AN ABSTRACT OF THE THESIS OF

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in Psychology presented on August 1, 1983

Title: MOTIVATIONAL SPECIFICITY OF THE SIGNAL VALUE OF ODOR CUES: A RECONSIDERATION AND EXTENSION

Abstract approved: Stephen F. Davis

For over fifteen years, numerous studies utilizing a straight runway apparatus have demonstrated that rat subjects exude either quatitatively and/or qualitatively different odors on reward (R) and nonreward (N) occasions. Interestingly, several studies have provided substantial evidence that R and N odors exuded by rat subjects tested under different deprivation conditions are quantitatively and/or qualitatively different, suggesting motivational specificity (i.e., runway trained rat subjects deprived of food will not attend to or utilize odor cues exuded by startbox placed, water-deprived odor-donor rats and vice versa).

The present studies were designed to further investigate the contention of strict motivational specificity of conspecific odor cues. Additionally, other parameters were addressed which might interact with and/or influence

the utilization of R and N odors for both food- and water-deprived animals.

Experiment 1 administered the same reinforcer (32% sucrose-water) to squads of rat subjects experiencing the different deprivation conditions. The results indicated that runway trained rats tested under one deprivation state exuded odors that were effectively utilized by subsequent animals being tested under a different deprivation state. Similar results were obtained in Experiment 2 when the squad size was smaller and a more substantial reinforcer was employed (32% sucrose-milk). The results of both Experiments 1 and 2 strongly suggested that individual, natural animal odors may play some role in the runway behavior of the rat. This contention was further supported by the results of Experiments 3 and 4 when more traditional reinforcers were employed (i.e., food-deprived animals received food pellets and water-deprived animals received water). Moreover, Experiments 3 and 4 provided evidence that odors, exuded by water deprived rats may be less intense and/or salient than odors exuded by food-deprived subjects.

Taken collectively, the present studies seriously question the conception of strict motivational specificity with regard to the signal value of odor cues. The apparently discrepant results are discussed in terms of the particular experimental designs employed.

MOTIVATIONAL SPECIFICITY OF THE SIGNAL VALUE OF ODOR CUES: A RECONSIDERATION AND EXTENSION

A Thesis

Presented to

the Department of Psychology

EMPORIA STATE UNIVERSITY

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

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by

Melanie S. Weaver

August, 1983

Approved for the Major Department

Approved for the Graduate Council

ACKNOWLEDGEMENTS

The assistance of Sue Spence, Ailene Pryor, Susan Nash, Brenda Anderson, Kirk Young, and Marty Johnston in gathering the data for these experiments is gratefully acknowledged, but a very special thanks goes to Scott Moore and Hymie James for their invaluable aid and participation in this research project. Thanks is also expressed to my committee members, Dr. Cooper Holmes and Dr. John Parrish for their helpful comments on the original draft of this thesis and to Kathleen Davis for a job well done on the typing of this manuscript.

Above all, my sincerest appreciation and utmost indebtedness is extended to my thesis director, Dr. Stephen F. Davis, for his guidance, assistance, and never ending patience throughout the duration of this project. Thank you, Dur, for making a potentially onerous undertaking become the most enjoyable and learned experience of my academic career.

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CHAPTER 1

INTRODUCTION

Over 40 years ago, J.W. DeMand (1940) published a study indicating that maze learning of the albino rat could be influenced by the presence of animal odor trails. Utilizing an elevated multiple-T maze and three groups of rat subjects, DeMand demonstrated that those animals given an odor trail marking the true path through the maze achieved faster times and made fewer errors than did those animals receiving no odor trails or odor trails marking blind alleys. These results indicated, and DeMand concluded, that certain measurements of learning may be greatly influenced by these uncontrolled animal odors. He further suggested that the response being measured may not, in fact, be the actual learning ability of the animal but, rather, the olfactory acuity of the animal. DeMand's contention would appear to be rather straight forward and of some importance; since, uncontrolled, these odors could pose great potential interpretation problems for animal researchers. Unfortunately, DeMand's contention, as well as his study, went unheeded until almost 30 years later when Ludvigson and Sytsma (1967) and Ludvigson (1969) demonstrated that rat subjects were capable of mastering a double-alternation pattern of reward and nonreward through the use of olfactory cues. In these two studies a straight

runway, divided into start, run, and goal segments, served as the experimental apparatus. All subjects were administered eight daily trials in a double-alternation (DA) sequence of reward (R) and nonreward (N) (i.e., RRNNRRNN). Specifically, all subjects within a group received the same condition (R or N) on a given trial with all subjects receiving the first trial before any subjects received the second trial. The runway was swabbed with a damp sponge only between trials, thus allowing any odors that were present to accumulate. Eventually, a pattern of running fast on R trials and slowly on N trials developed in the goal segment of the runway.

Stemming from these two seminal publications (Ludvigson & Sytsma, 1967; and Ludvigson, 1969), an accumulating body of research has been generated investigating the properties of and the experimental conditions under which these odors occur. This growing body of literature has come to be known as the "odor hypothesis" and its data support the contention that rat subjects exude either quantitatively and/or qualitatively different odors on R and N occasions. Further, if these odors are allowed to persist they can influence the behavior of subsequent conspecifics. It is readily observed that the development of appropriate patterned responding (i.e., fast to R and slow to N) occurs only under odor maximizing conditions and not odor minimizing conditions.

The typical odor maximizing and odor minimizing DA sequences used in such odor studies are shown in Part A of Table 1. (See Table 1 on following page.) Part B graphically depicts the results of DA patterning for both sequences. The first animal in a group, which is typically tested in a clean odor-free apparatus and considered to be an odor-donor for the following subjects, never displays differential responding (e.g., Prytula, Davis, Allen, & Taylor, 1980; Prytula, Davis, & Fanning, 1981). Moreover, if these odors are allowed to dissipate from an enclosed apparatus (Pitt, Davis, & Brown, 1973) or if the runway is swabbed after each animal, the odors are not allowed to accumulate and the development of appropriate patterned responding does not occur.

In addition to the data reported by Ludvigson and Sytsma (1967) and Ludvigson (1969), several other studies suggest that rats experiencing R and N treatments exude differential odors that subsequent conspecifics can utilize as discriminative cues for corresponging R and N goal events. For example Prytula et al. (1980) trained two groups of animals under one of two different alternating sequences of R and N; single-alternation, SA, (RNRN) and double-alternation, DA, (RRNNRRNN). Following acquisition of appropriate patterned responding each group was shifted to the opposite schedule. Those animals initially trained under the SA schedule immediately displayed DA patterning. Likewise, those animals initially trained under DA

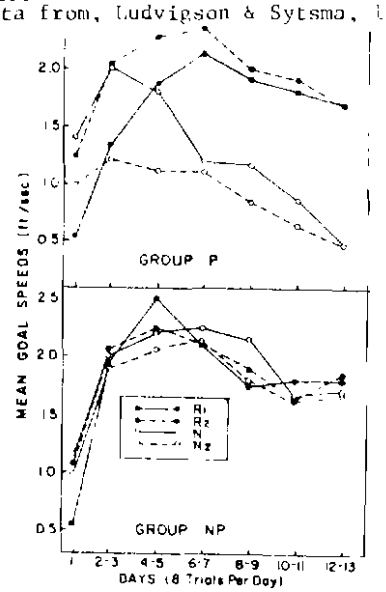
TABLE 1

A. Odor-Maximizing and Odor-Minimizing Double-Alternation Schednles
(from, Ludvigson & Sytsma, 1967)

GROUP	S	Trial 1	2	3	4	5	6	7	8	
P	1	R	R	N	N	R	R	N	N	ODOR-MAXIMIZING
	2	R	R	N	N	R	R	N	N	
	3	R	R	N	N	R	R	N	N	
	4	R	R	N	N	R	R	N	N	
	5	R	R	N	N	R	R	N	N	
	6	R	R	N	N	R	R	N	N	
	7	R*	R*	N*	N*	R*	R*	N*	N*	
NP	1	R	R	N	N	R	R	N	N	ODOR-MINIMIZING
	2	R	N	N	R	R	N	N	R	
	3	N	N	R	R	N	N	R	R	
	4	N	R	R	N	N	R	R	N	
	5	R	R	N	N	R	R	N	N	
	6	R	N	N	R	R	N	N	R	
	7	N*	N*	R*	R*	N*	N*	R*	R*	

*Any odors that are present in the apparatus are allowed to accumulate from S 1 to S 7 within the respective groups. Typically, the apparatus is swabbed following S 7 (last S in the group). Hence, S 1 is always tested in a clean, odor-free apparatus.

B. Double-Alternation Responding Under Odor-Maximizing and Odor-Minimizing Conditions
(data from, Ludvigson & Sytsma, 1967)



Odors Maximized (Group P)

------- fast to reward

------- slow to nonreward

Odors Minimized (Group NP)

------- nondifferential responding

patterning immediately displayed SA patterning. Due to the immediate shifts in behavior, these results strongly suggest that odor cues and not memory are the mediating factor(s) in the development of patterned responding. Seago, Ludvigson, and Remley (1970) presented further support for the "odor hypothesis" by indicating that when normal and anosmic (olfactory bulbs removed) rats were trained in a DA sequence of R and N, the bulbectomized subjects were capable of discriminating and demonstrating appropriate patterned responding only when a light cue was added on N trials (see also, Marrero, Davis, & Seago, 1973). In accordance with these findings Voorhees and Remley (1981), through single cell recordings of the rat's olfactory bulb, suggested not only that these odors are different from each other and can serve as discriminative cues, but also that R and N odors are detected at the mitral cell level.

It further has been demonstrated that R and N odors may also serve to elicit unconditioned approach and avoidance responses, respectively (e.g., Mellgren, Fouts, & Martin, 1973; Collerain & Ludvigson, 1972). When odor-donor subjects are placed in a chamber and allowed to exude an odor corresponding to a goal event (R or N), subsequent subjects placed in the same chamber will display faster escape speeds from N odors than from R odors, suggesting that odors produced when a rat receives non-reward is an aversive stimulus and odors produced by a

rat receiving reward may be an attractive stimulus.

The use of odor-donor subjects has generated several interesting new avenues for investigations into the nature of these odor cues. For example, it has been observed in numerous studies (see Ludvigson & Sytsma, 1967; Prytula et al., 1980; Seago et al., 1970) that the discriminiative effects of these odors, especially those of nonreward (Taylor & Ludvigson, 1980a), exert their most pronounced effects in the goal segment of the straight runway apparatus. As the R and N events are directly experienced in the goal box, this finding is not completely unexpected. However, Prytula and Davis (1974, 1976) have demonstrated that appropriate DA responding can be established in the start and run segments of the runway by placing odor-donors in these respective locations. When odor-donor R-N schedules are positively correlated with those of the run subjects (e.g., a donor R trial is followed by a run-subject R trial, etc.), appropriate patterned responding is developed in these designated segments. More specifically, if odor-donors are placed in the startbox, patterning will be established in all segments. However, if odor-donors are placed in the run segments, patterned responding will be established only in the run and goal segments. When the odor-donor schedule is changed to correlate negatively with that of the run subjects (e.g., a donor R trial is followed by a run-subject N trial, etc.), an immediate

and pronounced disruption in DA responding occurs in all segments of the runway. Although this disruption persists in the start and run measures, appropriate patterned responding will eventually re-emerge in the goal segment of the runway. Apparently, odor cues exuded by rats run earlier in the trial sequence are picked up by animals running to the same reward event later in the sequence. This suggests that rat subjects will readily utilize odor cues in different segments of the runway as long as odors further down the response chain are redundant. Eslinger and Ludvigson (1980a) carried the discriminative functions of these odors one step further. These researchers demonstrated that rat subjects can utilize R and N odor cues interchangeably. Utilizing donor-test triplets, rats discriminated R and N goal events based upon the opposite odor cues by running fast to N odors and slow to R odors. Hence, the use of opposite reward-event schedules for donor and test animals did not preclude the development of discrimination. As these data may appear to contrast somewhat with the Prytula and Davis (1974, 1976) studies which suggested that odor cues must be redundant in order to be utilized effectively, it would appear that the specific precedure for running the odor-donors and run-subjects must be taken into consideration. The Eslinger and Ludvigson (1980a) study utilized odor-donor triplets, sequentially

placing two odor-donors in the goalbox and administering each one either an R or N treatment. One test subject was then allowed to traverse the runway to receive either the same or opposite treatment. The runway was then swabbed before the next triplet was run. On the other hand, Prytula and Davis (1974, 1976) placed their odor-donors in the start or run segments and each was then followed by a run subject that was allowed to traverse the entire runway. Under these conditions the runway was not swabbed until all test subjects had been run, thus allowing odors to accumulate in the goal segment, thereby signalling the actual impending goal event.

