by McHose and Ludvigson (1966), research in the area of olfactory control of animal maze learning has increased drastically. From this accumulation of data, a two-fold picture concerning the nature and utilization of odor cues appears to be emerging. First, odors appear to serve a discriminative cue function, allowing subjects to forecast the nature of an impending goal event (Ludvigson and Sytsma, 1967; Amsel, Hug, and Surridge, 1969; Seago,

Ludvigson, and Remley, 1970; Morrison and Ludvigson, 1970; Davis, Crutchfield, Shaver, and Sullivan, 1970; Prytula, Cox, and Bridges, 1973; Prytula and Payne, 1974). Second, reward and nonreward experiences appear to produce odors which serve to elicit unconditioned approach and avoidance responses, respectively (Wasserman and Jensen, 1969; Collerain and Ludvigson, 1972; Mellgren, Fouts, and Martin, 1973). To date, numerous procedures have been employed in an attempt to control, and hopefully eliminate, odor cues in the runway-type situation. For example, odor-control techniques have included: swabbing the apparatus with water (Davis and Ludvigson, 1969), with Lysol (Davis, Crutchfield, Shaver, and Sullivan, 1970), or with mild disinfectant (Davis and Ludvigson, 1969); using removable paper flooring (Collerain and Ludvigson, 1972); and exhausting the runway air (Bloom and Phillips, 1973). However, the most stringent odor control procedure would appear to be the use of anosmic (i.e., olfactory sense removed) subjects. But, before the widespread use of anosmic subjects as an odor-control procedure is effected, it would seem important to ascertain what behavioral effects, if any, are produced by rendering the subject anosmic.

Although rats rendered surgically anosmic have been the focus of a number of recent studies, the behavioral effects of anosmia remain unclear and somewhat elusive. For example, in an attempt to determine the effects of surgical anosmia on runway behavior, Marrero, Davis, and Seago (1973) employed two groups (large and small reward) of anosmic ss. The results of this study indicated

that the performance of the large-reward anosmic Ss was somewhat inferior (significantly so in the start measure) to that of the small-reward anosmic Ss. A study by Davis, Harper, and Seago (1975) replicated the data reported by Marrero et al. (1973) and additionally, evaluated the effect of a shift from large-reward to small reward. Compared to the abrupt and precipitous drop in performance shown by the normal subjects experiencing the same reduction in incentive, the shift in incentive resulted in a much more gradual decline in the performance of the anosmic subjects. Thus, the results of the Marrero et al. (1973) and the Davis et al. (1975) studies strongly suggest that, in addition to eliminating the sense of smell, surgical anosmia additionally has a pronounced effect on motivational level. The effect would appear to be that of lowering the motivational level. Conversely, Seago, Ludvigson, and Remley (1970) reported that anosmic rats trained under a double-alternation pattern of reward-nonreward ran faster than did normal rats, particularly in the goal section of the apparatus. In addition, these investigators reported that several of the anosmic Ss were quite vicious.

Other investigations have pointed to the apparent inferiority of anosmic rats in various tasks. Early studies (Lindley, 1930; Honzik, 1936) investigating complex maze learning ability of anosmic and normal rats indicated that anosmic Ss made consistently more errors than did normal Ss. More recently, Phillips (1970) found that a group of anosmic rats failed to display learning set formation in a visual discrimination problem. Sieck (1970) re-

ported difficulty in handling anosmic rats and his data reflected better performance of anosmics in an active avoidance task, but decreased learning ability in a passive avoidance task. He speculated that the olfactory system was important in maintaining a balance between activating and directing mechanisms in the rat brain. Marks, Remley, Seago, and Hastings (1970), however, have reported somewhat different results. They reported that in both active and passive avoidance tasks, control rats were superior to anosmics, while in an operant task, anosmics maintained a higher rate of bar pressing than did control ss.

These particular studies suggest that the ablation of the rats' olfactory lobes influences behavior in subtle and varied ways. Therefore, a clearer picture of the effects of anosmia on behavior would seem to be warranted before subjects of this nature are employed as an odor-control technique.

Combining these lines of research, the present study was designed with several purposes in mind. First, it would appear to be of interest to investigate the effects of concurrently exposing anosmic subjects to different levels of reinforcement (i.e., a differential conditioning situation). If, as the Marrero et al. (1973), and Davis et al. (1975) data suggest, the effect of anosmia is to lower the motivational level, then one might predict that NCE's would not be shown by anosmic subjects in this situation. Additionally, it should be recalled that both the Marrero et al. (1973), and Davis et al. (1975) studies indicated that anosmic subjects receiving large reward showed inferior performance relative

to anosmic subjects receiving small reward. These results suggest that the anosmic subject may find the receipt of large reward to be somewhat aversive. The concurrent receipt of both large and small rewards on a within-subject basis would also appear to be an excellent manner by which to ascertain the relative attraction and/or aversion to different reward magnitudes by the anosmic subject.

