

**THE NOSE KNOWS BEST: ODOR - CUE  
PRODUCTION AS A FUNCTION OF NONREWARD  
CONDITIONS AND GOALBOX CONFINEMENT**

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**JUDITH ANN BRAMLETT**

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

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

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by  
Judith Ann Bramlett

May, 1979



## ABSTRACT

The relationship between reward-nonreward conditions and goalbox confinement duration was investigated to examine the production of frustration odors. Differences in odor production were indexed by the speeds of animals approaching the goalbox of a straight runway in which conspecifics had received the same treatment conditions. Those animals that displayed double-alternation patterning were considered to be utilizing an odor cue laid down by a previously run subject. The results indicated that: (a) a minimal (1 pellet) reward precluded the production of odor cues strong enough to influence behavior, (b) confinement duration had little or no effect on the production of frustration odors, and (c) frustration odors are exuded very quickly. Implications of the present data for the frustration-odor hypothesis and simple animal movement are discussed.

THE NOSE KNOWS BEST:  
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by

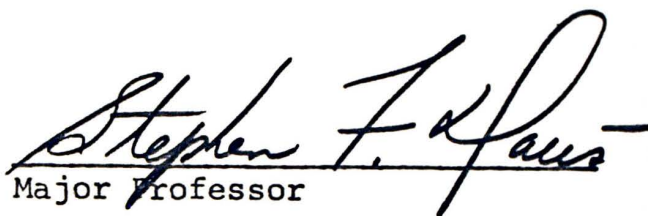
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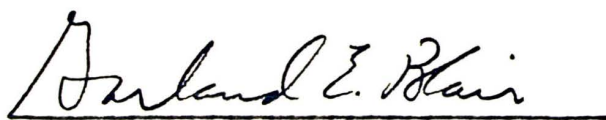


To the Graduate Council:

I am submitting herewith a thesis written by Judith Ann Bramlett entitled "The Nose Knows Best: Odor-cue Production as a Function of Nonreward Conditions and Goalbox Confinement." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Arts, with a major in Psychology.

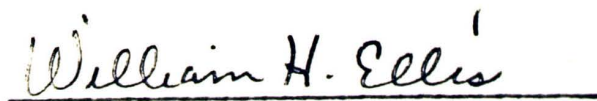
  
Major Professor

We have read this thesis and  
recommend its acceptance.

  
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## CHAPTER I

### INTRODUCTION

For over two decades, scientists have been studying the role of olfaction in animal behavior. The impetus for one area of this research was the serendipitous discovery of differential responding in nondifferentially rewarded animals (McHose and Ludvigson, 1966). These investigators hypothesized that the rats exuded qualitatively or quantitatively different odor trails that functioned as discriminative stimuli for subsequent animals run in the experiment. Subsequently, Ludvigson and Sytsma (1967) reported that differential responses could be established to the odor of reward and the odor of nonreward. They found double-alternation patterning in one group of rats which consistently experienced the same reward-nonreward condition as that experienced by previously run subjects. No patterning was found for a group in which the reward-nonreward contingencies were uncorrelated from subject to subject. Further, Ludvigson (1969) showed that besides being a discriminative cue for subsequent rats, the effect of odor cues is cumulative over trials. For example, the performance of subjects run later in a group was more influenced by odors. Amsel, Hug, and Surridge (1969) have also

shown that established patterning can be disrupted by mixing the reward and nonreward contingencies.

Wasserman and Jensen (1969) were the first investigators to propose a relationship between the emission of odors and frustration. Though not directly stated, these investigators were referring to the frustration theory proposed by Amsel (1959). This theory states that the occurrence of nonreward after some minimal number of rewards produces an emotional reaction, frustration. Further, fractional anticipatory components of this frustration reaction can, theoretically, become conditioned to environmental stimuli. Amsel argued that these anticipatory frustration reaction ( $r_f-s_f$ ) phenomena affects overt response strength in three ways: (1) by increasing over-all drive strength, (2) by serving as a drive stimulus whose reduction may be reinforcing and to which other responses may be conditioned, and (3) by inhibiting overt behavior (Lawson, 1965). Obviously, the strength of the frustrative reaction depends, up to a point, upon the strength of the expectation of reward ( $R_r-S_r$ ). It has been demonstrated that under certain experimental conditions, the frustrative reaction can result in an enhancement or persistence of responding (Amsel and Roussel, 1952; Goodrich, 1959), or a decrement in subsequent responding (Davis and Ludvigson, 1969).



It was only a matter of observation and logic before scientists began to realize that, in addition to behavioral effects, frustrative experiences also appeared to result in the excretion of a characteristic odor. Mellgren, Fouts, and Martin (1973) demonstrated that the odor of nonreward or frustration definitely served as an aversive stimulus. They also posited that there could be an odor of reward that may have served as an attractive stimulus. Taylor and Ludvigson (Note 1) speculated that both reward and nonreward (frustration) odors were excreted and functional with their subjects because subject discrimination was better if reward odor was removed. Ludvigson (Note 2) conjectured that though both odors may be present in the learning situation, frustration odor was the main odor involved in patterning. Davis, Prytula, Harper, Tucker, Lewis, and Flood (1974) and Davis, Prytula, Noble, and Mollenhour (1976) demonstrated that though the odors of reward and/or nonreward may serve as discriminable cues, these cues are not effective across deprivation states.

