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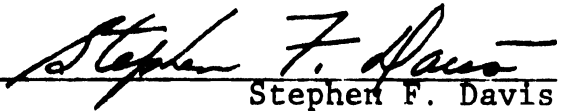
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in Psychology presented on July 17, 1981

Title: ODOR-BASED DOUBLE-ALTERNATION RUNWAY PERFORMANCE AS

A FUNCTION OF TEMPORAL PRESENTATION OF SMALL REWARD

Abstract approved: \_\_\_\_\_

  
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Previous studies designed to investigate odor production and utilization by rat subjects have typically used double-alternation schedules of reward versus nonreward (i.e., RRNNRRNN, where R is a reward trial and N is a nonreward trial). More specifically, rats entering the empty goalbox of a straight runway (on N trials) appear to exude a "frustration" odor or an odor of "nonreward" which may be utilized by subsequent subjects. When these odor cues are maximized, animals are able to learn this double-alternation schedule. Without such cues appropriate learning does not occur.

The present study was designed to investigate odor production and utilization in rat subjects receiving contrasting reward magnitudes (i.e., large (L) versus small (S)). In this

three-phase experiment, 14 subjects were assigned to one of two groups - Group LLSSLLSS or Group LLNNLLNN, where L is a large reward trial, S is a small reward trial, and N is a non-reward trial. To distinguish odor production from odor use, the subjects trained on the LLSSLLSS pattern preceded those trained on the LLNNLLNN pattern. As patterning failed to develop in Group LLSSLLSS as well as the first subject in Group LLNNLLNN, it was concluded that a discriminably different cue ("frustration" odor or odor of "nonreward") was not produced on S trials. However, shifting small-reward delivery on S trials from the beginning to the end of the goalbox-confinement period resulted in the immediate display of patterning by the first subject in the LLNNLLNN group and the subsequent development of patterning by the LLSSLLSS subjects.

Although the contrasting reward magnitudes did not influence the development of patterning, temporal presentation of small reward did. These results may not be supportive of previous attempts designed to relate frustration theory with odor production and utilization. Specifically, receipt of small reward in a previously large-reward situation did not result in the production of "frustration" odor, even though the situation would technically be considered frustrating.

ODOR-BASED DOUBLE-ALTERNATION RUNWAY PERFORMANCE  
AS A FUNCTION OF TEMPORAL PRESENTATION  
OF SMALL REWARD

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A Thesis  
Presented to  
the Department of Psychology  
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In Partial Fulfillment  
of the Requirements for the Degree  
Master of Science

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## PREFACE

Tolman (1945) once said, "... let it be noted that rats live in cages; they do not go on binges the night before one has planned an experiment; they do not kill each other off in wars; they do not invent engines of destruction, and if they did, they would not be so inept about controlling such engines; they do not go in for either class conflicts; they avoid politics, economics, and papers on psychology. They are marvelous, pure, and delightful."

What Tolman did not say was that these delightful little beasts have unwittingly confounded psychological research by exuding odors - odors undetected by psychologists until the mid 1960's.

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## CHAPTER 1

### INTRODUCTION

The use of rats in scientific studies of behavior is, by no means, anomalous. Typically a rat is placed in an experimental environment, tested under manipulated conditions, its behavior measured by the experimenter, and then removed from the apparatus so that another subject can be tested. Under such conditions, the psychologist generally assumes that the only change made in the testing environment is done by himself and not by the animal. However, over the past several years, a number of studies, using rats as subjects, have reported that the animal may significantly alter the experimental environment and thus affect the subsequent responding of other animals (e.g., Amsel, Hug, & SurrIDGE, 1969; Ludvigson & Sytsma, 1967; McHose & Ludvigson, 1966; Pitt, Davis, & Brown, 1973; Spear & Spitzer, 1966). Such studies have indicated that the rat alters the experimental environment by exuding odors (in the apparatus) which are utilized by subsequent subjects.

Such an indication has had a profound effect on animal learning and memory theory. While many learning theorists have employed the use of rats in their endeavors to obtain empirical evidence to support their respective theories, many have not controlled for odors and thus have not considered the effects that odors may have had on the subsequent responding of conspecifics. For example, Tolman and Honzick (1930)

hypothesized the existence of latent learning from observations made of rats in mazes. Although no controls existed for odor (odor phenomena had yet to be found) a theory of learning was established. This does not suggest that latent-learning lacks credibility because it lacked appropriate controls for odor (see Pratt & Ludvigson, 1970), but it does suggest that odors may have confounded the results upon which this theory is based. Nonetheless, it is of no doubt that the traditional view held by psychologists, particularly those interested in animal learning, is that instrumental responses made by rats in mazes and runways have been due to learning and/or memory. However, if one considers the impressive amount of odor research suggesting that instrumental responses may be more attributable to odors in these situations, a learning and/or memory hypothesis for such behavior is weakened (see Davis, Prytula, Doughman, & Perry, 1975; Wasserman & Jensen, 1969). The importance of odor research then, is not to raze existing assumptions of learning theory in animals, but rather to establish important implications of an animal's sensory processes in the study of animal learning.