The development of DA responding in all segments of the runway does not appear to be limited to the situation using odor-donor subjects. In particular, Prytula et al. (1981) established patterning in all segments of the runway through the use of one large squad of animlas which was conceptually divided into two groups: low odor buildup (initial animals) and high odor buildup (terminal animals). With the larger group there is, theoretically, a greater buildup and/or accumulation of odors in the goal area. In turn, these more potent odors would be expected to disseminate farther from the goal area toward the run and start segments to establish and maintain appropriate responding in these sections. To further support this contention, Prytula

et al. (1981) found that when naive animals were placed in initial and terminal positions of the squad, the terminal animals exposed to the intensified odor conditions developed patterning more rapidly than the initial naive animals in the squad. These results, along with those of Prytula and Davis (1974, 1976), indicate that the rat may be biologically "prepared" to respond appropriately to R and N odors. It will be recalled that the studies by Mellgren et al. (1973) and Collerain and Ludvigson (1972) yielded data supportive of such a preparedness interpretation. In contrast, the Eslinger and Ludvigson (1980a) study, in which animals were trained to approach N odors and avoid R odors, would suggest that the adaptive significance of these odors may well exceed the simple relationship of approaching an R odor and avoiding an N odor. In view of the apparent discrepancies between these sets of data, the <u>method</u> by which appropriate patterned responding is developed must certainly be taken into consideration when results and theoretical developments are discussed.

As can be seen, much is already known about the properties of these odors and the experimental conditions under which they are exuded. However, much less is known about their source and/or specific chemical nature. It appears that the odors of R and N are not only different from each other, but also differ from the odors of food and urine (Voorhees & Remley, 1981). Although the exact

source of these odors has not been located, McNeese and Ludvigson (Note 1) reported that these discriminable odor cues are not a function of the preputial gland or of the androgen-dependent accessory glands. Studies involving visible observation of urine (Eslinger & Ludvigson, 1980a) and flourescent emissions, as an indicant of urine (McNeese & Ludvigson, Note 1), also have yielded negative results. Further, Mellgren et al. (1973) have eliminated feces as a possible source of odor. As the odors exuded by rat subjects appear to be partially airborne but initially deposited on the apparatus flooring (Taylor & Ludvigson, 1980b), Weaver, Whiteside, Janzen, Moore, and Davis (1982) investigated the footpad sweatgland as a possible source of odor. Unfortunately, precluding odors exuded from the feet resulted in a significant intensification of patterned responding, suggesting that the odor exuded from the feet is a form of natural animal odor which serves to partially mask the odors of reward and non-reward. Hence, no sound conclusions can presently be made with regard to the source of these odors.

The "odor hypothesis" has been extended and generalized to include the notion of interspecific odors (Davis, 1970; Davis, Crutchfield, Shaver, & Sullivan, 1970). Moreover, it has been demonstrated that individual and sex differences appear to be functionally unimportant (Eslinger & Ludvigson, 1980b) in both the production and discriminative

use of R and N odors. By interchanging odor-donors after the subjects developed appropriate patterned responding with a particular donor, male and female test rats responded to donor rat odor cues in a similar manner regardless of gender factors, familiarity with the donor, or individual characteristics of the donors.

However, with regard to rat subjects trained under different deprivation states the generalizability of these discriminable R and N odors does not seem to apply. This consideration brings us to the line of experimentation most directly related to the present research. The initial report proposing that odors may be motivationally specific would appear to be that of Davis, Prytula, Harper, Tucker, Lewis, and Flood (1974). Motivational specificity suggests that rat subjects deprived of food will not attend to or utilize odor cues exuded by water-deprived rats and vice versa -- water-deprived subjects will not utilize odors exuded by food-deprived subjects as discriminable cues. Davis et al. (1974) conducted a three-phase study utilizing food-deprived startbox-placed odor-donor subjects and water-deprived runway-trained (run) test subjects. During Phase 1, odor-donor and run-subject pairs received positively correlated reinforcement schedules (RRNNRRNN). During Phase 2, the odor-donors' schedule was shifted to NNRRNNRR, i.e., the two schedules were negatively correlated during this phase. Phase 3

employed a shift from water deprivation to food deprivation for the run subjects with reinforcement schedules once again being positively correlated between the odor-donors and run-subjects. The data from Phases 1 and 2 indicated that the run subjects displayed appropriate DA responding only in the goal measure of the runway. This is to be contrasted with the Phase 3 data which indicated that appropriate patterned responding was developed in all segments of the runway when all subjects were tested under the same deprivation state (food-deprivation). A follow-up study, conducted by Davis, Prytula, Noble, and Mollenhour (1976), replicated the Davis et al. (1974) findings. This study was conducted similarly to the Davis et al. (1974) experiment with the exception that the run subjects were food-deprived and the odor-donor subjects were water-deprived during the third phase. Taken collectively, these data would appear to support the contention that odors produced by odor-donor subjects are attended to and utilized as discriminable cues by run subjects only when the deprivation states of these two sets of animals coincide.

Eslinger and Travis-Neideffer (Note 2) have reported a partial replication of the Davis et al. (1974, 1976) studies. This study was designed not only to replicate but also to rule out the possibility that the previous data may have been due to the specific training procedures utilized by Davis et al. (1974, 1976). [For purposes of

clarity the experimental designs used in the Davis et al. (1974, 1976) and the Eslinger & Travis-Neideffer (Note 2), studies are shown in Table 2 on the following page.] Specifically, Eslinger and Travis-Neifeffer (Note 2) conducted a two-phase study utilizing two groups of startbox-placed odor-donor subjects (one food-deprived, one water-deprived). Unlike the Davis et al. (1974, 1976) studies, the R-N events between donor and run subjects remained positively correlated throughout the experiment. Hence, only deprivation states were incongruent in appropriate phases. During Phase 1, the congruent groups consisted of water-deprived odor-donor subjects and water-deprived run subjects. The incongruent groups consisted of food-deprived odor-donor subjects and water-deprived run subjects. In Phase 2 the run subjects were shifted to the opposite deprivation state resulting in the congruent groups becoming incongruent and the incongruent groups becoming congruent. The findings of this study indicate that only when subjects are initially trained under congruent states (i.e., odor-donors and run subjects are both water-deprived) can they establish appropriate patterned responding which is maintained when the deprivation states are shifted to incongruent states. The prior congruent training somehow enabled the subjects to successfully discriminate on the basis of odor when the deprivation states differed. The results of this

TABLE 2

Experimental Design - Davis et al., 1974

Phases 1 & 2	Phase 3
Donor - Food Deprived	Donor - Food Deprived
Test - Water Deprived	Test - Food Deprived

- During Phases 1 and 3 both odor-donor and test subjects received their eight daily trials in a positively correlated sequence (RRNNRRNN).
- During Phase 2 the odor-donor schedule was shifted to negatively correlate (NNRRNNRR) with that of the test subject (RRNNRRNN).

Experimental Design - Davis et al., 1976

Phases 1 & 2	Phase 3
Donor - Water Deprived	Donor - Water Deprived
Test - Food Deprived	Test - Water Deprived

- During Phases 1 and 3 both odor-donor and test subjects received their eight daily trials in a positively correlated sequence (RRNNRRNN).
- During Phase 2 both odor-donor and test subjects received their eight daily trials in a reverse sequence (NNRRNNRR).

Experimental Design - Eslinger & Travis-Neideffer, Note 2

	Phase 1	Phase 2
CT	Donor - Water Deprived Test - Water Deprived	Donor - Water Deprived Test - Food Deprived
TC	Donor - Food Deprived Test - Water Deprived	Donor - Food Deprived Test - Food Deprived

- During both phases all subjects were given eight daily trials with RRNN and NNRR sequences being alternated every two days (i.e., two days of RRNN were followed by two days of NNRR, etc.).
- The R-N schedule was positively correlated for all donor-test pairs on each day.

study indicate that odors do differ with deprivation states. However, the specific deprivation conditions do not appear to pose absolute limits on the discriminative use of these odors. To digress somewhat, it is worth noting that pronounced and long-lasting effects of prior DA training also have been reported by Davis, Thomas, and Prytula (1981). In this study, it was shown that once established, DA patterning persisted even though Elavil and Thorazine drug-injection conditions were imposed.

In view of these data, the present studies were designed to further investigate the apparent limits on the discriminative use of odor cues that may be imposed by different deprivation states. As four separate experiments will be reported, the theoretical base and rationale for each one will be presented separately.

CHAPTER 2

EXPERIMENT 1

Data from the previous motivational specificity studies (Davis, et al. 1974, 1976; Eslinger & Travis-Neideffer, Note 2) are not without potential interpretation problems. In particular, when the rats in these studies were tested under different deprivation states, they also were receiving qualitatively and/or quantitatively different reinforcers. Hence, the lack of patterning displayed under these conditions could be attributed to either: 1) deprivation-state differences, or 2) reinforcer differences. Addressing this interpretation problem, Davis, Weaver, Nash, and Spence (1983), administered two different reinforcers to rats experiencing the same deprivation state. Data from this research suggested that food-deprived rats exuded a common odor under quinine (Q) and nonreward (N) reinforcement conditions. When two groups of animals, run as one large squad, received a DA schedule of R-N (Group 1) and R-Q (Group 2) a pattern of running fast to R trials, and slow to N and Q trials was established by both groups. Specifically, the squad consisted of seven animals receiving a R-N schedule of reinforcement followed by seven animals receiving a R-Q schedule of reinforcement. Under these conditions the first animal in the R-Q group displayed strong DA responding suggesting

that odors exuded under Q and N conditions are the same or are at least very similar.

The purpose of Experiment 1 was to investigate the other side of this interpretation problem by evaluating the effects of administering the same reinforcer to rat subjects experiencing different deprivation conditions. Throughout experimental testing all subjects received a 32% sucrose-water reward solution under conditions of either food-deprivation or water-deprivation. In support of the use of this reinforcer, previous studies (Burns, DeHart, & McRae, 1980; Burns, Dupree, & Lorig, 1978) have demonstrated that sucrose-water is an effective reinforcer for food-deprived rats.

As Davis et al. (1981) demonstrated the effective use of one large squad composed of two distinctive groups for the study of odor processes, this procedure was utilized during Phase 1 testing. Two subgroups, one food-deprived (FD) and one water-deprived (WD), constituted each squad. In one squad the FD animals preceded the WD animals, while in the second squad the WD animals preceded the FD animals. Phase 2 further investigated the effects of odors exuded under different deprivation conditions. On each day of Phase 2, the last subject in each of the second subgroups was rotated to the first position of his respective subgroup. Based upon the previous use of this rotation technique (Prytula et al. 1981), it might be predicted that if common, usable odors

were being produced by the first four animals, then each rotated subject should be able to maintain appropriate responding when moved to immediately follow these first four (different deprivation state) subjects.

Phase 3 testing regrouped the squads so that all FD subjects and all WD subjects were run as separate squads. This group rearrangement allowed an evaluation of any carryover effects from the previous incompatible deprivation testing conditions (Phases 1 and 2) into the compatible deprivation conditions imposed during Phase 3.

Method

Subjects. Sixteen, 90-day-old albino rats purchased from the Holtzman Company, Madison, Wisconsin, served as subjects. One week prior to pretraining the animals were randomly assigned to either a FD or WD condition (n = 8). Food-deprived subjects were placed on a food-deprivation regimen that maintained them at 85% of their free-feeding body weight while the water-deprived subjects were maintained on a 23-hour water-deprivation schedule with food freely available. Subjects experiencing these conditions were further assigned to subgroups of four subjects each: two WD (Subgroups A and B) and two FD (Subgroups A and B).

All animals were housed in individual cages and received their respective regimen following the daily experimental session. The deprivation schedules imposed

at this time were maintained throughout the duration of experimental testing.

Apparatus. The apparatus consisted of a single straight runway (11.4 cm wide x 12.7 cm high) having a gray startbox (28.1 cm), black run section (91.4 cm), and black goalbox (30.5 cm). Guillotine doors separated the startbox and goalbox from the run section. Start, run, and goal latencies, produced by the activation of a microswitch located on the start door and the interruption of a series of photoelectric cells (located 15.2, 92.4, and 116.8 cm beyond the start door) were recorded on all trials. A plastic receptacle mounted into the end wall of the goalbox was modified to allow the external attachment of a plastic water bottle. The drinking spout of the water bottle extended into the receptacle, thus allowing the subject easy access but preventing water from dripping onto the goalbox floor. A thin sheet of transparent plastic covered the top of the runway to prevent odors from dissipating. As this apparatus was employed in all experiments to be reported, only specific modifications will be reported in subsequent sections.

Procedure. A four-day pretraining phase immediately preceded experimental testing. All days of pretraining consisted of handling and taming, and habituation to the 32% sucrose-water reward solution in the home cage. On Day 3 each subject received a 5-min exploration

period in the unbaited apparatus. The fourth pretraining day was the same as the third, with the exception that the apparatus was baited and all photoelectric equipment was operative.

The specific squad and/or subgroup compositions and experimental design for each experiment to be presented are delineated in Table 3. For purposes of clarity, it is strongly recommended that the reader refer to this table when reading the method section pertaining to each experiment.

Prior to Phase 1 testing, the subgroups were combined to form two larger squads: Squad 1 - Subgroups A (FD) and B (WD) and Squad 2 - Subgroups A (WD) and B (FD). As can be seen from Table 3, in Squad 1, four FD animals preceded four WD animals while in Squad 2 four WD animals preceded four FD animals. During Phase 1 (18 days, 144 trials), the subjects within each squad were tested in a fixed (Position 1 - 8) running order (FXD) on all days.