Though most investigators agree that nonreward produces a frustrative reaction and that frustrated rats emit odor cues which influence the behavior of conspecifics, only Collerain (1978) and Collerain and Ludvigson

(1972, 1977) have reported studies attempting to directly relate frustration-producing operations and odor excretion. More specifically, 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 nonrewarded trials. Subjects traversing the T-maze avoided an arm containing these odors significantly more than an arm containing either the odor of reward or a neutral odor. Collerain and Ludvigson (1977) assessed the aversiveness of such frustration odors in the hurdle-jump apparatus. Hurdle-jump escape speeds of naive subjects were measured following different amounts of training for odor-donor subjects. In this situation, as many as 12 rewarded trials were required before nonreward produced frustration odor enough to maintain stable escape responding. The authors suggested that the difference in number of rewarded trials required to elicit an odor on the nonreward event may be attributed to the different tasks involved, i.e., simple withdrawal in the T-maze (Collerain and Ludvigson, 1972) versus hurdle-jump behavior (Collerain and Ludvigson, 1977). Additionally, both studies indicated that the aversion response to the odor of nonreward habituated during the course of training. Recently, Collerain (1978) reported

a series of three experiments designed to specifically evaluate trial-to-trial odor production as measured by the hurdle-jump escape response. The results of these studies indicated that such responding: (a) may serve as "a sensitive measure of changes in the production of frustration odor," and (b) that as few as four rewarded trials may be needed before a subsequent nonreward event produces an effective frustration odor. Differences in habituation to the hurdle-jump apparatus were felt to have contributed to the discrepancy between the Collerain and Ludvigson (1977) and Collerain (1978) studies regarding the number of rewarded trials required before nonreward served to elicit an effective frustration odor. Further, Collerain (1978) indicated that one viable use of such studies relating the production of frustration odors and hurdle-jump escape behavior "would be to assist in a further articulation of Amsel's (1958, 1962) frustration theory." For example, achievement of hurdle-jump responding in the presence of frustration odor elicited after only four nonrewarded trials is supportive of Brooks' (1969) frustration interpretation of the limited trial partial reinforcement extinction effect (LTPREE).

The majority of the studies either demonstrating



the production and influence of frustration odor (e.g., Bloom and Phillips, 1973; Pratt and Ludvigson, 1970; Prytula and Davis, 1974, 1976), or attempting to relate frustration odor and frustration theory (e.g., Collerain, 1978; Collerain and Ludvigson, 1972, 1977) has employed a nonreward condition consisting of confinement in an empty goal box. However, a number of studies investigating the effects of contrasting reward magnitudes (e.g., large versus small) on performance has been reported. For example, Bower (1961) demonstrated that performance to small reward (S-) in one situation (e.g., a white alley) was depressed, relative to that of subjects receiving small reward, when large reward (S+) was concurrently received in a second situation (e.g., a black alley). This phenomenon has been termed the "negative contrast effect" (NCE). As frustration theory has been employed to account for such behaviors (see, Bower, 1961; Ludvigson and Gay, 1976), it would seem reasonable to also anticipate the occurrence of frustration odors in situations involving contrasting reward magnitudes. Consistent with this view, it is interesting to note that the original data calling attention to the possible influence of odors (McHose and Ludvigson, 1966) were collected in a study

investigating differential reward conditioning. As mentioned previously, these investigators observed that nondifferentially reinforced control subjects ran slower when the preceding differentially reinforced animals had received small reward. This effect was tentatively attributed to the presence of the odor of nonreward exuded by the differentially reinforced animals. Unfortunately, no systematic investigation of frustration was made in that experiment. The present experiment was designed to directly investigate the production and utilization of frustration odors when animals received contrasting reward magnitudes.

As runway performance under a double-alternation schedule (RRNNRRNN) of reward (R) - nonreward (N) has been shown to be sensitive to frustration odors (see Davis et al., 1974; Davis et al., 1976; Ludvigson and Sytsma, 1967; Prytula and Davis, 1974, 1976; Seago, Ludvigson, and Remley, 1970), it was chosen as the present experimental task. According to frustration theory, receipt of large reward on R trials should lead to the development of  $R_r - S_r$ . Consequently, the receipt of zero or small reward on "nonreward" (N trials) should result in primary frustration  $R_f$ . Unlike the Bower (1961), Ludvigson and Gay (1967), and McHose and Ludvigson

(1966) studies, no discriminative S+/S- cues will be provided in the present testing situation. Hence, the effective  $R_r-S_r$  may, in actuality, be some average of R and N expectations. However, as Collerain (1978) demonstrated the production of odors following as few as four rewarded trials using 10, 35-mg. pellets as reward, one would expect that the average expectancy developed over a larger number of trials in the present situation from the receipt of 12, 45-mg. pellets (R trials) and 1, 45-mg. pellet (N trials) would be of sufficient strength to elicit  $R_f$  on N trials. Subjects experiencing zero pellets on nonreward will also be included in the present study; therefore, the prediction that they would exude frustration odors (i.e., display double-alternation patterning) earlier in training than the 12(R) - 1(N) subjects appears tenable. Theoretically, this would be due to the greater contrast between their average expectancy [even though it may be slightly smaller than that of the 12(R) - 1(N) subjects] and the receipt of nothing on N trials.