A number of studies designed to investigate animal learning in a runway apparatus found, quite unexpectedly, that control animals were responding in a manner comparable to that of experimental subjects. Indeed it was not learning that was occurring but responding based on exuded odors. One such initial observation of odor-based responding in rats came from a study designed to investigate differential instrumental

conditioning in rats (McHose & Ludvigson, 1966). In this study, non-differentially reinforced (control) subjects ran faster in a straight alley which discrimination subjects had previously been concessioned favorable rewards than in another alley where subjects had been given less favorable reward. The authors suggested that the differential responding in the non-differentially reinforced animals was a result of odors exuded by discrimination subjects. Since that initial observation, research designed to investigate odor-based responding has mushroomed.

From the accumulated body of research pertaining to odor-based responding, odor cues have been attributed two general qualities. First, odor cues may serve to signal an impending goal event. For example, Ludvigson and Sytsma (1967) have shown that rats can learn a double-alternation pattern of responding (two reward trials followed by two nonreward trials, etc.) when odor cues are made available from donor subjects. Other studies have confirmed this discriminative property of odors (e.g., Davis, 1970; Morrison & Ludvigson, 1970; Prytula, Cox, & Bridges, 1973). Second, odor cues may serve to elicit unconditioned approach and avoidance responses. Mellgren, Fouts, and Martin (1973) demonstrated that naive rats would approach a location where another rat had previously been rewarded more rapidly than they would escape from the same location. Conversely rats would escape from a location where another animal had previously experienced no reward (extinction) more rapidly than they would approach such a location. Wasserman

and Jensen (1969) and Collerain and Ludvigson (1972) have also reported studies suggesting that odors of reward and nonreward may serve to bring about unconditioned approach and avoidance responses respectively.

To substantiate the existence of different odors (reward or nonreward) in a testing situation, "squad order" studies have been conducted. These studies usually employ a single straight alleyway consisting of three sections (start, run, and goal) in which a squad of rats are tested under double-alternating conditions of reward and nonreward. It should be noted that under normal circumstances, rats cannot learn double-alternating patterns of responding (Bloom & Capaldi, 1961). However, studies have shown that when a squad of animals receive the same reward condition on a given trial, odor-based responding occurs (Davis, 1973; Howard & McHose, 1974; Ludvigson, 1969). To illustrate, a typical double-alternation sequence consists of two reward trials (RR) followed by two nonreward trials (NN). Animals typically receive eight trials per day so that animals are generally run according to the following sequence - RRNNRRNN. Under such conditions animals begin to respond (run) appropriately to double-alternating patterns of reward (running fast on reward trials and slow on nonreward trials).

Other studies have utilized varying apparatuses and subject designs to further substantiate reward and nonreward odors. Collerain and Ludvigson (1972) used a T-maze to differentiate between reward and nonreward or "frustration" odors.

Results from a study by Mellgren, Fouts, and Martin (1973), also suggested that rats produced qualitatively different odors of reward and nonreward and that such odors differed between themselves as well as control odors. The control odors in this study were, "no odor", and the odor that was present from another rat who was simply placed in the runway and had not experienced reward or nonreward.

As the number of studies reporting empirical evidence to support the existence of reward and nonreward odors increased, several studies were undertaken to find an anatomical source for these odors (e.g., McNeese, 1975). The anatomical structures which were implicated as possible sources of odors were. (a) the preputial gland, (b) androgen-sensitive glands (particularly the testes), and (c) urine and feces. Briefly, McNeese (1975) found no evidence to support his suspicion that these glands or emissions were responsible for the appropriate odors under consideration. Although no anatomical structure has been found to be the source of odors (reward or nonreward), other physiological and anatomical studies have been conducted to investigate the properties of these odors. Voorhees (1980) found that differential responding of cells in the medial olfactory-bulb occurred as a result of presenting reward and nonreward odors via strips of paper flooring from a runway in which odor-donor rats had been trained. Eslinger (1980) has attempted to examine the chemical difference of reward and nonreward odors present in the runway apparatus. It would appear then that the results of studies investigating the physiological make-up of reward and nonreward odors have

further supported evidence that such odors are produced by animals who experience reward and nonreward conditions in an experimental setting.

Recently, Collerain (1978) and Collerain and Ludvigson (1972, 1977) have attempted to relate odor excretions to frustration and frustration odor. More specifically, they have posited that an odor of nonreward ("frustration" odor) is exuded under frustration-producing operations. According to Amsel's (1958, 1962) frustration theory, receipt of nonreward in a previously rewarded situation results in an emotional reaction (frustration) with the magnitude of that reaction depending, up to a point, upon the strength of the expectation of reward ( $r_R - s_R$ ). This frustrative reaction (depending upon specific experimental conditions) may result in the enhancement (Amsel & Roussel, 1952; Goodrich, 1959), or decrement (Davis & Ludvigson, 1969; Davis & North, 1967, 1968) of subsequent responding. Hence, frustrative reaction may result in the excretion of characteristic "frustration" odors and be inferred through observed changes in responding.