On each day of Phase 2 (3 days, 24 trials) the animal in Position 8 (the last animal) was rotated to Position 5, thus allowing an animal that normally followed three animals of the same deprivation state to follow four animals of the opposite deprivation state. None of the subjects in the first A subgroups were rotated during this phase.

Phase 3 (3 days, 24 trials) involved: 1) a reversal of subgroup ordering within each squad (i.e., the B subgroups preceded the A subgroups in both squads), and 2) switching the second subgroup from one squad to the other. In other words, Squad 1 now consisted of both FD subgroups with Subgroup B preceding Subgroup A while Squad 2 consisted of both WD subgroups with Subgroup B preceding Subgroup A. The FXD running order was employed with the sequence for the first subgroup in each squad being the same as that which was in effect on the last day of Phase 2.

During all three phases of the experiment, each rat received eight daily trials in a DA (RRNNRRNN) sequence. On each trial, the appropriate subject was removed from the home cage and placed in the startbox. Following a 3-sec confinement, the start door was raised and the subject was allowed to traverse the runway. The R and N events consisted of 30-sec access to a full water bottle containing 32% sucrose-water and 30-sec confinement to an empty goalbox, respectively. An empty water bottle was in place on N trials. All daily trials were administered to the first squad before the second squad was run, with all animals within a particular squad receiving Trial 1 before Trial 2, and so forth. The order for running squads was alternated daily. The entire apparatus was swabbed with a water-dampened sponge and aired

for 5-min after the completion of each trial for each squad. The swabbing procedure was carried out twice with two separate sponges to assure that no sucrose odor or residue was present on the next trial.

Results and Discussion

General Statistical Procedures. As the same data-reduction techniques were employed for all experiments, they will be discussed briefly at this point. For purposes of clarity these procedures are further delineated in Table 4. The eight daily latencies for each subject were reciprocated and multiplied by the appropriate metric constant to yield speed scores (meter/sec.). Prior to analysis and graphing, the speed scores for the daily eight-trial double-alternation sequence were combined as follows: 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. Hence, the daily double-alternation performance was reduced to four scores for each subject. These scores were, in turn, used for purposes of graphing and analysis. (See Table 4 on following page.)

Visual inspection of Figures 1 and 2 indicates that both of the B subgroups displayed appropriate double-alternation responding in the goal measure during Phase 1, while the A subgroups failed to establish such appropriate responding. As will be elaborated, these results would appear to add further support to

TABLE 4

Data-Reduction Procedures

1. All latencies from the daily eight-trial sequence are reciprocated to yield speed scores.

2. The speed scores are then multiplied by the appropriate metric constant to yield speed scores in meters per second.

3. The eight daily speeds for each subject are then reduced to four representative scores thusly:

$$\frac{R + R}{2} \quad \frac{N + N}{2} \quad \frac{R + R}{2} \quad \frac{N + N}{2}$$

$$\downarrow \qquad \downarrow \qquad \downarrow \qquad \downarrow$$

$$R_1 \qquad N_1 \qquad R_2 \qquad N_2$$

4. These four composite scores are then used for graphing and analysis purposes.

the contention that absolute limits are not imposed on the discriminative use of odor cues under specific deprivation conditions. (See Figures 1 and 2 on following pages.)

An analysis of variance incorporating two between-groups factors, Deprivation Condition (Water-Deprived vs Food-Deprived) and Position Within The Squad (Subgroup A vs Subgroup B), and two within-groups factors (R vs N, and Days) was performed on the speed scores from the last eight days of Phase 1 (the point at which appropriate patterning appeared to have been established by both of the B subgroups). The results of this analysis yielded significance for the Deprivation Condition by Position Within The Squad, $F(1,12) = 5.21$, $p < .05$, and Position Within The Squad by R/N, $F(1,12) = 7.56$, $p < .05$, interaction effects. The Newman-Keuls procedure was used to probe these significant interactions. The results of these tests indicated that Subgroup B in Squad 1 ran significantly ($p < .05$) slower than the other three subgroups, and that significant ($p < .05$) R vs N differences were shown only by the two B subgroups. The significantly slower speeds shown by the B subgroup in Squad 1 would appear to be attributable to the development of patterning by these animals.

These data might be interpreted as suggesting that Subgroup A in both squads was not exuding any discernible

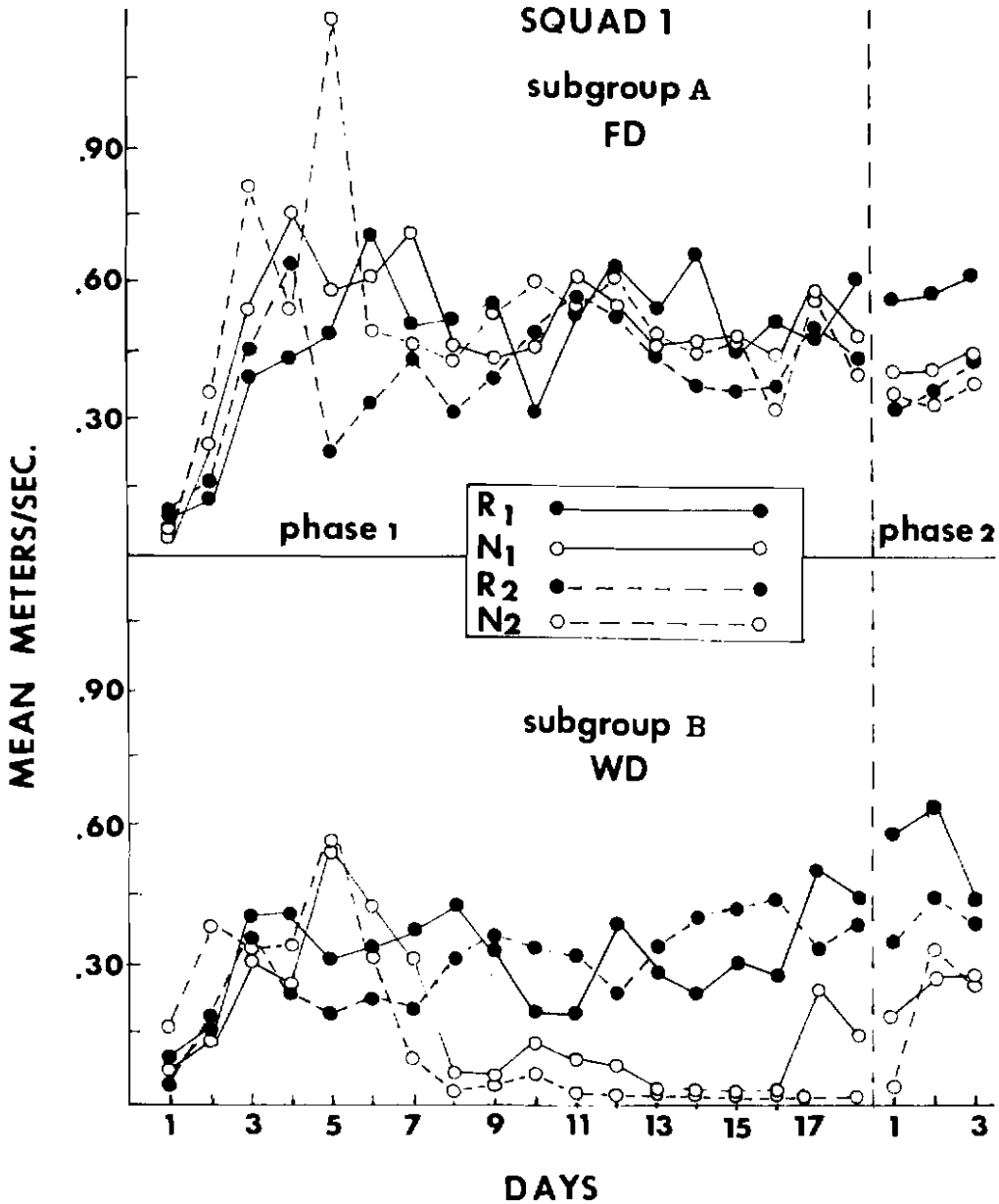


Figure 1 - Mean Goal Speeds for Squad 1, Subgroups A and B, During Phases 1 and 2 of Experiment 1.

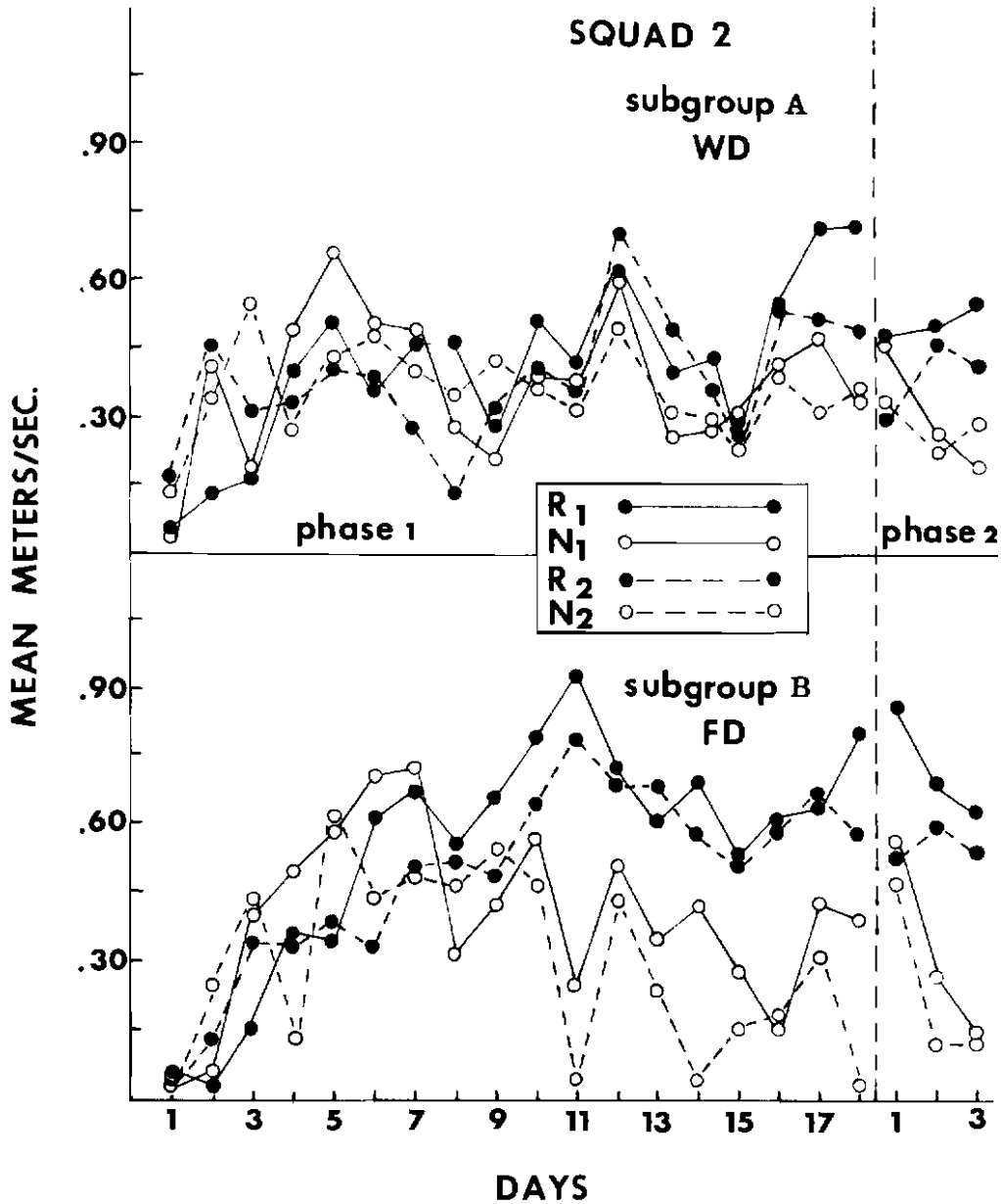


Figure 2 - Mean Goal Speeds for Squad 2, Subgroups A and B, During Phases 1 and 2 of Experiment 1.

odor cues that could be utilized by the following, opposite-deprivation B subgroups. Given this view, it would further be assumed that the patterning displayed by Subgroup B in both squads resulted from an accumulation of their own (within-subgroup) odor cues. However, a closer examination of the Phase 1 data reveals that some individual animals within both of the A subgroups had developed appropriate patterned responding. Unfortunately, this responding was not sufficient and did not occur in enough animals to be reflected in group means. Visual inspection of the data also indicated that the first animal in the FD Subgroup B (which followed the WD Subgroup A) displayed strong patterned responding. This finding is not predictable if one assumes that different deprivation states produce different odors.