To directly investigate a point originally raised by Collerain and Ludvigson (1972), each group (i.e., 12-1 and 12-0) was further divided into two distinct goalbox-confinement durations, immediate removal and



30-sec. confinement. These authors suggested that amount of subject movement may be related, in some manner, to scent production and/or utilization. However, as no avoidance differences were shown between subjects exposed to odors exuded by more active neutral-placement odorant animals and less active rewarded-placement odorant animals, Collerain and Ludvigson (1972) concluded that excreted odors appeared to be a function of the treatment received and not subject activity. Recently, Collerain (1978) has suggested that behavioral effects attributed to frustration odor may simply reflect detection of different spatial distributions of natural animal odor on R and N events. As more activity is typically observed on N (as compared with R) trials, one would expect more uniform distribution of such odors throughout the goalbox on N trials. Thus, the distribution of animal odor, rather than some unique odor produced by frustration, would be the effective cue controlling behavior of subsequent animals in the test situation. Assuming the correctness of this position, immediate removal of animals from the goalbox on N trials should preclude the development of double-alternation patterning. If unique odors are generated by frustration, then it would seem reasonable to anticipate the development of patterning under both

goalbox removal conditions. However, differences in confinement duration may influence the magnitude of such patterning. For example, it may be that immediate removal prohibits the animal from experiencing the complete frustrative reaction, while the longer (30 sec) confinement allows the full frustrative reaction to develop. Thus, odor excretion would be less and patterning should be attenuated for the immediate removal subjects. Given the above predictions suggesting that patterning should develop earlier in training for the 12-0 subjects than for the 12-1 subjects, it might further be predicted that the 12-0 subjects experiencing 30 sec confinement on N trials would both develop patterning earliest and establish it most strongly.

Subjects

Twenty-eight 90-day-old male, albino rats purchased from the Holtzman Company, Madison, Wisconsin served as subjects. All animals were housed in individual living cages with water available on an ad libitum basis. One week prior to the start of pretraining, all subjects were placed on food deprivation and were maintained at 85% of their free-feeding body weight for the duration of the experiment.

Apparatus

The apparatus was a single straight runway 11.43 cm. wide and 12.70 cm. high. A 38.10-cm. gray box was separated from a 91.44-cm. black run section by a masonite guillotine door. A second guillotine door separated the run section from a 38.48-cm. black goal box. Raising the start door activated a Lafayette (Model 54015) digital timer (start time). Passing through a photo-electric beam located 15.20 cm. beyond the start door stopped the first timer and started a second digital timer (run time). Breaking a second beam located 77.20 cm. beyond the first beam stopped the second timer and started a third digital timer (goal time). Breaking a

third beam located 5.12 cm. in front of the goal cup (a plastic receptacle recessed into the distal end of the goalbox) stopped the third timer. A thin, transparent plastic sheet covered the entire top of the apparatus and prevented the dissipation of odors.

### Procedure

Prior to pretraining, the subjects were randomly assigned to four treatment groups; 12-0(i), 12-0(D), 12-1(i), and 12-1(D). Additionally, each subject within each group was assigned a permanent number (1-7). This number determined the order in which the subject was run within his group on each of the 15 days of the experiment.

Pretraining began four days before the inception of the experiment. During the first two days of pretraining, all subjects were handled and tamed for one minute each and then habituated to the 45 mg. Noyes reward pellets in the home cage. On the third and fourth days of pretraining, each subject received a five-minute exploration period in the apparatus and habituation to the reward pellets both in the goalbox and in the home cage. During exploration trials in the apparatus, all photoelectric equipment was operative and both doors were raised.

During experimental testing, all subjects received



eight daily trials (4 R and 4 N) in a double-alternation (RRNNRRNN) sequence. A total of 120 trials was administered to each subject. An R event always consisted of 12, 45mg. Noyes pellets and each subject was removed from the goalbox as soon as the last pellet was injected. Subjects in Group 12-1(i) and Group 12-1(D) received 1, 45 mg. Noyes pellet on N trials, whereas subjects in Groups 12-0(i) and 12-0(D) were confronted with an empty goal cup on N trials. Subjects in groups designated (i) were removed immediately after consuming the one-pellet reward [Group 12-1(i)] or breaking the last photoelectric beam in the goalbox [12-0(i)] on N trials. Subjects in the groups designated (D) were confined in the goalbox for 30 seconds on N trials regardless of the goal event encountered.

During training, each rat was removed from the home cage and placed in the start box. After a 3-second confinement, the start door was raised and the animal allowed to traverse the runway. As soon as the rat had cleared the start box, the door was lowered to prevent reentry. Similarly, the door was closed after the subject had entered the goal box. Upon completion of the treatment condition, the subject was returned to the home cage. All daily trials were administered to an entire group

before another group was run, with all subjects, in numerical order, completing Trial 1 before Trial 2 was begun, etc. The whole apparatus was swabbed with a damp sponge after all subjects in a group had completed each trial. The intertrial interval for all subjects on reward trials was approximately seven minutes, while the intertrial interval on nonreward trials varied according to the confinement condition: approximately six minutes for (i) groups and eight minutes for (D) groups. The daily order for running groups was cyclic. Subjects were fed their daily ration after all groups had completed all trials.