In a T-maze study using odor-donor subjects, Collerain and Ludvigson (1972) reported that as few as 2-4 reinforced trials were sufficient to elicit odors on subsequent non-rewarded trials in the donor subjects. Experimental subjects transversing the T-maze avoided an arm containing "frustration" odors significantly more than an arm containing either the odor of reward or a neutral odor. To substantiate the aversiveness of such "frustration" odors, Collerain and Ludvigson (1972) employed the use of a hurdle-jump apparatus. Hurdle-

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jump speeds of naive subjects were measured following different amounts of training for odor-donor subjects. In this experiment, it was found that as many as 12 rewarded odor-donor trials (compared to 2-4 trials in the T-maze studies) were required before nonreward produced sufficient "frustration" odor to maintain stable escape responding in test subjects. Collerain and Ludvigson suggested that the different tasks involved in the T-maze (simple withdrawal) and the hurdle-jump apparatus (hurdle-jumping) could be attributed to the difference in the number of trials needed to elicit "frustration" odors.

In an attempt to evaluate trial-to-trial odor production, Collerain (1978) conducted a set of three experiments using a hurdle-jump apparatus. The results of these studies indicated that; (a) responding may serve as a "sensitive measure of changes in the production of frustration odor", and (b) that as few as four reward trials may be needed before a subsequent nonreward event produces an effective frustration odor. Collerain (1978) also indicated that studies relating the production of frustration odors and hurdle-jump escape behavior could be used in a further understanding of Amsel's (1958, 1962) frustration theory. For example, Collerain's (1978) results are supportive of Brook's (1969) frustration interpretation of the limited trial partial reinforcement effect (LTPREE). It is interesting to note, however, that most of the studies either demonstrating the production and influence of frustration odors (e.g., Bloom & Phillips, 1973; Ludvigson & Sytsma, 1967; Pratt & Ludvigson, 1970; Prytula &



Davis, 1974, 1976), or attempting to relate frustration odor and frustration theory (e.g., Collerain, 1978, Collerain & Ludvigson, 1972, 1977) have generated such odors through strict nonreward. Such experiences have typically consisted of confinement in an empty goalbox.

On the other hand, a number of studies have been reported in which runway performance was measured as a function of simultaneous or successive receipt of contrasting reward magnitudes (e.g., large, L, versus small, S). For example, Bower (1961) demonstrated that performance of subjects to small reward (S-) in one situation (e.g., a white alley) was depressed compared to that of subjects receiving only small reward, when large reward (S+) was concurrently received in a second situation (e.g., a black alley). This phenomenon has been termed the "simultaneous negative contrast effect" (Bower, 1961). Since frustration theory has been employed to account for such behavior (see, Bower, 1961; Ludvigson & Gay, 1967), it would also seem likely to anticipate the occurrence of frustration odors in situations involving contrasting reward magnitudes. As mentioned earlier, McHose and Ludvigson (1966) attributed differential responding of nondifferentially reinforced subjects to odors of nonreward. Unfortunately, no systematic investigation of frustration odor was made in the study.

In a recent set of experiments, Davis, Whiteside, Bramlett, and Peterson (in press) investigated the utilization and production of frustration odors that occurred as a result of

receiving a minimal goal object. In this series of studies (using the straight runway apparatus) it was found that rats failed to develop double-alternation patterning in the runway when they received contrasting reward magnitudes (i.e., large versus small reward). Further, it was found that double-alternation patterning did not occur when animals receiving contrasting reward magnitudes were given varying durations of goalbox confinement. Immediate removal of subjects receiving no reward had no effect on patterning when compared with subjects given longer duration in an empty goalbox. It appeared that "frustration" odor was exuded immediately after entering an empty goalbox. Collerain (1978) hypothesized that patterned responding could be a result of the differential distribution of characteristic animal odors on R and N trials. Hence, leaving an animal in an empty goalbox would allow a greater distribution of frustration odor. The results obtained by Davis et al. (in press) did not support this contention.

These results were inconsistent with a frustration interpretation of odor production. According to frustration theory (Amsel, 1958, 1962), receipt of large reward on L (large) trials should lead to the development of an expectancy of reward ( $R_r - S_r$ ). The receipt of small reward or no reward in these situations would result in primary frustration ( $R_f$ ). However, Davis et al. (in press) have shown that receipt of small reward in a previously large reward situation did not result in double-alternation patterning. They attributed the

failure to develop appropriate patterning to be a result of the animal's failure to produce frustration odors in a situation (albeit frustrating) in which a small reward was received.

As subjects used in the above mentioned series of experiments served as both odor donors and odor recipients (see Davis et al., in press) it would seem difficult to determine whether the failure to develop double-alternation patterning was due to the fact that subjects did not mark the goalbox or did not respond discriminately to odors that were present. For example, subjects trained under a LLSSLLSS schedule (where L is large reward and S is small reward) received a trial (either L or S), the apparatus cleaned and aired, and then a second group trained under a LLNNLLNN schedule (where L is large reward and N is no reward) received a trial (either L or N). The two groups were then compared. One purpose of the present study was to differentiate odor production from odor use. To accomplish this objective, two groups of animals (Group LLSSLLSS and Group LLNNLLNN) were run as one large squad. Hence, the apparatus was not cleaned and aired after Group LLSSLLSS finished a trial. This allowed subjects in Group LLSSLLSS to serve as odor donor subjects for the first subject in Group LLNNLLNN. As this process would allow odors to accumulate in the runway (Note 1), subsequent responding of the first subject in Group LLNNLLNN would be affected. It would also appear that a delay in the receipt of small reward might result in patterning by Group LLSSLLSS. This assumption was made based on the results obtained by Davis et al. (in

press). These authors assumed that an odor of nonreward is produced immediately upon entering an empty goalbox. Therefore, a second, and major, purpose of this study was to investigate the possibility that a delay in the receipt of small reward might result in the development of appropriate patterning by subjects trained under the LLSSLLSS sequence. These subjects will enter an empty goalbox, yet receive reward at the end of a 30-sec goalbox-confinement period. Unlike studies reported by Davis et al. (in press), entrance into an empty goalbox and the receipt of small reward were afforded subjects in the present experiment.