As Prytula et al. (1981) have suggested that larger squads produce greater odor-buildup, it might alternatively be argued that odor cues accumulated across all subjects within each squad. In particular, the A subgroups (Ss 1-4) were run under theoretically low odor-buildup conditions. In contrast, the B subgroups (Ss 5-8) were tested under theoretically higher odor-buildup conditions. Based upon this contention, Subgroup A in both squads might not be expected to display patterned responding due to weaker odor cues. However, the odors exuded by these subgroups would, theoretically, accumulate and be utilized by the subsequent animals in Subgroup B

of both squads. Assuming that low odor-buildup conditions (4 Ss) do not allow odors to accumulate sufficiently for the development of patterned responding, it would appear reasonable to suggest that B subgroups, in turn, did not establish patterned responding solely on the basis of their own within-subgroup odor cues. A more plausible explanation would be that these subgroups developed double-alternation responding due to odors that had, in fact, accumulated over all eight subjects within each squad.

As depicted in Figures 1 and 2, the Phase 2 rotation of subjects from Position 8 to Position 5 within the B subgroups resulted in some disruption of the previously established patterned responding. (As the daily subject-rotation procedure resulted in a daily change in the subject ordering within each of the B subgroups, statistical analyses were not performed on the data from Phase 2.) However, Figure 3 readily indicates that this disruption was not attributable to the performance of the rotated subjects, i.e., each rotated subject displayed appropriate DA responding during Phase 2. Thus, the disruption resulted from fluctuations in the performance of animals that followed the rotated subject. These results suggest that individual animal odors may play some role in the runway behavior of the rat. However, it is just as clear that the maintenance of patterning by the rotated subjects also is supportive

of odor commonality across deprivation state. (See Figure 3 on following page.)

Phase 3 further investigated the lack of patterned responding displayed by Subgroup A in both squads. If this failure to establish patterning was a result of low odor-buildup conditions, then placing these subgroups in the higher odor-buildup positions (i.e., second subgroup in the squad) should facilitate the development of DA responding. Figure 4 graphically supports this contention. In particular both of the A subgroups displayed patterned responding after only three days of training. (See Figure 4 on page 31.)

A three-factor split-plot factorial analysis of variance incorporating Groups (Subgroup A-WD vs Subgroup A-FD) as a between-subjects factor, and R vs N and Days as within-groups factors was performed on the speed data of the two A subgroups for the three days of Phase 3. The results of this analysis yielded significance for the Groups, $F(1,6) = 6.16$, $p < .05$, and R vs N, $F(1,6) = 7.87$, $p < .05$, factors. Thus, it is clear that even though both A subgroups displayed appropriate patterned responding on all days of Phase 3, the FD subjects were approaching the goal significantly faster than the WD subjects.

The data from Experiment 1 give rise to two points of considerable interest. First, it would appear that individual animal odors may play a role in the runway

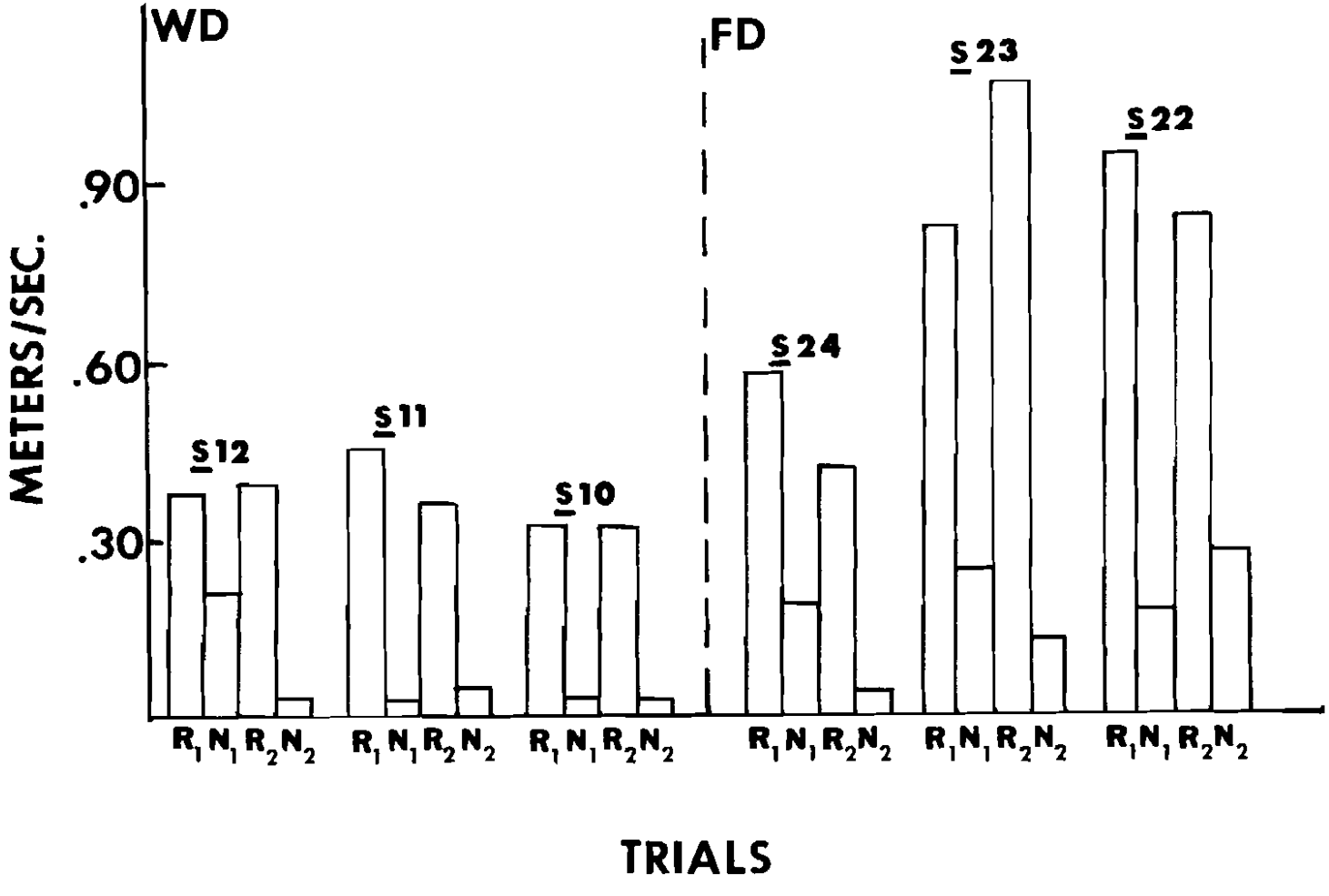


Figure 3 - Mean Goal Speeds for Rotated Subjects During Phase 2 of Experiment 1.

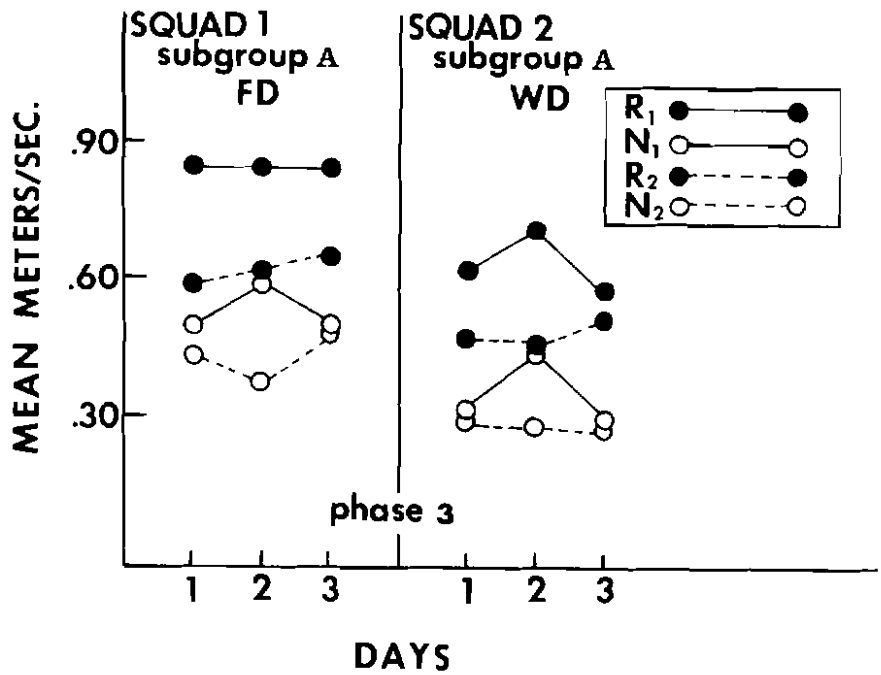


Figure 4 - Mean Goal Speeds for Squad 1, Subgroup A and Squad 2, Subgroup A During Phase 3 of Experiment 1.

performance of rat subjects. As noted, this was clearly demonstrated through the effects of the rotation technique of Phase 2. Secondly, and perhaps of potentially greater interest, is the fact that the training procedure utilized when rats are experiencing different deprivation conditions may affect the discriminative use of odor cues. In the present experiment demonstrating commonality of odors, independent groups of test animals were used, whereas the odor-donor technique was employed in the studies demonstrating motivational specificity. In particular, the previous studies (Davis et al., 1974, 1976; Eslinger & Travis-Neideffer, Note 2) utilized a startbox-placed odor-donor technique. If odors exuded by the odor donors were the same as, or similar to, those exuded by the run subjects (i.e., same deprivation states), patterning was developed in all runway segments (Davis et al., 1974, 1976). If the odors were dissimilar (i.e., different states), then patterning developed only in the goal area where the run animals encountered odor cues exuded by previous run animals experiencing the same deprivation state (Davis et al., 1974, 1976). These results certainly suggest that odors exuded under different states may be dissimilar. However, Eslinger and Travis-Neidiffer (Note 2) have established patterned responding in <u>all</u> segments of the runway utilizing the odor-donor technique, but this was accomplished <u>only</u> after the run subjects were previously trained with

odor-donors experiencing the same deprivation condition. The Eslinger and Travis-Neideffer (Note 2) results lead to the assumption that there may be some common element between odors exuded under different deprivation states. As already noted, the Phase 1 and Phase 2 data of the present experiment are supportive of such a "common-element" view.

CHAPTER 3

EXPERIMENT 2

The purpose of Experiment 2 was to further investigate: 1) the effect(s) of individual animal odors on the development of patterned responding, and 2) the effects of previous runway training on the utilization of odors as discriminative cues under different deprivation states. As in Experiment 1, all subjects received a common reinforcer while selected groups experienced different deprivation conditions. However, the reinforcer employed in Experiment 2 was a 32% sucrose-milk solution. The basis for the change in reinforcers from Experiment 1 to Experiment 2 resulted from visual inspection of Figures 1, 2, and 4. A comparison of the A subgroups (see Figures 1 and 2) suggests that patterned responding may have been present on the last two days of Phase 2 for the WD Subgroup A but not for the FD Subgroup A. In turn, as depicted in Figure 4, the Phase 3 patterning displayed by the WD Subgroup A appears to be stronger (i.e., greater R-N differences) than that shown by the FD Subgroup A. In light of these observations it might be argued that the sucrose-water mixture was not as reinforcing for the FD subjects as it was for the WD subjects. Therefore, a potentially more substantial reinforcer, sucrose-milk, was employed during Experiment 2.

Experiment 2 employed four groups consisting of

seven naive subjects each. This number of groups and subjects was needed to conduct Phase 2. It also provided a within-experiment replication for the randomized-running-order (RND) condition employed in Phase 1. Phase 1 addressed the effects of individual animal odors on the development of patterned responding and it was predicted that if individual animal odors do play a role in runway performance, then patterned responding might be precluded or at least very slow to develop under the RND condition. If individual odors do not play a role, then patterning should be established just as readily under the RND condition as under the more traditionally used FXD condition.

During Phase 2, 24 of the subjects were randomly assigned according to deprivation state, to one of six squads each composed of two subgroups having different deprivation states. The subgroups within each squad contained an equal number (i.e., 1, 2, or 3) of WD and FD animals. This particular squad composition allowed an evaluation of: 1) the odors exuded by initial subjects tested under each type of deprivation and 2) the utilization of these odors by subsequent animals tested under the different deprivation state.

As the results of Phase 2 testing might well be influenced by Phase 1 training, it can be pointed out that Phase 2 should also provide additional information regarding the effects of previous runway training on

the discriminative use of odor cues produced under different deprivation states. Given that a daily RND sequence was used in Phase 1, and a daily FXD sequence was used in Phase 2, several predictions might be entertained. First, as noted above, it might be assumed that the RND procedure might, in some way, preclude odor production and utilization in Phase 1 training. Hence, several days of training may be required in Phase 2 before the subjects would be able to effectively utilize odor cues. On the other hand, if the RND procedure results only in the masking of N and R odors by individual animal odors, then some learning about such N and R odors might take place during Phase 1 training. Under this condition, the utilization of N and R odors would become manifested more completely only under the FXD condition of Phase 1. Third, it might be argued that patterned responding would not be displayed during either phase. This view might assume that randomization would preclude odor production during Phase 1, while the small squad size would preclude odor utilization during Phase 2. However, with several days of training, patterned responding might be predicted for the second subgroups ($\underline{n}$ = 3) in Squads 5 and 6 ($\underline{n}$ = 6) during Phase 2 training. These results would be expected if odors exuded under different deprivation states are similar and accumulate across subjects (see Experiment 1).