## CHAPTER III

### RESULTS

All latencies were reciprocated and multiplied by the appropriate constant to yield speed scores (meters/sec). Prior to analysis, the speed scores for the 8-trial double-alternation sequence were combined thusly: the first two trials were averaged to yield an  $R_1$  composite score, the next two trials were averaged to yield an  $N_1$  composite score, and so forth. As the first subject in each group was always tested in a clean (swabbed) runway, they served as "odor-donor" rats for subsequently run animals. Therefore, their data were not included in either statistical analyses or graphical presentations.

Analysis of variance incorporating Nonreward Event (0 versus 1 pellet), Nonreward Removal (immediate versus 30-sec confinement), R versus N, and Days factors was performed on the data from Days 10-15 [the point at which double-alternation patterning had been established in the goal measure by Groups 12-0(i) and 12-0(D)]. Nonreward Event and Nonreward Removal effects were treated as between-subject factors, while the R-N and Days effects were treated as within-subject factors. Duncan's new multiple range test was used to evaluate contrast effects

in all cases. As many contrast effects could be enumerated, only those bearing directly upon the development of appropriate double-alternation patterning will be considered.

Start. Figures 1 and 2 show start-measure performance of Groups 12-1(i) and 12-1(D), and Groups 12-0(i) and 12-0(D), respectively. Start-measure analysis yielded significance for the Nonreward Removal by N-Event by Days interaction,  $F(5,100) = 3.81, p < .01$ , and the Nonreward Removal by R-N by Days interaction,  $F(15,300) = 2.13, p < .01$ . Simple main effects analyses incorporating Nonreward Removal and N-Event factors were done at Days 10-15 to probe the significant non-reward Removal by N-Event by Days interaction. These analyses yielded significant Nonreward Removal by N-Event interactions at Days 10, 13, and 15 [ $F(1,120) = 8.34, 7.86, \text{ and } 5.66; p < .01, < .01, \text{ and } < .05$ , respectively] . Simple main effects analyses incorporating Nonreward Removal and R-N factors were done at Days 10-15 to investigate the significant Nonreward Removal by R-N by Days interaction. Significant Non-reward by R-N interactions were also found at Days 10, 13, and 15 [ $F(3,480) = 3.75, 4.75, \text{ and } 3.19; p < .05, < .01, \text{ and } < .05$ , respectively]. Subsequent evaluation



of contrast effects failed to yield any consistent R-N differences indicative of the development of patterning. Thus, statistical analyses of the start-measure data indicate that frustration odor was not influencing behavior at this point in the instrumental chain.

Run. Run performance of Groups 12-1(i) and 12-1(D), and Groups 12-0(i) and 12-0(D) is shown in Figures 3 and 4, respectively. Run-measure analysis indicated that the Confinement Duration,  $F(1,20) = 6.67$ ,  $p < .05$ ; R vs. N,  $F(3,60) = 13.29$ ,  $p < .01$ ; Days,  $F(5,100) = 8.59$ ,  $p < .01$ ; R-N by N-Event interaction,  $F(3,60) = 4.04$ ,  $p < .05$ ; and Confinement Duration by N-Event by Days interaction,  $F(5,100) = 5.13$ ,  $p < .01$ , factors were significant. Simple main effects analyses, used to probe the significant R-N by N-Event interaction, indicated that the R vs. N effect was significant,  $F(3,80) = 3.0$ ,  $p < .05$ , within the 12-1 condition but not the 12-0 condition. Moreover, contrast effects indicated that the effect was attributable to  $R_1$  speeds being significantly ( $p < .05$ ) faster than  $N_2$  speeds.

The significant Confinement Duration by N-Event by Days interaction was also probed through the use of simple main effects analyses that evaluated Confinement Duration and N-Event factors at Days 10-15. These

analyses indicated that the Confinement Duration factor was significant at Days 11-15;  $F(1,120) = 6.34, 9.08, 6.30, 5.12, \text{ and } 6.99, p < .05, < .01, < .05, < .05, \text{ and } .01, \text{ respectively.}$  The Confinement Duration by N-Event interaction was significant at Days 10-15;  $F(1,120) = 4.57, 9.09, 10.48, 7.00, 5.55, \text{ and } 9.77, p < .05, < .01, < .01, < .01, < .05, \text{ and } < .01, \text{ respectively.}$  Contrast effects showed that Group 12-1(D) ran significantly ( $p < .05$ ) faster than Group 12-1(i) on Days 10, 11, 12, 13, and 15, and Group 12-0(i) on Days 12, 13, and 14. Group 12-0(D) also ran significantly ( $p < .05$ ) faster than group 12-0(i) on Day 14 and Group 12-1(i) on Day 15.