As runway performance under a double-alternation schedule of reward (R) - nonreward (N) has been shown to be sensitive to frustration or nonreward odors (see Davis et al., 1974; Davis et al., 1976; Seago, Ludvigson, & Remley, 1970), and to further elaborate the findings of Davis et al. (in press) double-alternation performance in a runway was chosen as the instrumental response for this study. If subjects in the LLSSLLSS group did not exude frustration odors then it could be predicted that the performance of the first subject in Group LLNNLLNN would not reflect appropriate responding. Likewise, if subjects in Group LLSSLLSS were simply not responding to discriminately different odors that were present, it could be predicted that the first subject of Group LLNNLLNN would show this by responding appropriately to these different odors. A second prediction of this study was that delay of small reward would result in appropriate patterning by subjects

in Group LLSSLLSS. To systematically investigate these predictions, the present study was divided into three phases. Phase 1 involved the administration of 96 trials in which patterning would be allowed to develop. Phase 2 involved a subject rotation procedure in which the last subject of Group LLNNLLNN was rotated to the first position of that group. This allowed the experimenter to observe changes in responding of individual animals (in Group LLNNLLNN) as a result of odors produced by the subjects in Group LLSSLLSS. Finally, Phase 3 incorporated the withholding of small reward from Group LLSSLLSS for 30-sec to assess the function of temporal presentation of small reward on double-alternation patterning.

## CHAPTER 2

### METHOD

Subjects. Fourteen male albino rats, purchased from the Holtzman Company, Madison, Wisconsin served as subjects. The subjects were approximately 90 days old at the beginning of the experiment. Each animal was individually caged with water readily available on an ad libitum basis.

Apparatus. The experimental apparatus consisted of a single straight runway having a 38.10-cm gray start box, a 91.44-cm black run section, and 30.48-cm black goalbox. Start and run sections of the runway were separated by a guillotine door, as were the run and goal sections. Attached to the start door was a microswitch which activated the first of three Lafayette (Model 54015) digital timers. The first, second, and third timers recorded start, run, and goal latencies, respectively. Three photoelectric beams, located 15.20-cm, 92.40-cm, and 116.80-cm beyond the start door were in place to automatically start and stop the timers (that is, when a subject passed through the first photobeam the first timer was stopped and the second timer was simultaneously activated; breaking the second photobeam stopped the second clock and activated the next, etc.).

Located at the distal end of the goalbox was a plastic box which served as the goal cup. A pellet dispenser (Lafayette Model 80200), located next to the goalbox delivered single

pellets via a plastic tube which extended into the goal cup. The pellet dispenser was used on small reward trials. After breaking the last photobeam, the pellet dispenser automatically delivered the reward. On large reward trials, pellets were manually placed in the goal cup prior to the beginning of that trial. A sheet of thin transparent plastic covered the top of the entire runway apparatus to prevent the dissipation of odors.

Procedure. One week prior to the start of experimentation two equal groups were randomly formed (n=7). At this time subjects were placed on a food deprivation regimen to maintain 85% of their free-feeding body weight.

A four-day pretraining phase immediately preceded testing. On Days 1 and 2, all subjects were handled and tamed, and habituated to the 45mg Noyes reward pellets in their home cages. On Days 3 and 4 subjects continued pellet habituation in their home cages, but were also given a 5-min exploration period in the runway apparatus. The two guillotine doors were raised to allow free exploration of all three sections of the runway.

During experimental testing all subjects received eight daily trials in double-alternation sequence. Subjects 1-7 received their daily trials in a LLSSLLSS pattern, where L is a large reward trial (12 45mg Noyes pellets) and S is a small reward trial (1 45mg Noyes pellet). Subjects 8-14 received their daily trials in an LLNNLLNN pattern where L is a large reward trial and N is a nonreward trial. On S trials

(subjects 1-7) and N trials (subjects 8-14) animals were confined to the goalbox for 30-sec.

Experimental testing was divided into three distinct phases. During Phase 1, Subjects 1-7 and Subjects 8-14 were administered 96 trials (8 trials per day for 12 days) in the sequence described above. In Phase 2 (3 days, 24 trials) Subjects 1-7 received LLSSLLSS trials identical to those administered in Phase 1. A daily rotation process, which consisted of rotating the last subject in the LLNNLLNN sequence (e.g., Subject 14 was rotated to position 8 on Day 1 of Phase 2, Subject 13 was rotated to position 8 on Day 2 of Phase 2, and Subject 12 was rotated to position 8 on Day 3 of Phase 2), was instituted for Subjects 8-14 during Phase 2.