Second, by extending research on anosmia into a previously uninvestigated area (i.e., differential conditioning), the present study was designed to provide additional information concerning the effects of anosmia in general and its effects on runway behavior in particular. Obviously, a clearer picture of these effects would appear to be important in its own right, but such a picture would also aid in resolving the question concerning the advisability of using anosmic subjects as odor controls.

Chapter II

METHOD

Subjects

Twenty-seven naive, male albino rats purchased from the Sprague-Dawley Laboratories, Madison, Wisconsin served as subjects, and were approximately ninety days old at the time of surgery. All animals were rendered surgically anosmic in the following manner. First, each subject was anesthetized with sodium pentobarbital. Then, using a stereotaxic instrument, trephine openings were placed on each side of the sagittal suture above the olfactory bulbs. The olfactory bulbs and connecting tracts were removed from each subject with an aspirator. Beginning one week before the start and continuing for the duration of the experiment, all subjects were placed on food deprivation and maintained at 85% normal body weight. All subjects were housed in individual cages with water always available. Maintenance of the deprivation schedule took place at the completion of each daily experimental session.

Apparatus

The apparatus consisted of two straight runways (11.43 cm. wide, 12.70 cm. high) made from 12.7 mm. thick pine lumber. One runway and its goal box was painted black, while the other runway and its goal box was painted white. Both runways were serviced by a common gray start box (38.10 cm.) that could be positioned in front of either runway. Each runway was divided into a 91.44 cm.

run section, and a 30.48 cm. goal box. The start and goal boxes were separated from the run section by masonite guillotine doors. Raising the start door activated a standard electric timer (start time). Passing through a photoelectric beam located 15.24 cm. beyond the start door stopped the first timer and activated the second timer (run time). Breaking a second beam (located 76.20 cm. beyond the first beam) stopped the second timer and started a third timer (goal time). Breaking a third beam (located 5.08 cm. in front of the goal cup) stopped the third timer. The goal cup in each goal box consisted of a plastic receptacle (4 cm. wide, 4 cm. high, and 3.40 cm. deep) recessed into the end wall. Hardware-cloth tops covered the entire apparatus.

Procedure

Food deprivation was initiated nine days prior to the beginning of the experimental project. A pretraining phase was begun five days before the start of the experiment. During pretraining, all subjects were handled and tamed (Days 1-2), allowed to individually explore the runways (Days 3-5), and pellet habituated in the home cages (Days 1-5).

At the start of pretraining, three equal groups were randomly formed. Group 1L-1S received one 500 mg. food pellet on S+ trials, and one 45 mg. food pellet on S- trials during acquisition. Group 11S-1S received eleven 45 mg. food pellets on S+ trials, and one 45 mg. food pellet on S- during acquisition. Finally, Group 1S-1S received one 45 mg. food pellet on both S+ and S- trials during

An 18-day acquisition phase was initiated immediately after pretraining. During this phase all subjects received 2 S+ and 2 S- trials per day. Administration of the four daily trials to each S was determined by random assignment of one of the six possible sequences of + and - with the restriction that no sequence could occur more than twice in succession. The use of the black and white runways as S+ or S- cues was counterbalanced within each group. Subjects were confined to the start box for 5 seconds before the start door was raised and the trial initiated. Subjects were removed from the goal box as soon as the reward was taken into the mouth. Additionally the order for running subjects was randomized daily, with all Ss receiving Trial 1 before Trial 2 was administered, etc.

A 5-day (40 Trial) extinction phase followed acquisition. The same procedure as used in acquisition prevailed during extinction, with the exception that all subjects were confined to the empty goal box for 30 seconds on all trials.

Following the extinction phase, the subjects were sacrificed using an overdose of sodium pentobarbital they were then perfused with normal saline in a 10% neutral buffered formalin solution. The entire brain was then removed and stored in a formalin solution. Visual inspection of the brain revealed that the olfactory bulbs and tract had been successfully removed from all subjects.

Chapter III

RESULTS

Figures 1-3 present mean start, run and goal speeds (meters/second) respectively, for the three groups during Phases I and II. Analyses of variance were performed on the data from Days 17-18 of Phase I (the point at which differential responding should have been the strongest) for all three measures. The results of these analyses corroborate the graphical impressions that differential conditioning, let alone NCE's was not shown by either Group 1L-1S or Group 11S-1S. Tables 1-3 summarize these analyses.