Goal. Figures 5 and 6 show the goal-measure performance of Groups 12-1(i) and 12-1(D), and Groups 12-0(i) and 12-0(D), respectively. Goal speed analysis yielded significance for the R vs. N factor,  $F(3,60) = 29.49, p < .01$ ; R-N by N-Event interaction,  $F(3,60) = 15.84, p < .01$ ; R-N by Days interaction,  $F(15,300) = 5.29, p < .01$ ; and N-Event by R-N by Days interaction,  $F(15,300) = 3.29, p < .01$ . Subsequent simple main effects analyses evaluating N-Event and R-N factors were performed at Days 10-15. These analyses indicated that the N-Event factor [ $F(1,480) = 9.96, 10.99, 13.64,$

10.99, 20.25, and 12.85, Days 10-15 respectively;  $p < .01$  in all cases], and R-N by N-Event interaction [ $F(3,480) = 4.69, 11.38, 11.17, 11.11, 16.22,$  and  $16.54$ , Days 10-15, respectively;  $p < .01$  in all cases] were significant. Additionally, the R vs. N factor was found to be significant at Days 11-15 [ $F(3,480) = 5.19, 5.24, 4.53, 5.81,$  and  $7.09$ , respectively;  $p < .01$  in all cases].

Contrast effects indicated that at Day 10,  $N_1$  speeds for subjects receiving 1 pellet on N trials were significantly ( $p < .05$ ) faster than the  $N_1$ ,  $R_2$ , and  $N_2$  speeds of subjects receiving nothing on N trials. However, from Day 11 through 15, it was found that the  $N_1$  and  $N_2$  speeds of subjects receiving nothing on N trials were significantly slower ( $p < .01$ ) than their speeds at  $R_1$  and  $R_2$ , and the  $R_1$ ,  $N_1$ ,  $R_2$ , and  $N_2$  speeds of subjects receiving 1 pellet on N trials. These results are supportive of the graphical impression (see Figures 5-6) that significant patterning was shown only by those subjects not receiving a goal object on N trials [i.e., Groups 12-0(i) and 12-0(D)].



## CHAPTER IV

### DISCUSSION

As double-alternation patterning was shown by the 12-0 subjects, the results of the present study, would appear to agree with previous work on the existence and potential use of nonreward odors exuded by rats (Davis and Ludvigson, 1969; Mellgren, Fouts, and Martin, 1973; Collerain and Ludvigson, 1972, 1977; Prytula and Davis, 1974, 1976). On the other hand, these results seem to disagree with Bower (1961) as regards to the nature of the frustrating events. Bower (1961) posited that when a reward is smaller than what is expected, frustration was experienced. Since no patterning was shown by Groups 12-1(i) and 12-1(D), it can be inferred that either the one-pellet nonreward was sufficient to preclude frustration (hence, odor), or that the number of trials was not high enough to produce an average expectancy large enough to elicit  $R_f$  on nonreward.

Analysis of the data shows that confinement durations in the goal section had no effect on patterning. Thus, both Groups 12-0(i) and 12-0(D) displayed patterning in the goal measure by Day 10. Close inspection of Group 12-1(i) at Day 15 suggests that patterning may have been



developing. This would contradict the initial prediction that longer goalbox confinement would facilitate frustrative reactions. Similarly, the run-speed analysis indicated that the effect of confinement duration was significant for Days 11-15. Again, contrary to the initial predictions, delayed confinement increased running speeds. Why this increase in speeds for the delayed confinement groups is not carried over into the goal section is only a matter of conjecture. One possible explanation is that as the  $r_F$ - $s_F$  built up and was conditioned to the instrumental response in the run section, these groups showed enhanced responding. Upon reaching the goal area, frustration odors become noxious enough that responding was slowed. This analysis would seem to support the aversive nature of the frustration odor.

Since the confinement in the goal section did not significantly affect running speed, this experiment seems to negate Collerain's (1978) hypothesis that patterned responding could be due simply to distribution of characteristic animal odor. Immediate removal of the animals from the goalbox on N trials in the present experiment did not prevent double-alternation patterning. Thus, it would appear that an explanation based solely upon animal movement is not sufficient to account for this

data. Since patterning developed by both the 12-0 groups at approximately the same time, it would appear that frustration odors are exuded immediately and that these odors remain long enough to be used as a discriminative cue for subsequent animals.

Since the present experiment began with the double-alternation sequence, one would question whether the animals had built up any, or a strong enough,  $r_F-s_F$  to influence behavior. More research is needed in this area. Specifically, work should be done to give animals enough rewarded trials such that  $R_r-S_r$  is strong enough that a decrease in reward magnitude on N trials would certainly be detected by the animals and frustration elicited. Also, differential reward magnitudes should be studied to shed light on exactly how much contrast in reward magnitude is needed before the behavior of animals is altered. Collerain (1978) found that two rewarded events in the hurdle-jump apparatus did not significantly alter behavior of animals when they confronted nonreward. Research should be done to ascertain the minimum number of rewarded trials needed to alter the behavior of rats running in a straight runway.

In conclusion, this investigator feels that, though the results of this experiment posed some additional questions for researchers in the area of odor cue

production, these results do provide some new data on the production and operation of odor cues. First, lack of patterning in the 12-1 groups suggests that the receipt of a minimal (1 pellet) reward on N trials was ample enough to preclude the production of odor cues sufficiently strong to influence behavior. Second, simple subject movement and differential distribution of animal odor is not solely responsible for the development of patterning. Lastly, the development of patterning by Group 12-0(i) indicates that odors are exuded instantly upon confrontation of nonreward when reward is expected.