Phase 3 (5 days, 40 trials) involved the withholding of S-trial pellet delivery for Group LLSSLLNN subjects until the end of the 30-sec goalbox confinement period. Previously, (Phases 1 and 2) the one-pellet reward was present in the goal cup when the subject entered the goalbox on S-trials. The running order for Subjects in the LLNNLLNN group, during Phase 3, remained identical to that which was in effect on the last day of Phase 2.



## CHAPTER 3

### RESULTS

All animals (both group LLSSLLSS and Group LLNNLLNN) were run as one large squad. Inasmuch as the first subject of Group LLSSLLSS was tested in a clean runway (the runway was swabbed prior to the beginning of a new trial), this animal was considered to be a "donor subject" and was subsequently omitted from the statistical analyses. Likewise, the data from the first subject of Group LLNNLLNN were also omitted from statistical analysis as it served as a "donor subject" (even though the runway apparatus was not cleaned after Group LLSSLLSS had completed a trial).

All latencies were reciprocated and multiplied by a constant of .3046 to yield speed scores in meters per second. Before statistical analysis was performed, each eight-trial double-alternation sequence was reduced to four scores per daily sequence for each subject. This was accomplished in the following manner: The first two trial speeds (LL) were averaged to yield a composite score ( $L_1$ ), the next two trials (SS or NN, according to group) were averaged to yield a composite score ( $S_1$  or  $N_1$ ), the fifth and sixth trials (LL) were averaged to yield a composite score ( $L_2$ ), and the last two trials (SS or NN) were averaged to yield a composite score ( $S_2$  or  $N_2$ ). The appropriate composite score ( $L_1$ ,  $S_1/N_1$ ,  $L_2$ ,  $S_2/N_2$ ) for each subject was in turn added to the composite

scores of the other subjects comprising the group (LLSSLLSS or LLNNLLNN) and then averaged to yield a composite mean speed for each group. Hence, each daily eight-trial double-alternation sequence was reduced to four composite speed scores for each subject, in turn, for each group. These composite speeds were used for statistical analyses and graphing purposes.

Even though the occurrence of odors (be it "frustration" odor or the odor of nonreward) occur primarily in the goalbox, performance in all sections of the runway (start, run, and goal sections) was analyzed statistically and then graphed. Figures 1-3 show start, run, and goal speeds respectively, for Groups LLSSLLSS and LLNNLLNN for the three phases of the experiment.

For all sections of the apparatus, a split-plot analysis of variance incorporating Groups (LLNNLLNN vs LLSSLLSS) as a between subjects factor, and Double-Alternation (DA) Performance ( $L_1$ ,  $S_1/N_1$ ,  $L_2$ ,  $S_2/N_2$ ), and Days as within-subjects factors was performed on the data. Statistical analysis was begun on Day 9 (the point at which double-alternation patterning appeared to have been established in the goal means). A rejection level of .05 was used for all statistical tests.

Phase 1. Analysis of the speed scores for the start section of the runway apparatus yielded no significant differences for S vs N [  $F(1,10) = 2.01$  ], DA Performance [  $F(3,30) = 1.41$  ], or S-N x DA Performance [  $F(3,30) = 1.21$  ] effects. Likewise, analysis of speed scores for the run section of the apparatus yielded no significant differences for Groups [  $F(1,10) = 3.20$  ],

DA Performance [  $F(3,30) = 1.10$  ], or Groups x DA Performance [  $F(3,30) = 1.35$  ] effects. Analysis of speed scores in the goalbox yielded significance for the Groups [  $F(1,10) = 5.33$  ], DA Performance [  $F(3,30) = 4.85$  ], and Groups x DA Performance [  $F(3,30) = 5.71$  ] effects. Analyses of simple main effects indicated the DA Performance factor was significant [  $F(3,160) = 7.29$  ] only for the LLNNLLNN subjects. The L<sub>1</sub> and L<sub>2</sub> speeds for the LLNNLLNN subjects did not differ but were significantly faster than their N<sub>1</sub> and N<sub>2</sub> speeds. The N<sub>1</sub> and N<sub>2</sub> speeds for this group did not differ significantly.

Phase 2. Statistical analysis was not performed on the data during Phase 2. Analysis was omitted due to the fact (as described earlier in Chapter 2) that a daily rotation of subjects in the LLNNLLNN group was performed during this phase and resulted in a daily change in group composition. Although, no statistical figures are available, the mean speeds for Phase 2 are shown in Figures 1-3. Additionally, the performance of the LLNNLLNN subjects rotated from the last (Day N-1) to the first position in the LLNNLLNN running order is shown in Table 1. Table 1 also shows the performance of the first LLSSLLSS subject on the last 5 days of Phases 1 and 3. The speed scores on Table 1 clearly indicate that the effects of rotating subjects from the last position to first position in the LLNNLLNN sequence was to eliminate the double-alternation patterning shown on the previous day. As is shown by Table 1 and Fig 3, the strength of double-alternation patterning shown by Group LLNNLLNN (omitting the first subject) was not greatly influenced

by this rotation procedure and squad composition.