Analyses performed on the five extinction days indicated that in all three measures both the Reward Alternative (former S+ vs former S-) factor (start, $F = 7.62$, $df = 1/189$, $p < .01$; run, $F = 22.46$, $df = 1/189$, $p < .01$; goal, $F = 4.33$, $df = 1/189$, $p < .05$), and the Trials factor (start, $F = 11.02$, $df = 4/189$, $p < .01$; run, $F = 9.51$, $df = 4/189$, $p < .01$; goal, $F = 8.33$, $df = 4/189$, $p < .01$) were significant. Additionally, Groups by Trials interaction was significant in the start measure ($F = 2.47$, $df = 8/189$, $p < .05$), as was the Groups by Reward Alternative interaction in the run measure ($F = 6.72$, $df = 2/189$, $p < .01$). Tables 4-6 summarize these analyses. Using simple main-effects analyses and Newman-Keuls procedures, the Groups by Trials interaction was further investigated. The results of these analyses indicate that the groups differed significantly in the start measure at Day 4 ($F = 4.66$, $df = 2/21$, $p < .05$) and at Day 5 ($F = 5.13$, $df = 2/21$, $p < .05$) with Group

1S-1S extinguishing significantly ($p < .05$) faster than Groups 1L-1S and 11S-1S on these days. Further, using simple main-effects analyses, the Groups by Reward Alternative interaction indicated a significantly depressed performance preference to S- compared to S+ in the run section for Group 1L-1S ($F = 9.37$, $df = 1/21$, $p < .01$) and Group 11S-1S ($F = 10.02$, $df = 1/21$, $p < .01$). Groups by Reward Alternative interaction showed borderline significance in the start and goal measures during extinction, thus supporting the impression that the significant Reward Alternative differences were primarily attributable to differential responding by Groups 1L-1S and 11S-1S.

Chapter IV

DISCUSSION

The most striking feature of the present study is the complete absence of differential responding, hence, no NCE's, during Phase I on the part of the differentially-rewarded groups (1L-1S and 11S-1S). These results are, obviously, not consistent with the data reported by Bower (1961), Ludvigson and S.E. Gay (1966), Ludvigson and R.A. Gay (1967), or Davis, Gilbert, and Seaver (1971) which showed significant NCE's, especially pronounced in the start measure. On the other hand, the data of the present study is also not consistent with that reported by Goldstein and Spence (1963). It will be recalled Goldstein and Spence (1963) found that differential conditioning was primarily a function of reward magnitude. Hence, according to the position advocated by Goldstein and Spence (1963), one would expect to find differential responding. In addition, one would expect that the performance of Group 1S-1S would be inferior to the S+ performance of Groups 1L-1S and 11S-1S, but equivalent to the S- performance of these groups. Again, it is readily apparent that these predicted results did not occur in this study.

A two-component model of differential conditioning developed by Davis and Ludvigson (1974) would appear to be helpful in clarifying the results of the present study. This model proposes that differential conditioning results from: (1) a nonemotional process, such as that suggested by Goldstein and Spence (1963), which entails differential habit or incentive formation; and (2) an overlay of

frustration that may accompany the basic discrimination and which would be expected to heighten the depression of S- speeds (i.e., produce a true NCE). Since the data of the present study indicated that differential responding failed to develop, it would appear that one effect of surgical anosmia is to drastically reduce the first component of the Davis and Ludvigson (1974) model. In support of this position, the studies reported by Marrero, Davis, and Seago (1973), and Davis, Harper, and Seago (1975) have indicated that one effect of surgically-produced anosmia is to reduce incentive motivation.

Looking for a specific mechanism by which this behavior is mediated, it is tempting to implicate the limbic system, and the amygdala in particular. Anatomically the olfactory bulbs send fiber tracts directly to the cortico-medial nucleus of the amygdala. The limbic system is generally regarded as a primitive motivational system. Past research has indicated that amygdalectomy interferes with avoidance learning (e.g., Robinson, 1963; Weiskratz, 1956). On the basis of the present data, it would appear that a reduction in input to the amygdala via the olfactory system might possibly reduce motivational level.

Turning to Phase II (Extinction), Figures 1-3 indicate that performance for all three groups (1L-1S, 11S-1S and 1S-1S) declined during this phase. Additionally, there appears to be two other interesting aspects to this phase; (1) there was a tendency (significant in the start measure) for the small reward control group to extinguish more rapidly than the differential-conditioning

groups, and (2) within the differential-conditioning groups there was a tendency (significant in the run measure) for them to extinguish more rapidly to the former S- alternative (i.e., differential extinction). This later result would suggest that some, although limited, differential incentive formation did take place during acquisition for Groups 1L-1S and 11S-1S. The fact that there was a slight tendency for these groups to prefer (i.e., faster speeds) the S+ during Phase I is supportive of this position.