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## APPENDIX: FIGURES

Figure 1. Mean Start Speeds - Groups 12-1(i) and 12-1(D)

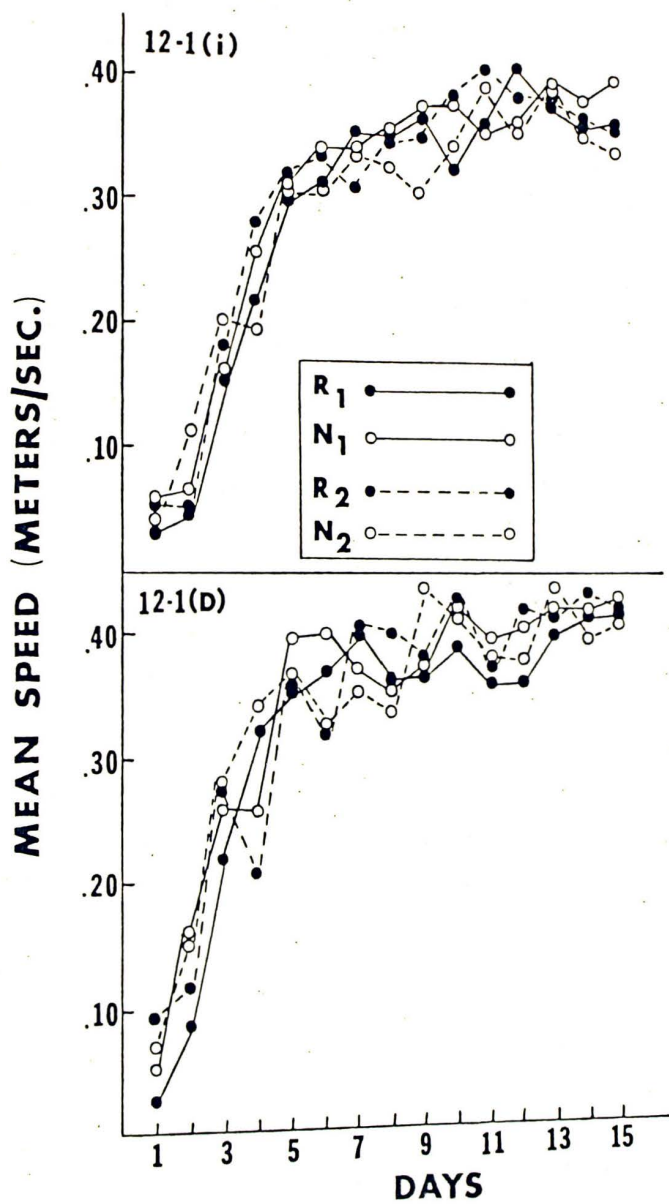


Figure 2. Mean Start Speeds - Groups 12-0(i) and 12-0(D)



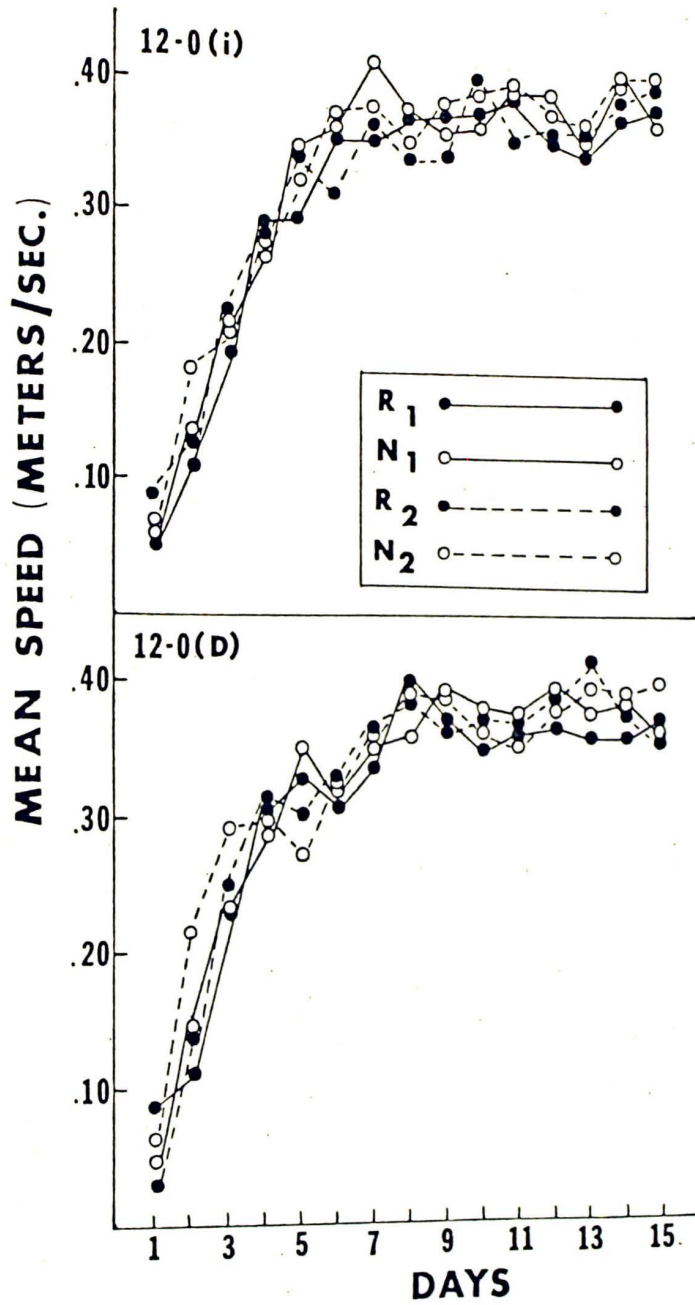


Figure 3. Mean Run Speeds - Groups 12-1(i) and 12-1(D)