Phase 3. The Groups [  $F(1,10) = 2.49$  ], DA Performance [  $F(3,30) = 1.19$  ], and Groups x DA Performance x Days [  $F(12,120) = 1.69$  ] factors were not found to be significant for start speeds. Analysis of variance for speed scores in the run section also revealed no significant differences: Groups [  $F(1,10) = 2.16$  ], DA Performance [  $F(3,30) = 1.33$  ], and Groups x DA Performance x Days [  $F(12,120) = 1.57$  ]. Significant differences were found to exist in goalbox performance. Analysis of variance revealed that the following factors were significant: Groups [  $F(1,10) = 5.17$  ], DA Performance [  $F(3,30) = 11.18$  ], and Groups x DA Performance x Days [  $F(12,120) = 2.66$  ]. Simple main effects analyses yielded significant Groups [  $F(1,190) = 5.14, 4.79$ , Days 1 and 2 respectively ], Groups x DA Performance [  $F(3,190) = 2.98, 2.84, 3.11, 9.43, 17.35$ , Days 1-5, respectively ] effects. Contrast effects indicated  $N_1$  and  $N_2$  speeds of Group LLNNLLNN were significantly slower than all other speeds on Days 1-3 of this phase. On Day 3, the  $S_2$  speeds of Group LLSSLLSS were significantly slower than all  $L_1$  and  $L_2$  speeds. On Days 4 and 5,  $S_1/N_1$  and  $S_2/N_2$  speeds were significantly slower than all  $L_1$  and  $L_2$  speeds. The  $N_1$  and  $N_2$  speeds were found to be significantly slower than  $S_1$  and  $S_2$  speeds.

## CHAPTER 4

### DISCUSSION

One major purpose of this study was to investigate the production and utilization of "frustration" odor when a minimal goal object was received. In this regard, the results would appear to be equivocal. For example, appropriate double-alternation patterning was not shown during Phase 1 by LLSSLLSS subjects. This result suggests that the odor of nonreward is not exuded when a minimal goal object is received. However, a consideration of the Phase 3 data appeals to a different interpretation. The strong double-alternation patterning that developed during this phase indicates the presence and influence of nonreward odor. A resolution of these conflicting results would appear to lie in a consideration of temporal presentation of small reward on S trials. During Phase 1, small reward was present as the subject entered the goalbox. During Phase 3, small reward was delivered at the end of the S-trial confinement period. Hence, it would appear that entrance into an empty goalbox is a necessary condition for the production of odors. This data and interpretation corroborates the results reported by Davis et al. (in press). In Phase 2 of this study, the accumulated nature of an odor, if one were present, by the LLSSLLSS subjects did not appear to have had an effect on the first subject in Group LLNNLLNN (see Table 1).

Taken collectively, these data suggest that contrasting reward magnitudes do not result in the production of nonreward odor when the subject experiences small reward immediately upon entrance into the goalbox. Such odors are produced, however, when the subject enters an empty goalbox and the small reward is delivered at the end of the confinement period.

The development of odor-based double-alternation patterning in Group LLSSLLSS that resulted from withholding the one-pellet reward could be interpreted as reflecting a lack of perfect correspondance between the elicitation of frustration and odor production. Given this interpretation, frustration, theoretically, occurred in L vs S contrast situations, but odor production occurred only when an empty goalbox was initially encountered. Considering these findings, the term, "frustration" odor may not be appropriate when used to explain all double-alternation patterning. Assuming Amstel's (1958,1962) frustration theory to be correct, receipt of large reward in one situation (the runway apparatus) would lead to the development of an expectancy of reward ( $R_r - S_r$ ). The receipt of small reward or no reward in this situation should result in primary frustration ( $R_f$ ). If frustration occurs, then according to Collerain (1978) and Collerain and Ludvigson (1972, 1977), "frustration" odor should have been exuded by animals. This was apparently not the case in the present study. Considering these results, a more appropriate term should be considered (i.e., odor of nonreward) since patterning was observed only when animals entered an empty goalbox.

The data obtained from the present study could also be interpreted as an indication that a frustration interpretation of reward contrast (see Bower, 1961; Ludvigson & Gay, 1967) is not correct. It may be that there was no emotional response (frustration) immediately after receipt of small reward. Thus differential odors were not exuded and appropriate patterning not observed. If one considers this interpretation, frustration does not result when an animal receives contrasting reward magnitudes (S vs L). Hence, Collerain (1978) and Collerain and Ludvigson (1972, 1977) may be correct in their attempt to relate odor excretions to frustration and their use of "frustration" odor. The problem, obviously, resides in the determination of what is frustrating to the laboratory rat. Obviously further research is needed to determine which of the above interpretations is correct. Nonetheless, whether or not such odors are elicited by, or coincide with, the frustrative reaction does not diminish the importance of their adaptive role of signalling no reward to conspecifics.

In a broader sense, the results of this study, and those of other studies investigating odor excretions, further elaborate the importance of an animal's sensory processes in learning situations. It would appear then, that research seeking to understand animal learning should be concerned with the establishment of appropriate controls for odor excretions. Without such controls, animal learning theory will lack a more parsimonious understanding of behavior. Obviously, animal

psychologists are only just now beginning to fully appreciate the full capabilities of the rat's olfactory sense. We have nearly eight decades of animal research that appears to be in need of very careful scrutinizing for possible olfactory confounding. Certainly, we should take care to avoid such problems in the future.