Method

Subjects. Twenty-eight, 90-day-old, naive, male Holtzman rats served as subjects. One week prior to experimental testing the animals were randomly assigned to either a FD or WD condition (n = 14). Subjects in these groups were further assigned to one of four equal groups (n = 7): two food-deprived (FD1 and FD2) and two water-deprived (WD1 and WD2). Appropriate feeding regimens for these groups were the same as those delineated in Experiment 1. These schedules were maintained throughout the duration of experimental testing.

Apparatus. The apparatus was modified by removing the water bottle and attaching a 1/2-tsp metal measuring spoon (goalcup) to the end wall of the goalbox.

Procedure. The five days preceding Phase 1 constituted pretraining. Rats were handled and tamed (Days 1-5) and habituated to the 32% sucrose-milk reward solution in the home cage (Days 3-5). On Days 4 and 5 each subject was allowed to explore the baited apparatus for a 5-min period. Photoelectric equipment was operative only on Day 5.

As can be seen in Table 3, Experiment 2 employed four groups of animals (n = 7): FD1, FD2, WD1, and WD2. During Phase 1 (12 days, 96 trials) the order for running subjects within all groups was randomized (RND) daily. To accomplish this, on each day of Phase 1 a new randomized running sequence was assigned to each

group. This sequence was then held constant throughout the eight daily trials. Hence, subjects did not precede or follow the same subject on all days of experimental testing. The trial-sequencing (i.e., RRNNRRNN) and trial-administration procedures employed in Experiment 2 were the same as described in Experiment 1. On an R event, 1 ml of the sucrose-milk reward was present in the goalcup. On R trials, subjects were removed from the goalbox after consuming the reward. An N event consisted of a 30-sec confinement to an empty goalbox. The empty 1/2-tsp was in place during N trials. All daily trials were administered to an entire group before another group was run. The order for running individual groups was randomized daily. After the completion of each trial for each group, the runway cleaning procedures of Experiment 1 were employed.

Prior to Phase 2 (4 days, 32 trials) testing, one animal from each group was randomly eliminated. The remaining 24 subjects were randomly distributed, according to deprivation state, across three squads (Squad 1, $\underline{n}$ = 2; Squad 2, $\underline{n}$ = 4; and Squad 3, $\underline{n}$ =6) consisting of two subgroups (SGA and SGB) each. Although these squads did not consist of an equal number of subjects, an equal number of subjects <u>were</u> contained in the two subgroups within a particular squad (i.e., 1, 2, or 3 WD and FD animals). This arrangement allowed squads to be counterbalanced with regard to the ordering

of deprivation states. Animals within each squad were tested in the same FXD running order on all days of Phase 2 while the order for running squads was randomized daily.

Results and Discussion

The results of Phase 1 lend further support for the individual animal odor hypothesis proposed in Experiment 1. Visual inspection of Figures 5 and 6 indicates that none of the four groups, FD1, FD2, WD1, or WD2, established reliable patterned responding under the daily RND conditions. (See Figures 5 and 6 on following pages.)

Prior to overall statistical analysis, separate analyses of variance were performed on the speed data from Days 7-12 for Group WD1 vs WD2, and FD1 vs FD2. As these analyses failed to yield any significant effects, Groups WD1 and WD2, and FD1 and FD2 were pooled for further analysis. A subsequent analysis incorporating one between-groups factor, Deprivation Condition (Water-Deprived vs Food-Deprived), and two within-groups factors (R vs N, and Days) was subsequently performed over the speed scores from Days 7-12. The results of this analysis also failed to yield any significant effects and corroborate the visual impression described above.

It should be noted that when food-deprived subjects receiving food pellets (see Davis & Prytula, 1979;

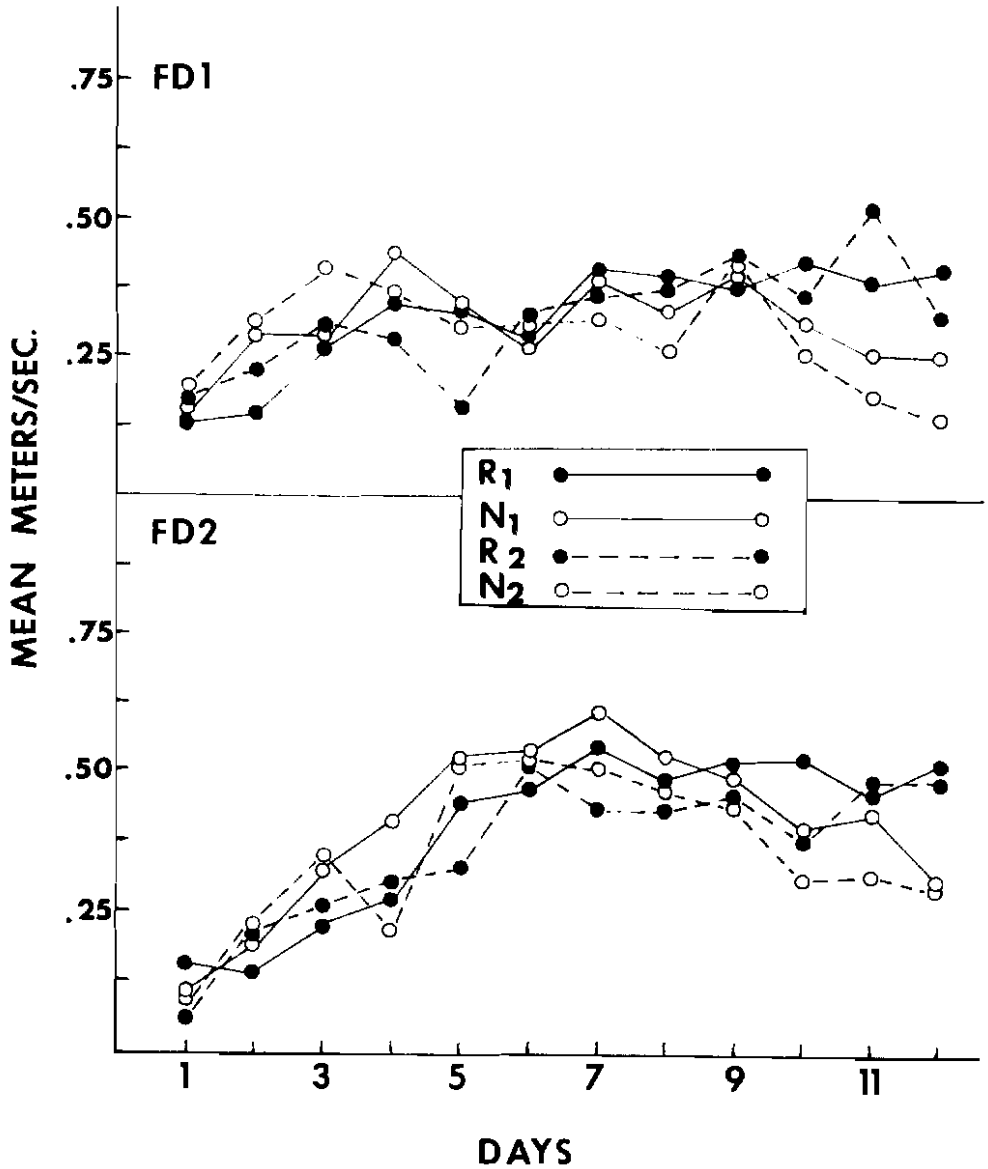


Figure 5 - Mean Goal Speeds for Groups FD1 and FD 2 During Phase 1 of Experiment 2.

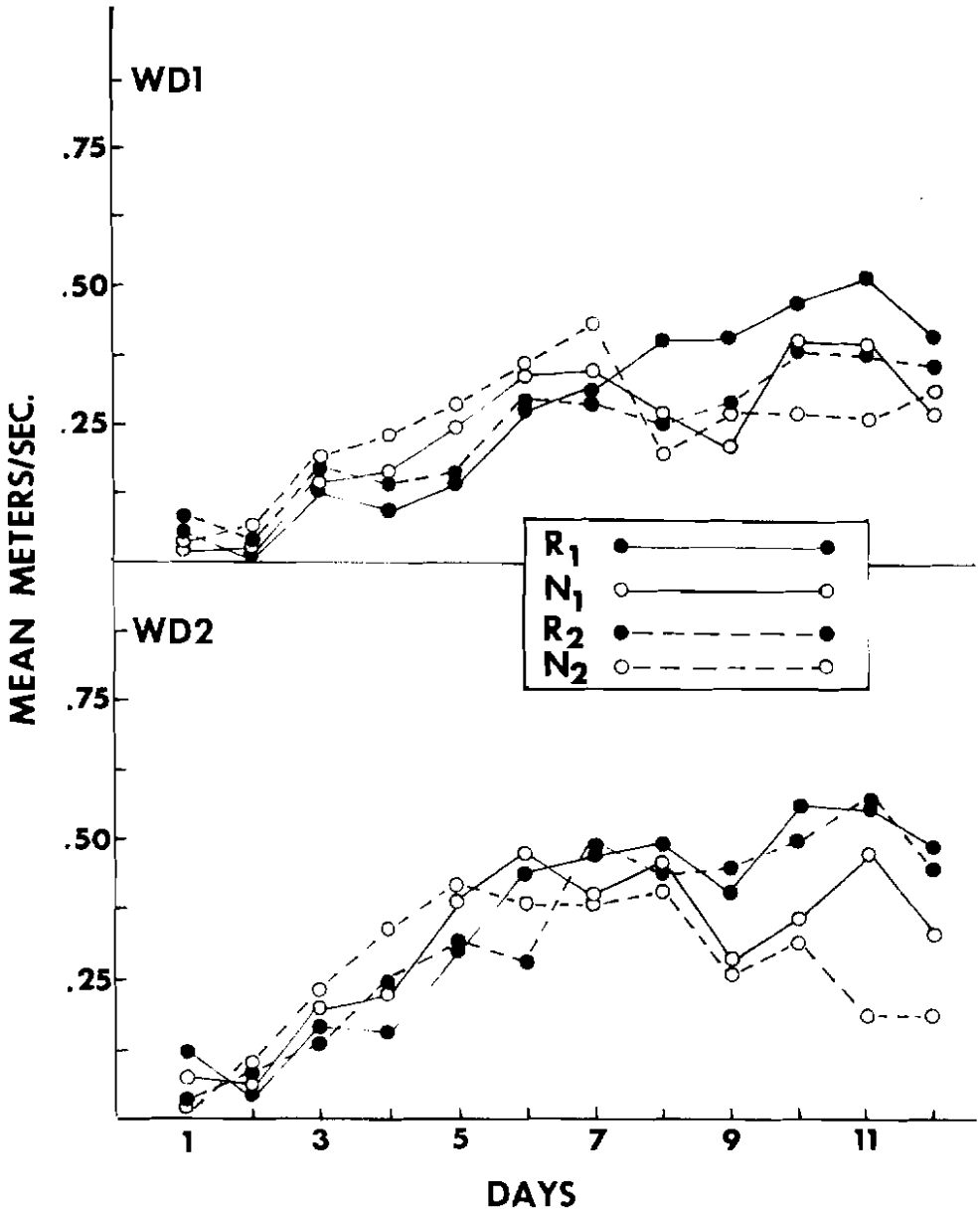


Figure 6 - Mean Goal Speeds for Groups WD1 and WD2 During Phase 1 of Experiment 2.

Ludvigson & Sytsma, 1967; Prytula, Davis, & Fanning, 1981) and water-deprived subjects receiving sucrose reinforcement (see Davis, Burns, Howard, & Voorhees, 1982) are tested under a daily, FXD running order, appropriate patterned responding is typically displayed around Day 7. As no patterned responding was displayed by any of the four groups during the 12 days of Phase 1 training, these results strongly suggest that individual animal odors may play a significant role in determining the development of appropriate DA responding.

Although patterned responding was not evident for Groups FD1, FD2, WD1, and WD2 during Phase 1, the results of Phase 2 suggest that the randomization procedure utilized in the Phase 1 training did not preclude odor production. As can be seen from Figure 7, appropriate patterned responding was displayed by SGA in Squads 4 and 5 and SGB in Squads 1, 2, 3, 4, 5, and 6 within only four days of runway training under the daily, FXD sequence. Further inspection of Figure 7 reveals that nondifferential responding was displayed by SGA in Squads 1, 2, 3, and 6. Hence, it appears that the randomization procedure results in the masking of N and R odors by individual animal odors (see Experiment 1). (See Figure 7 on following page.)