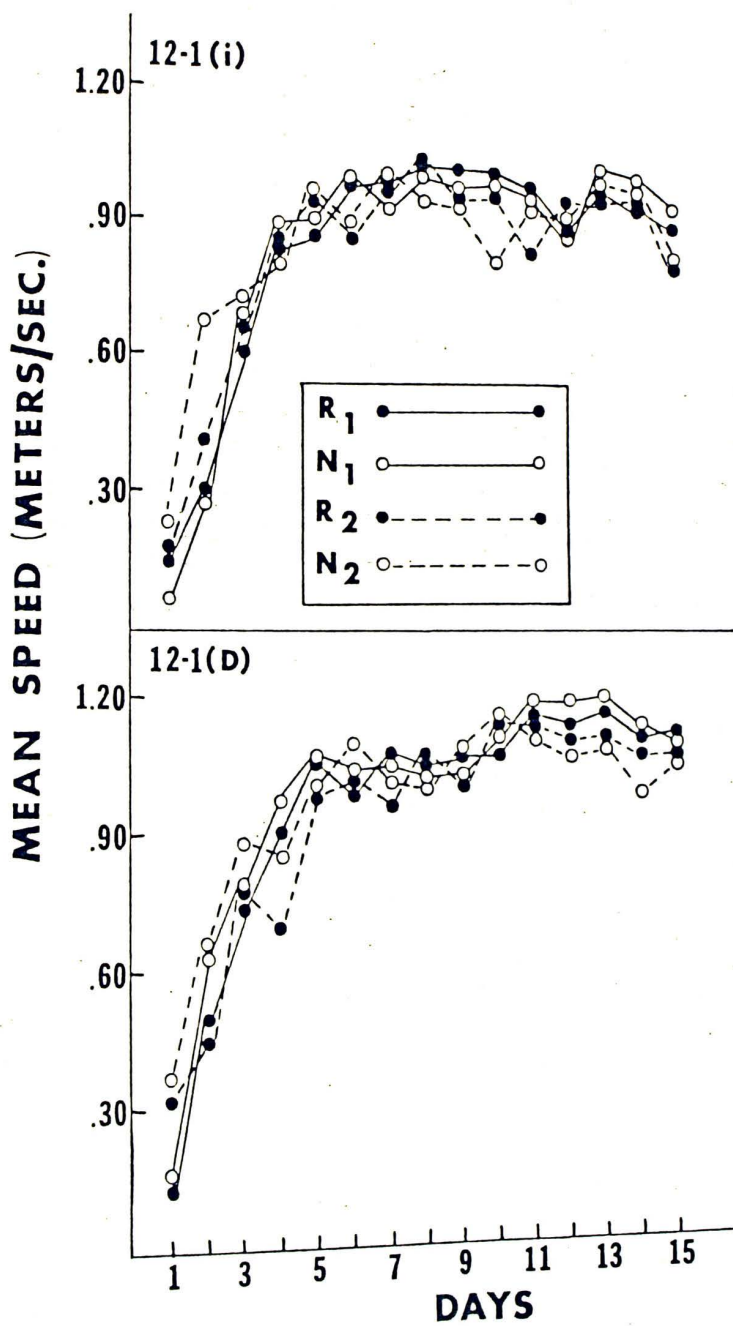


Figure 4. Mean Run Speeds - Groups 12-0(i) and 12-0(D)