In conclusion, the present study not only seems to pose ~~some~~ possible questions for further research in this area, but it also adds to the existing research on odor-based responding in animals. First, nonreward or "frustration" odor was not produced by animals initially encountering small reward in a previously large reward situation. Second, an odor of nonreward was apparently exuded when small reward was presented after a goalbox confinement period. Finally, "frustration" odor may not be an appropriate descriptor for the odor exuded in these situations - nonreward odor may be more appropriate.



**REFERENCE NOTE**

## REFERENCE NOTE

1. Ludvigson, H.W. "Frustration odor" in rats. Paper presented at the meeting of the International Congress of Physiological Sciences, Paris, France, July, 1977.

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## APPENDICES

APPENDIX A

TABLES

Table 1. Mean Goal Speed of First Subject  
in Sequence - Phase 2

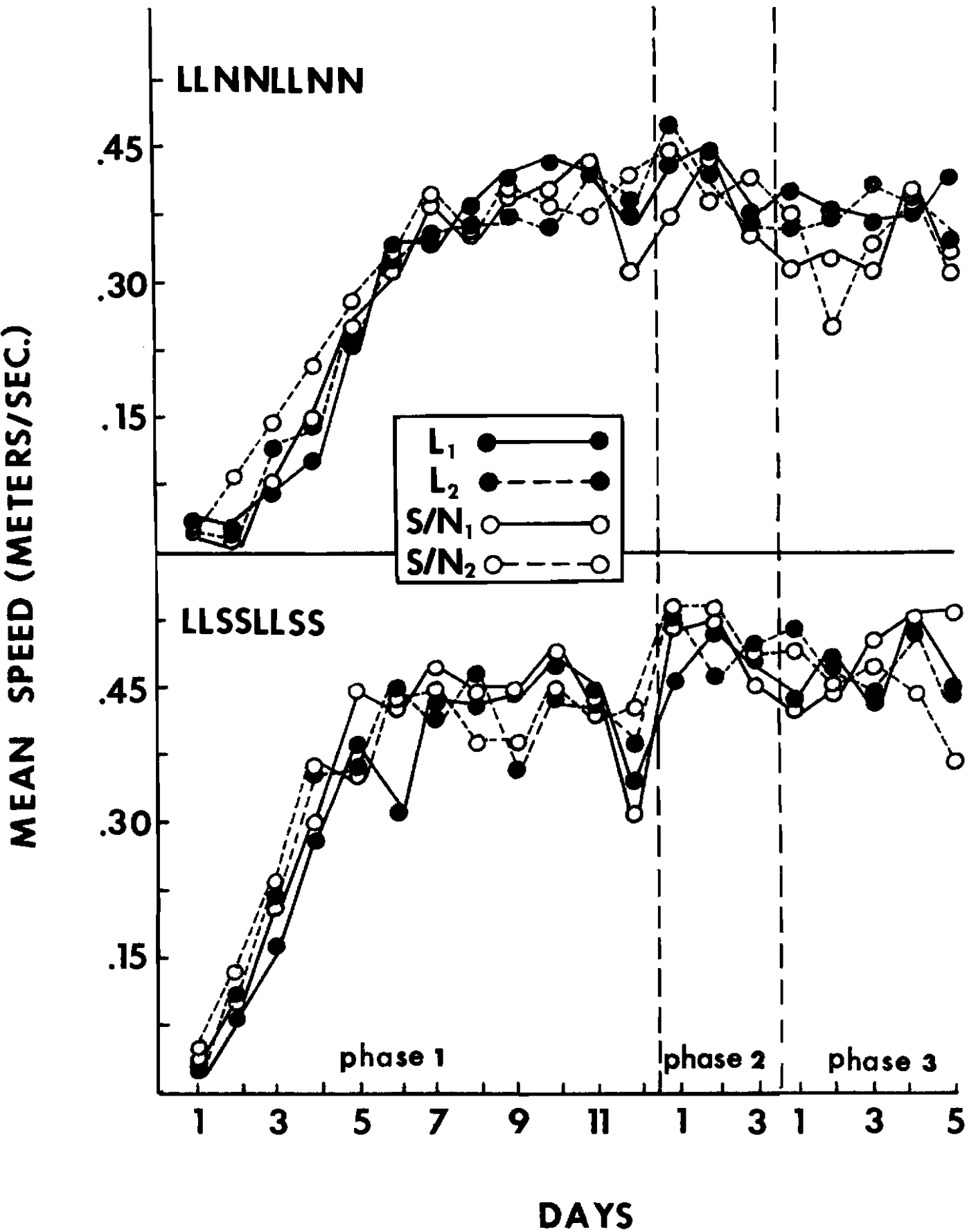
	GROUP LLNNLLNN				GROUP LLSSLSS			
	L <sub>1</sub>	N <sub>1</sub>	L <sub>2</sub>	N <sub>2</sub>	L <sub>1</sub>	S <sub>1</sub>	L <sub>2</sub>	S <sub>2</sub>
<u>Phase 1</u>								
Day 8	.56	.61	.53	.59	.65	.64	.70	.65
Day 9	.58	.56	.57	.65	.61	.71	.72	.61
Day 10	.60	.58	.53	.56	.58	.70	.70	.73
Day 11	.56	.53	.59	.57	.72	.70	.63	.71
Day 12	.57	.55	.54	.60	.69	.72	.69	.63
<u>Phase 2</u>								
Day 1	.42	.43	.51	.49	.72	.69	.68	.70
Day N-1*	.61	.14	.54	.04				
Day 2	.70	.62	.58	.72	.71	.72	.63	.71
Day N-1*	.48	.05	.57	.07				
Day 3	.51	.55	.46	.53	.75	.78	.66	.65
Day N-1*	.53	.04	.49	.09				
<u>Phase 3</u>								
Day 1	.45	.03	.42	.01	.70	.68	.67	.68
Day 2	.43	.01	.42	.04	.54	.72	.56	.63
Day 3	.42	.02	.50	.02	.72	.71	.65	.61
Day 4	.41	.05	.50	.01	.67	.64	.71	.69
Day 5	.46	.04	.46	.02	.65	.62	.63	.65