One of the stated objectives of the present study was to investigate the relative attractiveness or aversiveness of different reward magnitudes in the differential conditioning situation. As previously mentioned, the data reported by Marrero et al. (1973), and Davis et al. (1975) supported the contention that the receipt of a single large pellet reward was an aversive event for the anosmic subject. Obviously, the data from the present study does not support this contention. At present there would appear to be no clear-cut resolution of this discrepancy. However, one could point to methodological differences as possible determinants. In the present study the subjects concurrently experienced both large and small reward, whereas subjects in the Marrero et al. (1973), and Davis et al. (1975) studies experienced only one reinforcement level at a given time. Thus, it would appear that concurrent exposure to both reinforcement values has the effect of negating any aversive properties of the single pellet large reward. Concerning the use of anosmic subjects as an odor-control technique, the present study, in concert with the Marrero et al. (1973), and

Davis et al. (1975) data strongly caution against the wide-spread use of the anosmic subjects as an odor controlling method. Surgical anosmia does, indeed, produce distinctive behavioral effects! Hence, other odor-controlling methods such as: scrubbing the runway down with water (Davis and Ludvigson, 1969), using Lysol to disinfect the runway (Davis, Crutchfield, Shaver, and Sullivan, 1970), using Windex to clean the runway, (Davis, 1973), and the use of exhaust fans and air deodorants (Davis, and Ludvigson, 1974), should be considered for implementation.

In summary then, the findings of the present study indicated that: (1) differential conditioning (hence no NCE) did not develop for the anosmic subjects during Phase I; (2) differential extinction (i.e., slower speeds to former S-) was shown by the differential conditioning groups thus indicating that some differential incentive formation did develop during Phase I; and (3) the previously found aversion to one large reward pellet was not displayed by the anosmic subject in the differential conditioning situation. The picture concerning the effects of surgically-produced anosmia on the runway behavior of the rat is becoming somewhat more clear. However, there obviously remains a great deal of work to be done in this area before the full picture is seen.

APPENDIX A: TABLES

TABLE 1

Analysis of Variance:
Mean Start Speed - Acquisition Phase

Source	<u>SS</u>	<u>df</u>	<u>MS</u>	<u>F</u>
Between Subjects	15.89	23		
A (Groups)	1.51	2	.75	1.10
Subjects Within Groups (error)	14.38	21	.68	
Within Subjects	2.23	24		
B (+ vs -)	.01	1	.01	.10
A X B	.12	2	.06	.60
B X Subjects Within Groups (error)	2.10	21	.10	

TABLE 2

Analysis of Variance:

Mean Run Speed - Acquisition Phase

Source	<u>SS</u>	<u>df</u>	<u>MS</u>	<u>F</u>
Between Subjects	2.47	23		
A (Groups)	.09	2	.04	.39
Subjects Within Groups (error)	2.38	21	.11	
Within Subjects	1.03	24		
B (+ vs -)	.17	1	.17	4.25
A X B	.02	2	.01	.25
B X Subjects Within Groups (error)	.84	21	.04	

TABLE 3

Analysis of Variance:
Mean Goal Speed - Acquisition Phase

Source	<u>SS</u>	<u>df</u>	<u>MM</u>	<u>F</u>
Between Subjects	27.05	23		
A (Groups)	.30	2	.15	.11
Subjects Within Groups (error)	26.75	21	1.27	
Within Subjects	2.45	24		
B (+ vs -)	.18	1	.18	1.86
A X B	.21	2	.10	1.07
B X Subjects Within Groups (error)	2.06	21	.09	

TABLE 4

Analysis of Variance:

Mean Start Speed - Extinction Phase

Source	<u>SS</u>	<u>df</u>	<u>MS</u>	<u>F</u>
Between Subjects	64.75	23		
A (Groups)	5.49	2	2.74	.97
Subjects Within Groups (error)	59.26	21	2.82	
Within Subjects	72.32	216		
B (Former + vs -)	2.04	1	2.04	7.62**
C (Trials)	11.81	4	2.95	11.02**
A X B	.43	2	.21	.80
A X C	5.29	8	.66	2.47*
B X C	.46	4	.11	.42
A X B X C	1.69	8	.21	.78
Pooled Interaction Within Subjects (error)	50.60	189	.26	

*p .05

**p .01

TABLE 5

Analysis of Variance:

Mean Run Speed - Extinction Phase

Source	<u>SS</u>	<u>df</u>	<u>MS</u>	<u>F</u>
Between Subjects	13.17	23		
A (Groups)	.08	2	.04	.06
Subjects Within Groups (error)	13.09	21	.62	
Within Subjects	17.51	216		
B (Former + vs -)	1.37	1	1.37	22.46**
C (Trials)	2.32	4	.58	9.51**
A X B	.82	2	.41	6.72**
A X C	.18	8	.02	.36
B X C	.55	4	.13	2.25
A X B X C	.74	8	.09	1.51
Pooled Interaction Within Subjects (error)	11.53	189	.06	

**p .01

TABLE 6

Analysis of Variance:

Mean Goal Speed - Extinction Phase

Source	<u>SS</u>	<u>df</u>	<u>MS</u>	<u>F</u>
Between Subjects	118.08	23		
A (Groups)	.09	2	.04	.01
Subjects Within Groups (error)	117.99	21	5.61	
Within Subjects	58.03	216		
B (Former + vs -)	1.04	1	1.04	4.33*
C (Trials)	8.00	4	2.00	8.33**
A X B	.76	2	.38	1.58
A X C	1.16	8	.14	.60
B X C	1.01	4	.25	1.05
A X B X C	.70	8	.08	.36
Pooled Interaction Within Subjects (error)	45.36	189	.24	

*p .05

**p .01

APPENDIX B: FIGURES

FIGURE 1

MEAN START SPEEDS (METERS PER SEC.) FOR GROUPS 1L-1S, 11S-1S and 1S-1S
DURING ACQUISITION AND EXTINCTION

MEAN METERS / SEC.