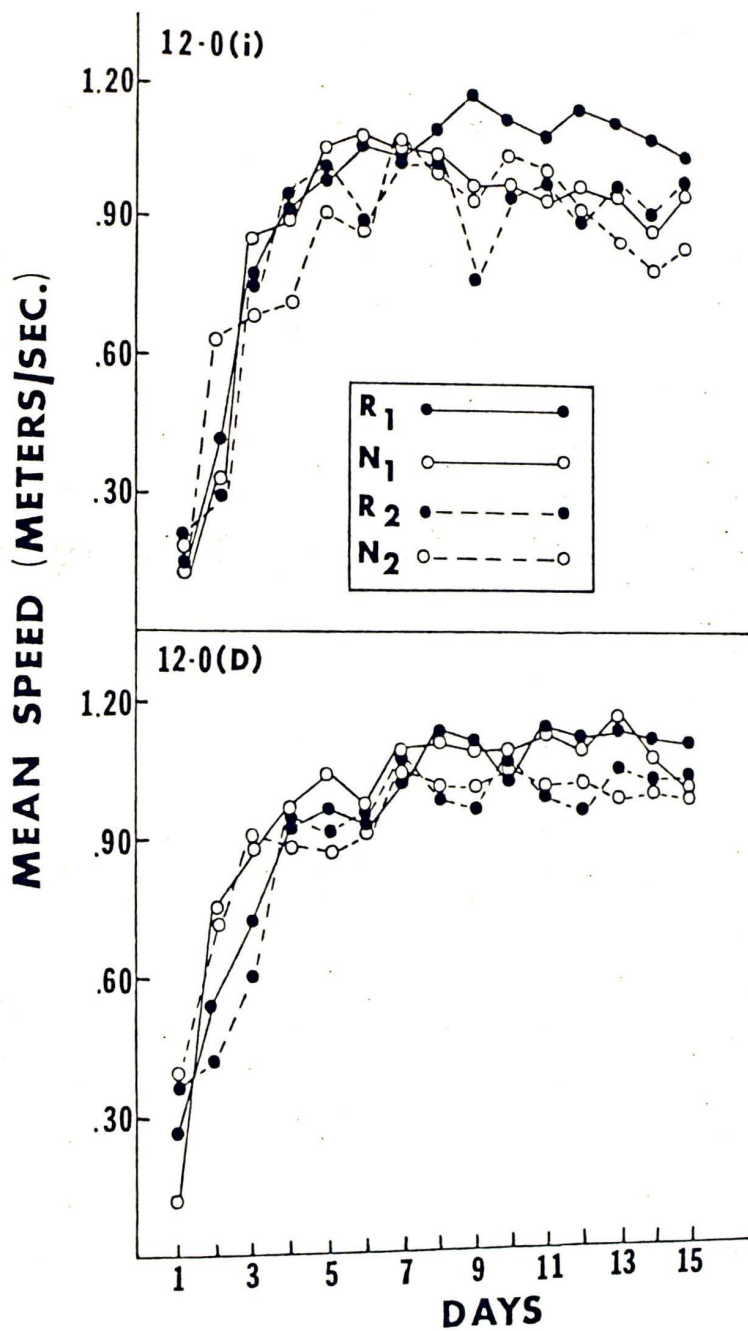


Figure 5. Mean Goal Speeds - Groups 12-1(i) and 12-1(D)

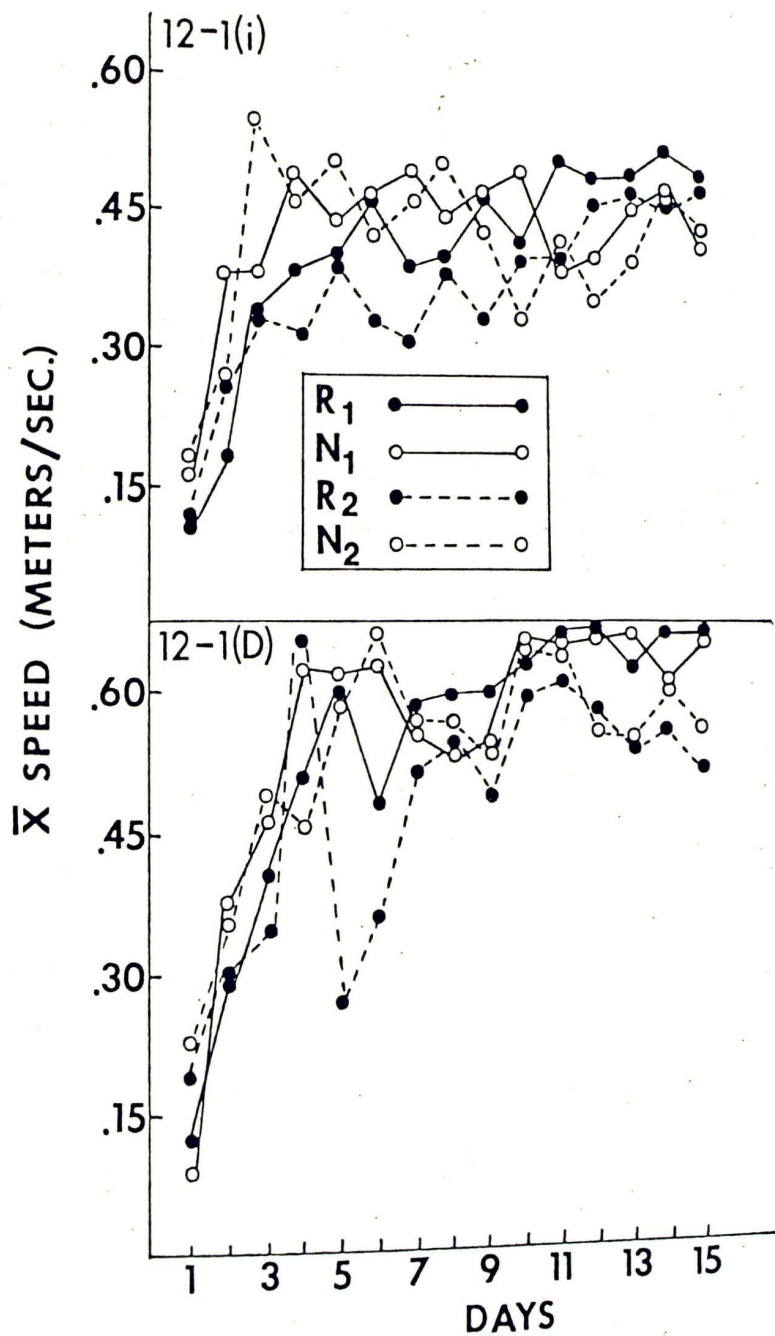


Figure 6. Mean Goal Speeds - Groups 12-0(i) and 12-0(D)