A separate analysis of variance incorporating one between-groups factor (SGA vs SGB) and two within-groups factors (R vs N, and Days) was performed on the speed

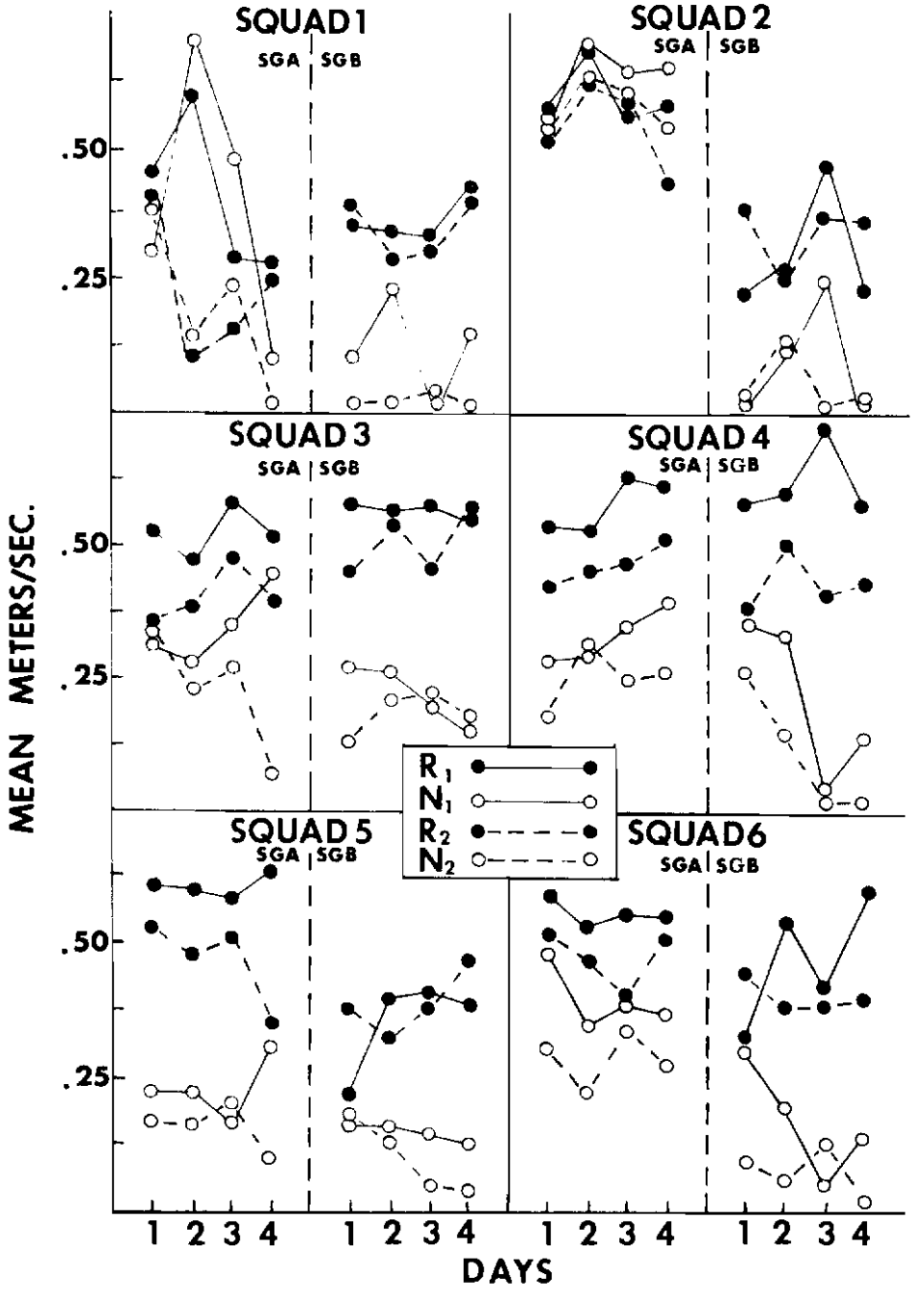


Figure 7 - Mean Goal Speeds for Squads 1-6, Subgroups A and B, During Phase 2 of Experiment 2.

scores for all days of Phase 2 for Squads 3-6. As SGA and SGB in Squads 1 and 2 contained only one subject each and, therefore, precluded the calculation of any within-group variability, statistical analyses were not performed on these squads. However, the results of the analyses of Squads 3-6 indicated that significant R vs N effects were developed in all cases. More specifically, the Squad 3 analysis yielded significance for the SGA/SGB by R/N interaction, $F(1,23) = 4.37$, $p < .05$. Subsequent examination of this interaction (Newman-Keuls procedure) indicated that significant ($p < .05$) R vs N differences were shown only by SGB in Squad 3. As only the R vs N main effect was shown to be significant, $F(1,23) = 8.68$, $p < .01$, in the Squad 4 analysis, it can be concluded that both SGA and SGB had developed appropriate patterned responding during Phase 2. The Squad 4 results were mirrored by the results of the Squad 5 speeds, i.e., only the R vs N effect yielded significance, $F(1,37) = 9.07$, $p < .01$. However, the SGA/SGB by R/N interaction, as with Squad 3, was found to be significant, $F(1,37) = 5.39$, $p < .05$, in the Squad 6 analysis. Again, significant ($p < .05$) R vs N differences were shown only by SGB.

The lack of patterning displayed by SGA ($n = 1$) in Squads 1 and 2 is to be expected. These results are consistent with data reported by previous studies (Prytula et al., 1980; Prytula et al., 1981) which

indicate that the first animal in a group does not display differential responding due to the lack of odor cues.

Of particular interest is the fact that SGA in Squads 4 ($\underline{n}$ = 2) and 5 ($\underline{n}$ = 3) displayed patterned responding. Subjects comprising each of these subgroups and the other corresponding subgroups, i.e., SGA in Squads 3 ($\underline{n}$ = 2) and 6 ($\underline{n}$ = 3), were tested under theoretically low odor-buildup conditions (see Prytula et al., 1981). Assuming that low odor-buildup conditions do not allow odors to accumulate sufficiently for the development of patterned responding (Experiment 1), it would appear reasonable to suggest that these subgroups were able to establish such rapid patterned responding due to previous runway training. Apparently some learning about N and R odors took place during Phase 1 (RND condition), only to manifest itself during Phase 2 (FXD condition). Once the individual animal odors are fixed (i.e., each $\underline{S}$ follows the same $\underline{S}$ on all trials) novel animal odor(s) no longer compete with N and R odors, and subjects can effectively utilize these odors as discriminative cues. As SGA in Squads 3 and 6 did not display differential responding with an equal amount of previous runway training (12 days), the patterning or lack of patterning displayed by SGA in Squads 3, 4, 5, and 6 may be somewhat dependent upon the strength of R and N odors exuded by individual animals.

If one assumes odor commonality across deprivation states, then only SGB in Squads 1, 2, 3, and 4 were tested under theoretically low odor-buildup conditions. Within Squads 5 and 6, each SGB consisted of three subjects and followed SGA which also consisted of three subjects. Hence, SGB subjects in Squads 5 and 6 were tested under theoretically higher odor-buildup conditions than the other subgroups. This should allow for the sufficient accumulation of odors for the development of patterned responding. The results indicate that this is exactly what happened. Likewise, although run under theoretically low odor-buildup conditions, SGB in Squads 1, 2, 3, and 4 also displayed patterned responding. It is of particular interest to note that the SGB animals in Squads 1, 2, 3, and 6 were able to establish appropriate patterned responding even though the preceding SGA animals displayed no such behavior. These results are in accord with those reported in Phase 1 of Experiment 1 and further suggest that odors are being produced by the initial animals experiencing one deprivation state and being utilized by the terminal animals (SGB) experiencing a different deprivation state. The argument for odor similarity is further strengthened by the patterned behavior displayed by SGB ($\underline{n}$ = 1) in Squads 1 and 2. As previously mentioned, the first animal in a group always displays nondifferential responding. If the SGB animal within

both Squads 1 and 2 was not utilizing odors exuded by the preceding SGA animal, then patterned responding should not have developed by either SGB subject. Moreover, the rapidity with which the SGB subjects within all six squads learned to utilize odor cues exuded by the preceding (different deprivation state) animals further suggests that some learning about N and R odors took place during Phase 1 testing. It should be reiterated that in Phase 1 of Experiment 1 when naive subgroups (FXD order) followed different-deprivation subgroups, patterned responding did not develop until approximately Day 12. Hence, it appears somewhat improbable to suggest that the subgroups in Phase 2 of Experiment 2 would have developed patterned responding in 4 days without the previous Phase 1 training.

Taken collectively, three salient points are suggested by the results of Experiment 2. First, given that none of the four groups displayed patterned behavior after 12 days of Phase 1 training (RND condition), it appears that individual animal odors do play a role in the development of DA responding. Second, the rapidity with which the subgroups developed patterned responding during Phase 2 (FXD condition) certainly supports the contention that previous runway training, even under randomized conditions, enables subjects to obtain information about R and N odors. Further

indicative of this contention is the fact that even those subgroups tested under theoretically low odor-buildup conditions (i.e., SGB in Squads 1, 2, 3, and 4 and SGA in Squads 4 and 5) developed patterned responding. However, it should be reemphasized that the strength of R and N odors exuded by individual animals might be taken under advisement. Third, and possibly of greater importance, is the fact that SGB in all six squads established patterned responding in only four days when following animals of a different deprivation state. This finding certainly lends further support for the Experiment 1 data which indicate that odors exuded under different deprivation states may be similar.

CHAPTER 4

EXPERIMENT 3

Experiment 3 was specifically designed to further investigate the runway performance of animals tested under the daily, within-groups randomized (RND) sequence. Visual inspection of the Phase 1 data of Experiment 2 (Figures 5 and 6) for Groups FD1, FD2, WD1, and WD2 suggests that these animals were beginning to pattern under the RND conditions. As the possibility of this patterned responding was most pronounced on the last day of Phase 1 training (Day 12), it might be predicted that extending RND runway training to 14 days would allow subjects to more completely develop odor-based DA responding. Hence, Phase 1 of Experiment 3 tested two groups, FD and WD, with extended training under the same RND procedure employed in Phase 1 of Experiment 2. The only exception was that each group was administered a reinforcer that more directly corresponded to its deprivation state (i.e., FD animals received food pellets and WD animals received water). As the main thrust of Experiment 3 was to evaluate the RND procedure, the use of the more traditional and/or appropriate reinforcers should not be viewed as a confounding factor. As has been demonstrated in numerous studies (e.g., Davis & Prytula, 1979; Ludvigson & Sytsma, 1967; Prytula et al., 1981) FD subjects, tested under a FXD sequence receiving

a food-pellet reward, display patterning at approximately Day 7. More importantly, Davis et al. (1982) demonstrated that nondifferential responding was displayed by WD subjects receiving a double-alternation schedule of 32% sucrose-water and plain water. Hence, it would appear that any potential development of patterned responding should not be affected by the change in reinforcers.

During Phase 2 of Experiment 3 both Groups FD and WD were tested under the FXD sequence. If patterned responding occurs during Phase 1 RND training, then it would be expected to continue undisrupted into Phase 2 training. This view assumes that subjects can eventually discriminate among N, R, and individual animal odors under the RND condition if acquisition training is extended, and continue this discrimination undisrupted when the FXD conditions are imposed. On the other hand, if patterned responding is not established under the RND condition of Phase 1, then additional information can be obtained concerning the length of time required for these groups to develop patterned responding under the FXD condition of Phase 2. Assuming that previous RND training allows subjects to learn something about the discriminatory use of N and R odors (Experiment 2), then patterned responding might be expected to manifest itself somewhat more rapidly during Phase 2 (FXD) even if it is not shown in Phase 1.

Phase 3 constituted a reversal phase during which Groups FD and WD were returned to the RND condition of Phase 1. Previous positive data gathered under the FXD sequence (e.g., Ludvigson & Sytsma, 1967) prompts the assumption that both groups will display DA responding during Phase 2, regardless of the RND technique employed in Phase 1. Hence, it might be further predicted that once the animals have learned to utilize N and R odors as discriminatory cues they should continue to disregard individual animal odors and maintain patterned responding.

Method

Subjects. Fourteen, 120-day-old, naive, Holtzman rats served as subjects. One week prior to pretraining the animals were randomly assigned to FD and WD groups (n = 7). Maintenance regimens for these groups remained the same as those of the two previous experiments.

Apparatus. As Group FD received food-pellet reward and Group WD received water reward, respectively, on R trials, the receptacle mounted on the end wall of the goalbox was modified accordingly to accept both food pellets and a plastic water bottle.

Procedure. The five days preceding Phase 1 constituted pretraining. All days of pretraining consisted of handling and taming, and habituation to the 45-mg Noyes reward pellets in the home cage for Group FD. The WD subjects received their regular daily access to water in the home

cage at this time. On Day 3 each subject received a 5-min exploration period in the unbaited apparatus. On Days 4 and 5, the apparatus was baited with the appropriate reward and all photoelectric equipment was operative.

During Phase 1 (14 days, 112 trials) the order for running subjects within each group, FD and WD, was randomized daily. Phase 2 (8 days, 64 trials) employed the FXD sequence. During this phase all subjects were run in the order which was in effect for the respective groups on the last day of Phase 1. On each day of Phase 3 (2 days, 16 trials) the subjects were again run in the RND sequence within each group. (Please refer to Table 3 for a complete delineation of the experimental design employed in Experiment 3.)

In all three phases, trial-administration and runway cleaning procedures were the same as those employed in the two previous experiments. The order for running groups was alternated daily. An R event for Group WD consisted of 15-sec access to a full water bottle, while Group FD received 12, 45-mg Noyes pellets on R trials. Group FD subjects were removed after consuming the reward pellets. On an N event all subjects received a 15-sec confinement period in the empty goalbox. An empty water bottle was in place during N-trial confinement for Group WD subjects.