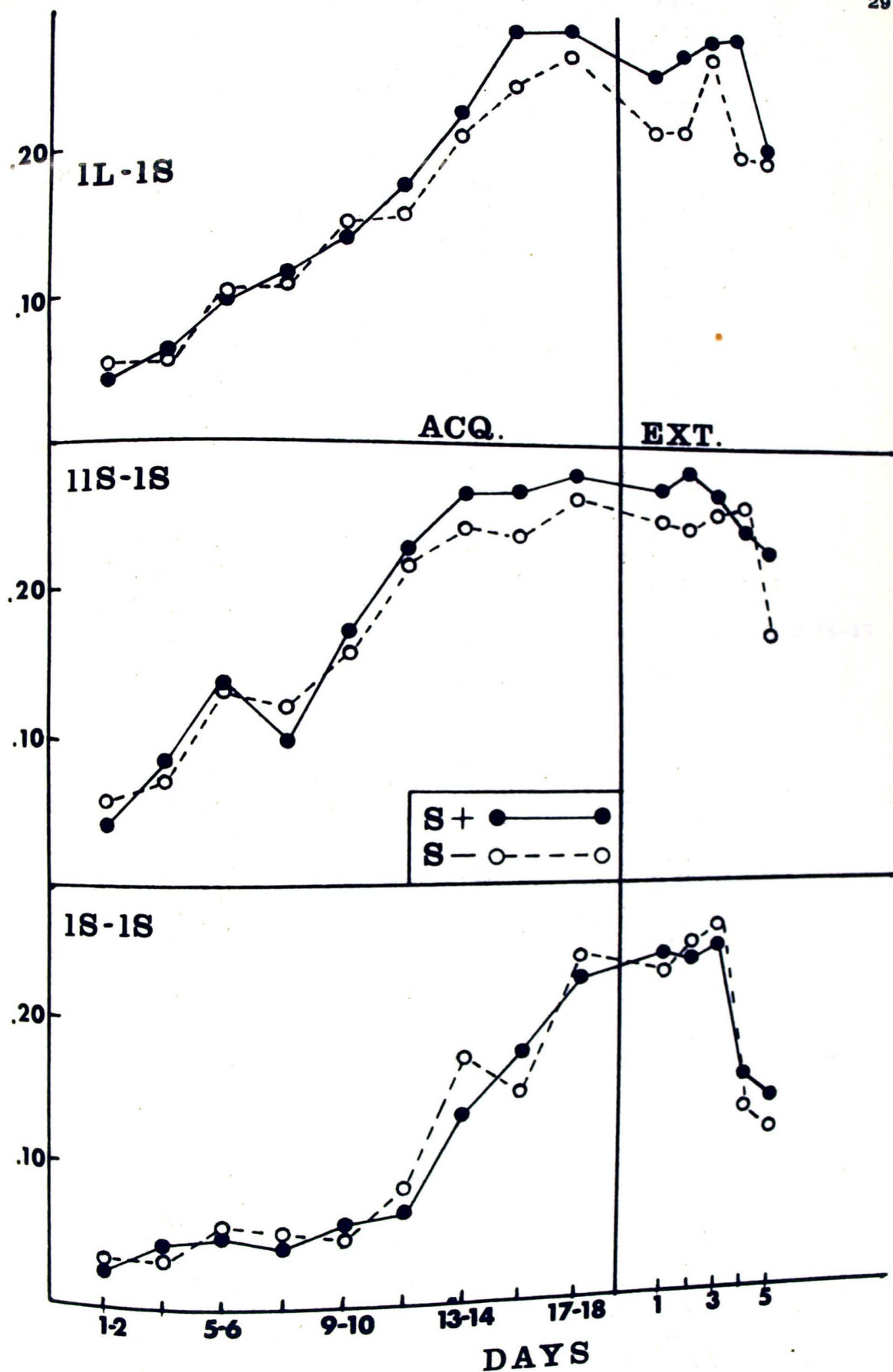


FIGURE 2

MEAN RUN SPEEDS (METERS PER SEC.) FOR GROUPS 1L-1S, 11S-1S and 1S-1S
DURING ACQUISITION AND EXTINCTION

MEAN METERS / SEC.