\*Performance as last subject in LLNNLLNN sequence on preceding day.

**APPENDIX B**

**FIGURES**

Figure 1. Mean Start Speeds - Groups LLSSLSS  
and LLNNLLNN



**Figure 2. Mean Run Speeds - Groups LLSSLSS  
and LLNNLLNN**



MEAN SPEED (METERS/SEC.)

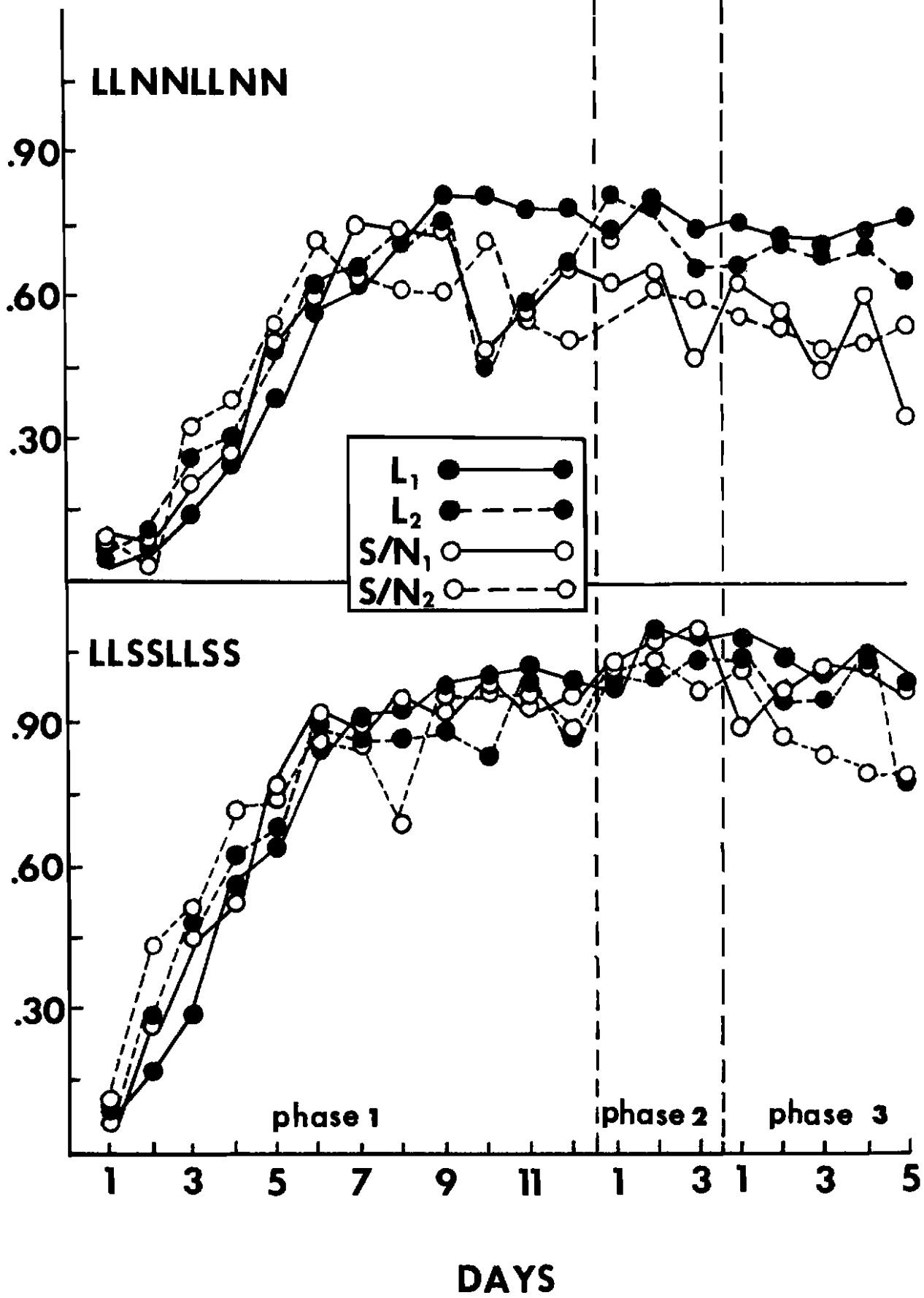


Figure 3. Mean Goal Speeds - Groups LLSSLSS  
and LLNNLLNN