Results and Discussion

Visual inspection of Figure 8 indicates that Group WD did not develop appropriate patterned responding during Phase 1 under the RND sequence. In contrast, Group FD had established patterned responding by Day 12 of Phase 1. An analysis of variance incorporating one between-groups factor, Deprivation Condition (Water-Deprived vs Food-Deprived) and two between-groups factors, R vs N and Days, was performed on the speed data from the last three days of Phase 1 (the point at which appropriate patterning appeared to have been established by Group FD). The results of this analysis yielded significance for the Deprivation Condition by R/N interaction, $F(1,12) = 8.29$, $p < .05$, and the Deprivation Condition by Days interaction, $F(2,24) = 4.30$, $p < .05$. Subsequent Newman-Keuls tests indicated that significant ($p < .05$) R vs N differences were shown on Days 12-14 only by Group FD. Further, it was found that Group FD approached the goal significantly ($p < .05$) faster than Group WD on Days 12 and 14. (See Figure 8 on following page.)

During Phase 2, when tested under the FXD sequence, patterned responding was maintained by Group FD and established by Group WD on Day 7. Further, this patterning persisted into Phase 3, when the RND condition was reinstated, for both Groups FD and WD. These visual impressions and conclusions were supported by statistical

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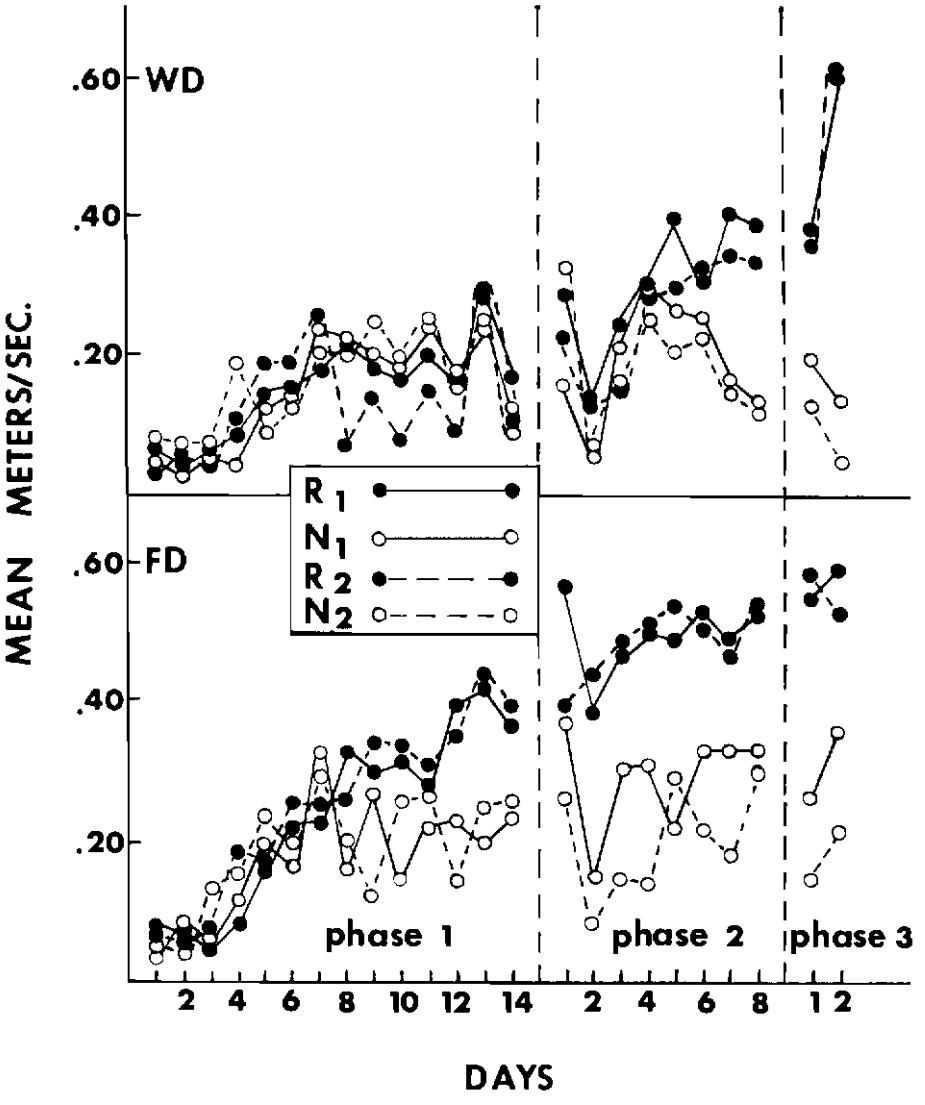

Figure 8 - Mean Goal Speeds for Groups WD and FD During Phases 1, 2, and 3 of Experiment 3.

analyses, similar to the one conducted on the Phase 1 data, of the Phase 2 and Phase 3 speeds. More specifically, the Phase 2 analysis indicated that the Deprivation Condition by R/N by Days interaction was significant, $F(2,24) = 6.23$, $p < .01$. Subsequent analysis of this interaction (Newman-Keuls tests) indicated that Group FD displayed significant patterned responding (R speeds faster than N speeds) on Days 1 ($p < .05$) and 2-8 ($p < .01$), while Group WD displayed such appropriate responding only on Days 7 and 8 ($p < .01$). Further, it also was found that Group FD approached the goal significantly ($p < .05$) faster than Group WD on Days 1, 2, 3, 7, and 8. In accord with the last point raised above, the Phase 3 analysis yielded significance only for the R vs N main effect, $F(1,12) = 12.78$, $p < .01$.

The fact that Group FD did establish patterned responding during Phase 1, by Day 12, suggests that FD subjects can eventually discriminate among N, R, and individual animal odors when trained under the RND condition. However, it should be recalled that FD rats run in a FXD sequence and receiving pellet reinforcement typically display strong patterning after approximately seven days of training (see Davis & Prytula, 1979; Ludvigson & Sytsma, 1967; Prytula et al., 1981). In view of this retarded development of patterning shown by Group FD under RND conditions, and the complete lack of patterning shown by Group WD in Phase 1, it would

appear that individual natural animal odors may serve to mask or obscure R and N odors under the RND conditions. As noted, when tested under the FXD sequence during Phase 2, both groups displayed patterned responding. In light of these results, it is proposed that once the individual animal odors are fixed by having each subject follow the same animal on all trials, there are no longer any novel animal odor(s) that compete(s) with the R and N odors. Thus, the R and N odors can now be more effectively utilized as discriminative cues.

That Group WD failed to establish patterned responding during Phase 1 (RND), also might suggest that N and R odors exuded by WD subjects are less salient than N and R odors exuded by FD subjects. Consequently, it would be even more difficult for WD subjects to discriminate among N, R, and individual animal odors when tested under the RND sequence. In view of such an assumption, it might be suggested that the lack of patterning displayed by Group WD was a result of natural animal odors over-shadowing these presumably less intense water-related R and N odors. However, as suggested by Phase 2, running the WD subjects under the FXD condition allows the less intense R and N odors to be used more effectively as discriminative cues. As appealing as this interpretation might be, it should be mentioned that the development of patterning by WD animals may not be influenced by such

natural animal odors. If the odors exuded under this deprivation state are less salient and/or intense, such retarded patterning may simply indicate that patterning takes longer to develop under this deprivation state.

Figure 8 further reflects a slight disruption in the patterned responding of Group FD on Day 1 of Phase 2. As this disruption resulted from the first R and N trials of the day, it is possible that these subjects had not completely adapted to the individual odors of all animals in the group. It will be noted that the second R and N trials on this particular day are again in accord with those on the last day of Phase 1. That no disruption was evidenced on the first day of Phase 3 training, when the RND sequence was reinstated, was not completely unexpected. Recall that Group FD had previously established patterned responding under the RND sequence in Phase 1. In accord with the Phase 3 results for Group FD, Group WD also continued to display patterned responding during the Phase 3 reversal to the RND sequence. These results are certainly in accord with a previous drug study (Davis et al., 1981) which suggests that once patterning has been established, it is relatively resistant to disruption.

CHAPTER 5

EXPERIMENT 4

Experiment 4 was a 3-phase study designed to further investigate: 1) the saliency of N and R odor cues exuded by FD and WD subjects receiving corresponding reinforcers (i.e., FD subjects received food pellets and WD subjects received water) and 2) the similarity of these odor cues between deprivation states when both the within-day running sequence (FXD and RND) and deprivation state (FD and WD) were manipulated within and between groups. During all three phases either the WD or the FD condition was held constant across all subjects while the FXD and RND running order conditions differed among groups.

During Phase 1 the WD condition was held constant across all subjects. The FXD running-order sequence was employed for Groups F-F-F and F-R-R while the RND running-order sequence was employed for Group R-F-F. As the specific RND/WD conditions employed for Group R-F-F are identical to those employed for Group WD during Phase 1 of Experiment 3, it might be predicted that Group R-F-F will replicate those results and fail to establish patterned responding during Phase 1 of the present experiment.

In view of the Davis et al. (1982) study and the results of Phase 2 in Experiment 3 which indicate that WD subjects (receiving a 32% sucrose-water and plain water reinforcer, respectively) tested under the FXD

condition develop patterned responding around Day 7, it might be predicted that both Groups F-F-F and F-R-R will display patterned responding during Phase 1 when tested under the same FXD/WD conditions. However, in making comparisons among these groups, it should be pointed out that the conditions employed in the previous studies and those employed in the present experiment are not strict replications. In particular, three discrepancies appear to exist: 1) Groups F-F-F and F-R-R consist of only six subjects each; the two forementioned studies employed seven subjects within their respective groups, 2) those subjects displaying patterned responding in Phase 2 of Experiment 3 had previously experienced, albeit under the RND condition, 14 days of Phase 1 training, and 3) Davis et al. (1982) utilized a 32% sucrose-water reinforcer whereas the present experiment utilizes a plain water reinforcer. In view of these inconsistancies and the contention that odors exuded by WD subjects receiving a plain water reinforcer may be somewhat less salient than odors exuded by FD subjects receiving a food reinforcer (see Experiment 3, Phase 1), it could also be predicted that Groups F-F-F and F-R-R will fail to establish patterned responding during Phase 1. In other words, if odors exuded by WD subjects are somewhat less substantial, then it might be argued that those groups displaying patterned responding in the previous studies were enabled to do so on the basis

of: 1) greater odor accumulation resulting from the use of seven subjects, 2) previous runway training, or 3) the use of a 32% sucrose-water reinforcer. However, a closer examination of these inconsistencies suggests that only the size of group employed may be germane to the present phase of this experiment. First, even though the WD subjects in Experiment 3 had experienced 14 days of Phase 1 training under the RND condition, patterned responding was still not displayed until Day 7 of Phase 2. If, in fact, some learning about the predictive value of R and N odor cues was taking place during this previous runway training, patterned responding would have been expected to occur earlier under the FXD condition of Phase 2. As this was not the case, it might be argued that odors exuded by WD subjects are less salient and can be overshadowed by individual animal odors which in turn precludes any learning about R and N odor cues. Hence, these subjects were probably enabled to establish patterned responding on the basis of greater odor accumulation resulting from the use of seven subjects rather than the previous runway training they experienced. Secondly, the Davis et al. (1982) study further demonstrated that nondifferential responding was displayed when subjects received a DA schedule of 32% sucrose-water and plain water. These results suggest that both types of reward are equally reinforcing and that the use of a plain water reinforcer in the present experiment should

not hinder the development of patterned responding. That Group WD in Phase 2 of Experiment 3 also developed patterned responding when receiving a plain water reinforcer is further indicative of this contention. Thus, if groups F-F-F and F-R-R fail to establish patterned responding during Phase 1 of the present study it feasibly can be attributed to: 1) that odors exuded by WD subjects receiving a water reinforcer are less salient, 2) that six subjects simply does not allow sufficient accumulation of these odors for patterned responding to be established, or 3) a combination of these two factors.

During Phase 2 the FD condition was held constant across all subjects. The FXD running-order sequence was employed for Groups F-F-F and R-F-F while the RND running-order sequence was employed for Group F-R-R. If Groups F-F-F and F-R-R develop patterned responding during Phase 1 under the FXD/WD conditions, then discriminative responding might be expected to continue without disruption when shifted to the FXD and RND conditions respectively, during Phase 2. These results would be expected only if odors exuded under the different deprivation state conditions are similar. If, in fact, both FD and WD subjects are able to maintain patterned responding when shifted from the FXD to the RND condition (see Experiment 3, Phase 3), then the RND condition imposed upon Group F-R-R should have no disruptive effect. On the other hand, if odors exuded under different deprivation states are somewhat

dissimilar, then some disruption in patterned responding would be expected to occur for both groups before subjects utilize the specific R and N odors exuded under the FD condition as discriminative cues.