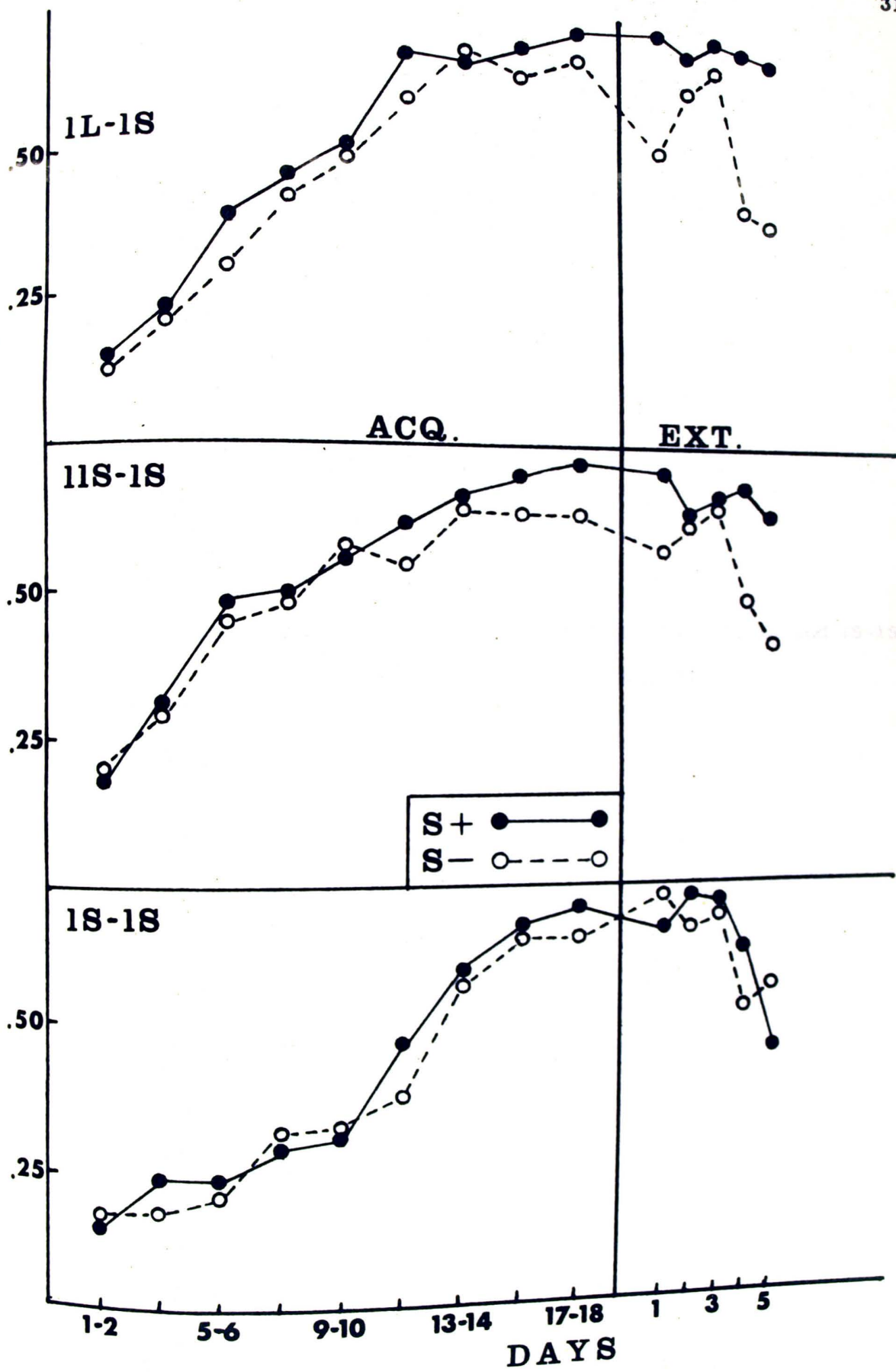
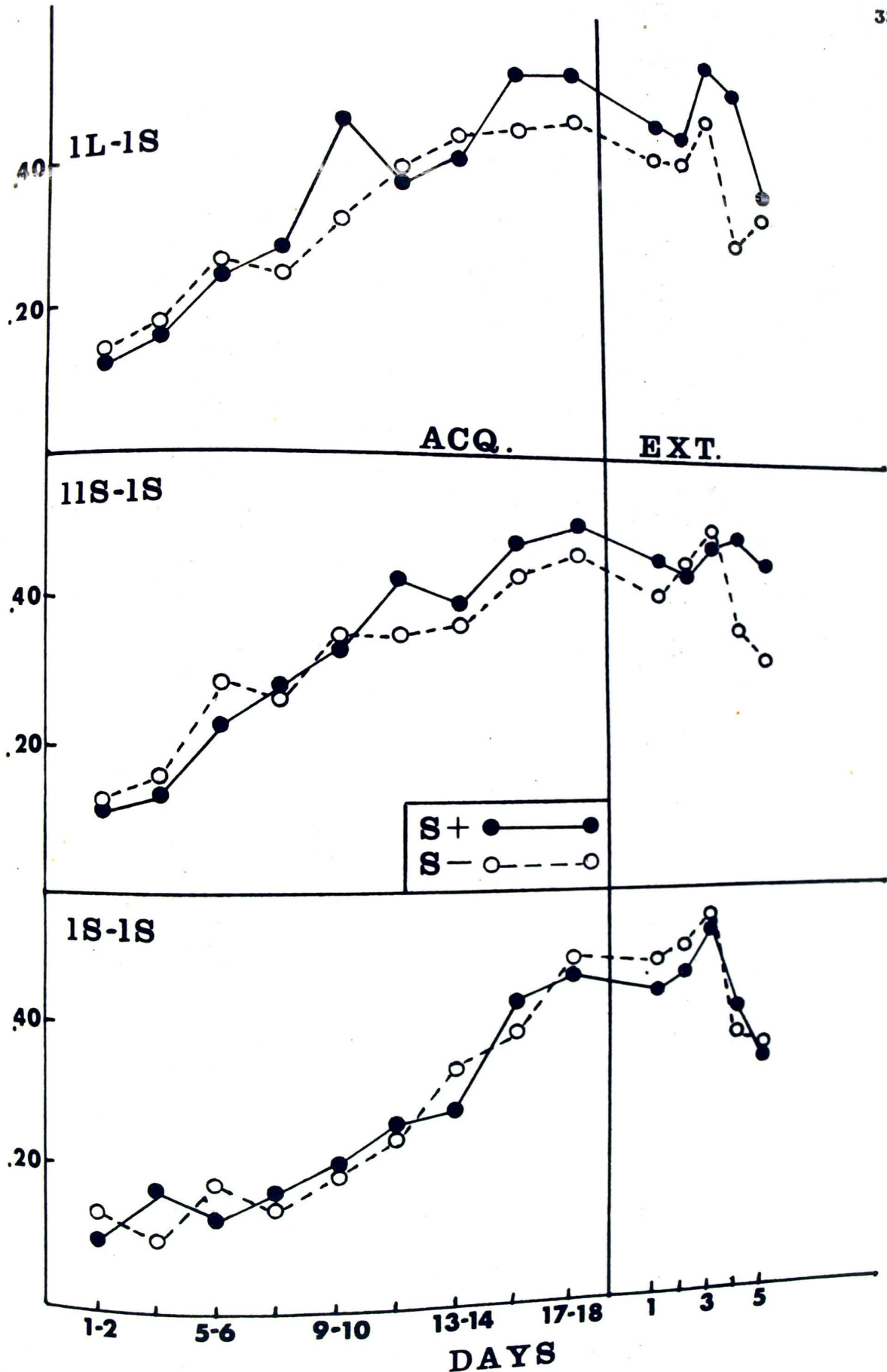


FIGURE 3

MEAN GOAL SPEEDS (METERS PER SEC.) FOR GROUPS 1L-1S, 11S-1S and 1S-1S
DURING ACQUISITION AND EXTINCTION

MEAN METERS / SEC.



BIBLIOGRAPHY

- Amsel, A. The role of frustrative nonreward in noncontinuous reward situations. Psychological Bulletin, 1958, 55, 102-119.
- Amsel, A., Hug, J.J., and Surridge, C.T. Subject-to-subject trial sequence, odor trails, and patterning at 24-h ITI. Psychonomic Science, 1969, 15, 119-120.
- Bloom, J.M., & Phillips, J.M. Conspecific odors as discriminative stimuli in the rat. Behavioral Biology, 1973, 8, 279-283.
- Bower, G.H. A contrast effect in differential conditioning. Journal of Experimental Psychology, 1961, 62, 196-199.
- Collerain, I., and Ludvigson, H.W. Aversion of conspecific odor of frustrative nonreward in rats. Psychonomic Science, 1972, 27, 54-56.
- Davis, S.F. Heterogeneous squad composition, odor cues, and the partial reinforcement effect. Perceptual and Motor Skills, 1973, 36, 1163-1169.
- Davis, S.F., Crutchfield, W.P., Shaver, J., and Sullivan, T. Interspecific odors as cues for runway behavior. Psychonomic Science, 1970, 20, 166-167.
- Davis, S.F., Gilbert, R.F., and Seaver, W.E. III. Stimulus onset and its effect on S+ and S- performance in differential conditioning. Psychonomic Science, 1971, 25, 29-31.
- Davis, S.F., Harper, W.E., and Seago, J.D. Runway performance of normal, sham, and anosmic rats as a function of magnitude of reward and magnitude shift. Unpublished manuscript, 1975.

- Davis, S.F., and Ludvigson, H.W. The "depression effect" and the problem of odor control. Psychonomic Science, 1969, 14, 93-94.
- Davis, S.F., and Ludvigson, H.W. Differential conditioning as a function of exposure time to discriminative and nondiscriminative cues preceding response. Bulletin of the Psychonomic Society, 1974, 4, 385-388.
- Goldstein, H., and Spence, K.W. Performance in differential conditioning as a function of variation in magnitude of reward. Journal of Experimental Psychology, 1963, 65, 68-93.
- Honzik, C.H. The sensory basis of image learning in rats. Comparative Psychological Monographs, 1936, 13.
- Lindley, S.B. The maze-learning ability of anosmic and blind rats. Journal of Genetic Psychology, 1930, 37, 245-267.
- Ludvigson, W.H., and Gay, R.A. An investigation of conditions determining contrast effects in differential reward conditioning. Journal of Experimental Psychology, 1967, 75, 37-42.
- Ludvigson, W.H., and Gay, S.E. Differential reward conditioning: S- contrast as a function of the magnitude of S+. Psychonomic Science, 1966, 5, 289-290.
- Ludvigson, H.W., and Sytsma, D. The sweet smell of success: Apparent double alternation in the rat. Psychonomic Science, 1967, 9, 283-284.
- Marks, H.E., Remley, N.R., Seago, J.D., and Hastings, D.W. Effects of bilateral lesions of the olfactory bulbs of rats on measures of learning and motivation. Physiology and Behavior, 1971, 7, 1-6.

Marrero, B., Davis, S.F., and Seago, J.D. Runway performance of normal and anosmic rats as a function of reward magnitude: A preliminary report. Bulletin of the Psychonomic Society, 1973, 2, 375-376.

McHose, J.H. and Ludvigson, H.W. Differential conditioning with nondifferential reinforcement. Psychonomic Science, 1966, 6, 485-486.

Mellgren, R.L., Fouts, R.S., and Martin, J.W. Approach and escape to conspecific odors of reward and non-reward. Animal Learning and Behavior, 1973, 1, 129-132.

Morrison, R.R., and Ludvigson, H.W. Discrimination by rats of conspecific odors of reward and non-reward. Science, 1970, 167, 904-905.

Phillips, D.S. Effects of olfactory bulb ablation on visual discrimination. Physiology and Behavior, 1970, 5, 13-15.

Prytula, R.E., Cox, T.P., and Bridges, C.C. Acquisition and extinction of a runway response as a function of a between-or within-subjects odor condition. Psychological Reports, 1973, 32, 367-373.

Prytula, R.E., and Payne, J.H. Acquisition and extinction of a runway response under an odor-intensified or-minimized conditions, within-subjects trial administration and a one-minute intertrial interval. Perceptual and Motor Skills, 1974, 38, 119-129.

- Seago, J.D., Ludvigson, H.W., and Remley, N.R. Effects of anosmia on apparent double-alternation in the rat. Journal of Comparative and Physiological Psychology, 1970, 71, 435-442.
- Sieck, N.H. The role of the olfactory system in avoidance learning and activity. Physiology and Behavior, 1972, 8, 705-710.
- Wasserman, E.A., and Jensen, D.D. Olfactory stimuli and the "pseudo-extinction" effect. Science, 1969, 166, 1307-1309.
- Weiskrantz, L. Behavioral changes associated with ablation of the amygdaloid complex in monkeys. Journal of Comparative and Physiological Psychology, 1956, 49, 381-391.