Regardless of whether or not patterned responding is established by Groups F-F-F and F-R-R during Phase 1, all three groups would be expected to display patterning at some time during Phase 2. In particular, as Phase 2 employes the FXD/FD conditions for both Groups F-F-F and R-F-F, these subjects might be expected to establish patterned responding around Day 7 as suggested by previous studies utilizing similar conditions (see Davis & Prytula, 1979; Ludvigson & Sytsma, 1967; Prytula et al., 1982). Likewise, as the results of Experiment 3 suggest that naive FD subjects (receiving a food reinforcer) tested under the RND condition eventually develop patterned responding on Day 12, it might be predicted that Group F-R-R will also display patterned responding when tested under these same conditions during Phase 2. Recall that this group was not expected to develop patterned responding under the RND/WD conditions employed in Phase 1.

During Phase 3, the WD condition was reinstated and held constant across all subjects. Additionally, the running order conditions employed for each group during Phase 2 remained in effect during Phase 3. As all three groups should develop patterned responding during Phase 2, Phase 3 will allow a more direct evaluation concerning

the similarity of odor cues exuded under the different deprivation state conditions. Specifically, the running order for each group is held constant from Phase 2 to Phase 3. Hence, it would appear somewhat plausible to suggest that any extended disruption in patterned responding during Phase 3 would be due to the shift in deprivation state.

Method

Subjects. Eighteen, 110-day-old, naive, male Holtzman rats were randomly distributed across three groups (n = 6): F-F-F, F-R-R, and R-F-F. One week prior to pretraining all animals were placed on a 23-hr water deprivation regimen with food available on a free-feeding basis. This schedule remained in effect until the end of Phase 1 training. Two days prior to Phase 2 testing all subjects were shifted to a food-deprivation regimen that maintained them at 85% of their free-feeding body weight. Water was now available on an *ad libitum* basis. At the end of Phase 2 and 2 days prior to Phase 3 training, all subjects were returned to the water-deprivation schedule employed during Phase 1 training. Hence, a one-day interim existed between Phases 1 and 2 and Phases 2 and 3. On all days of experimental testing all animals received their respective feeding regimen following the daily experimental session.

Apparatus. As all groups received a water reinforcer during Phases 1 and 3 and a food reinforcer during Phase 2,

the apparatus utilized in Experiment 3 was again employed during Experiment 4.

Procedure. A one-week pretraining phase immediately preceded Phase 1 of experimental testing. On all days of pretraining, animals were handled and tamed and administered their regular daily access to water in the home cage. On Days 6 and 7 each subject received a 5-min exploration period in a baited (water bottle present) apparatus with all photoelectric equipment operative. During the one-day interim between Phases 1 and 2, the subjects were shifted from water deprivation to food-deprivation and habituated to the 45-mg Noyes reward pellets in the home cage. The one-day interim separating Phases 2 and 3 simply consisted of shifting all animals back to the Phase 1 water-deprivation condition.

During Phase 1 (13 days, 104 trials) the order for running subjects within Group R-F-F was randomized daily (please refer to Table 3). Subjects within Groups F-F-F and F-R-R were run in a fixed order on all days.

During Phase 2 (17 days, 136 trials) the running order for subjects in Groups F-F-F remained constant while Groups R-F-F and F-R-R were shifted to the opposite running-order condition. Thus, the order for running subjects within Group F-R-R was randomized daily while subjects within Group R-F-F were run in a fixed order. Group R-F-F subjects were run in the order which was in effect on the last day of Phase 1.

During Phase 3 (8 days, 64 trials) all groups were tested under the same running-order conditions employed in Phase 2. Throughout Experiment 4 testing, the order for running groups was randomized daily.

In all three phases, trial administration and runway cleaning procedures were the same as those employed in the previous experiments. During Phases 1 and 3 an R event consisted of 30-sec access to a full water bottle. An N event consisted of 30-sec confinement in the goalbox with an empty water bottle in place. During Phase 2, 12, 45-mg Noyes pellets were present on R trials. Subjects were removed upon consumption of the pellets or after 30-sec. On N trials animals received 30-sec confinement to an empty goalbox.

Results and Discussion

Visual inspection of Figure 9 indicates that during Phase 1, when tested under the WD condition, all groups displayed nondifferential responding. An analysis of variance of the last 5 days of Phase 1 failed to yield any significant effects. (See figure 9 on following page.)

In contrast, switching subjects to the FD condition during Phase 2 resulted in the development of patterned responding by all groups at approximately Day 12. An analysis of variance performed on the goal-measure speed scores from the last seven days of Phase 2 (the point at which appropriate patterned responding appeared to have been developed by all groups) yielded significance only

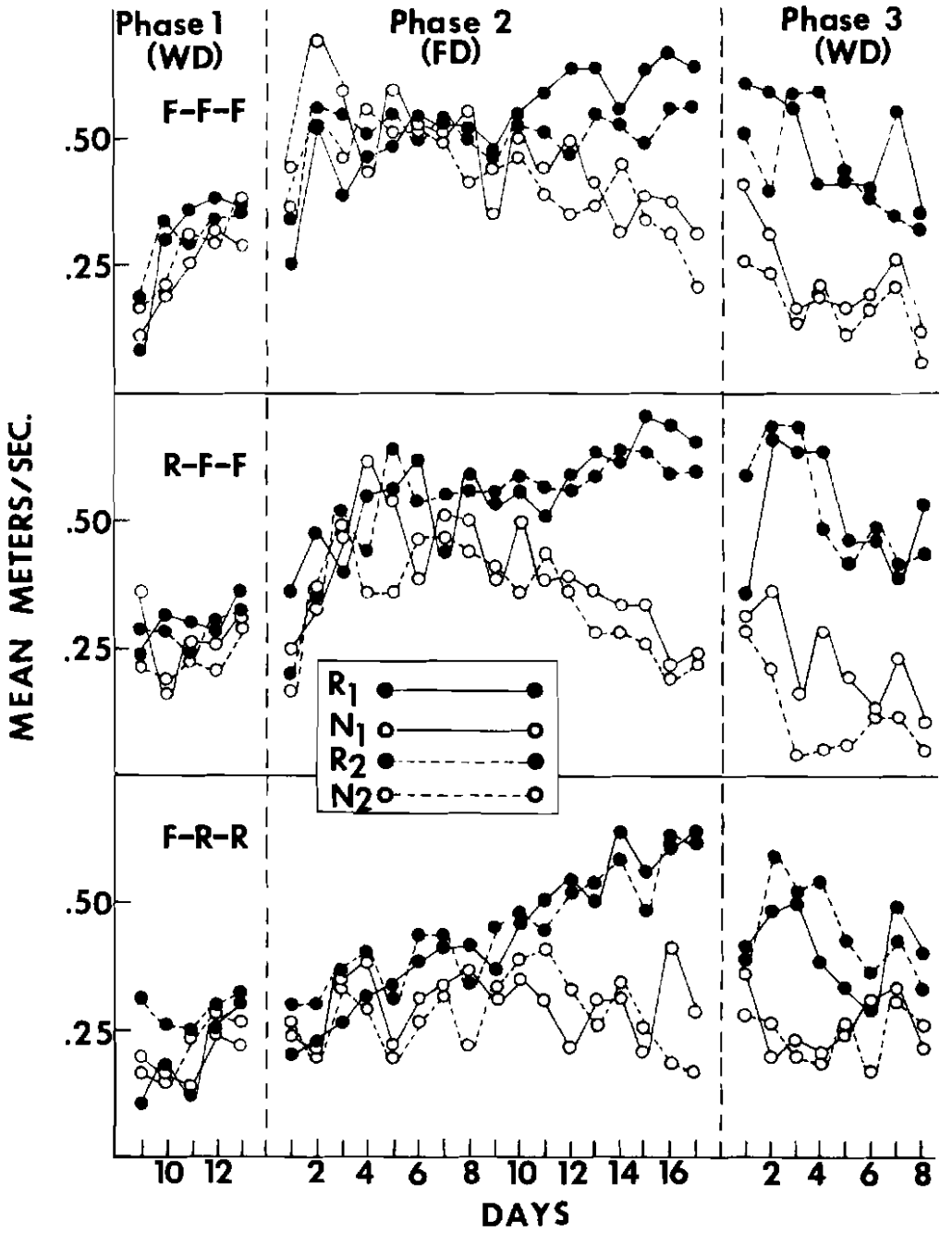

Figure 9 - Mean Goal Speeds for Groups F-F-F, R-F-F, and F-R-R During Phases 1, 2, and 3 of Experiment 4.

for the R vs N factor, $F(1,15) = 11.46$, $p < .01$. This finding corroborates the graphical impression (see Figure 9) that appropriate responding had been established by all groups under the FD condition of Phase 2. It should be further noted that the same pattern of results occurred for all groups, regardless of the running-order sequence, during Phases 1 and 2.

Although reinstating the WD condition in Phase 3 resulted in a slight disruption on Day 1, patterned responding was reestablished by all groups on Day 2. As can be seen in Figure 9, this patterning continued for Groups F-F-F and R-F-F (FXD condition), but underwent further disruption by Group F-R-R (RND condition) on Days 6-8. An analysis of variance of the Phase 3 speed data yielded significance for the R vs N, $F(1,15) = 6.36$, $p < .05$, and Groups by R/N by Days, $F(14,105) = 2.13$, $p < .05$ factors. Newman-Keuls tests indicated that R speeds were significantly ($p < .05$) faster than N speeds on all days of Phase 3 for Groups F-F-F and R-F-F. On the other hand, R speeds were significantly ($p < .05$) faster than N speeds for Group F-R-R only on Days 2-4 of Phase 2 (i.e., nonsignificant differences were shown on Days 1, 5, 6, 7, and 8).

As noted, the nondifferential responding displayed by Group R-F-F throughout Phase 1 was somewhat expected. Recall that Group WD in Phase 1 of Experiment 3 also failed to establish patterned responding when tested

under similar RND/WD conditions. That Group R-F-F replicated these results lends further support to the contention that odors exuded by WD subjects receiving a water reinforcer are less salient than odors exuded by FD subjects receiving a food reinforcer (see Experiment 3, Phase 1). This contention gains additional support from the performance displayed by Groups F-F-F and F-R-R when tested under the FXD/WD conditions employed during Phase 1. In complete contrast to the data reported by Davis et al. (1982) and Phase 2 of Experiment 3, neither of these groups developed DA responding. Hence, it appears that odors exuded by WD subjects are less salient and further, that six subjects does not allow sufficient accumulation of odors for patterned responding to occur even under the FXD condition.

During Phase 2, when tested under the RND/FD conditions, patterned responding was established by Group F-R-R on Day 12. These results are certainly in accord with those of Phase 1 in Experiment 3 which indicate that naive subjects tested under similar conditions develop patterned responding on Day 12. Additionally, patterned responding was also established by Groups F-F-F (Day 13) and R-F-F (Day 12) when tested under the FXD/FD conditions. Although this patterning is in accord with previous studies utilizing similar conditions (see Davis & Prytula, 1979; Ludvigson & Sytsma, 1967; Prytula et al., 1982), these results are not

strict replications. More specifically, the previous studies utilized seven subjects and reported patterned responding on Day 7, whereas Phase 2 patterning was not evident in the present experiment until approximately Day 12. These particular results suggest that the use of six animals per group may have significantly reduced the extent to which odors accumulate in the goalbox resulting in the retarded development of patterning.

The results of Phase 3 indicate that all three groups displayed some disruption on Day 1 when the WD condition was reinstated. Recall that this was the only change imposed upon all groups; the running order condition remained unchanged between Phases 2 and 3. As patterned responding had been reestablished by all three groups on Day 2 of Phase 3, this disruption could most likely be attributed to the one-day interim that existed between Phases 2 and 3. Despite the disruptions noted, the data are in accord with the Phase 2-Phase 3 shift results of Experiment 3 and the previous drug study (Davis et al., 1981), in suggesting that once patterning is established, it is relatively resistant to a variety of experimental manipulations.

That FD subjects developed patterning, albeit retarded (Phase 2), and WD subjects did not (Phase 1), appears to suggest that less intense odors were exuded by the WD subjects. Further indicative of such a contention are the relatively slower speed scores displayed by the WD

group in Phase 1 and the diminution of speed scores when the WD condition was reinstated in Phase 3. In light of this interpretation, it is quite possible that the use of only six subjects resulted in even less intense odor accumulation which in turn resulted in the lack of patterning displayed under the FXD running order condition during Phase 1 (Groups F-F-F and F-R-R). Further, the disruption on Days 6-8 of Phase 3 by Group F-R-R, when shifted to the WD state condition but still run in a RND sequence, suggests that odors may be less intense allowing natural animal odors to compete with the R and N odors once again. However, the use of six subjects should again be emphasized.

CHAPTER 6

GENERAL DISCUSSION

To reiterate, the present studies were designed to further investigate the contention of strict motivational specificity of conspecific odor cues. In conducting this particular research endeavor, several further parameters were addressed which may interact with and/or influence the utilization of R and N odors for both FD and WD animals. As a number of independent variables were manipulated simutaneously throughout Experiments 1-4, certain specifics of the overall data will now be integrated, contrasted, and/or compared in an effort to elucidate these specific parameters and their potential effect(s) on the discriminative use of odor cues.

Taken collectively, the present studies seriously question the conception of strict motivational specificity with regard to the signal value of odor cues. For example, when all subjects received a sucrose-water reward, it was clearly demonstrated that a small subgroup of rats trained under one deprivation state developed patterning when immediately following a small subgroup trained under a different deprivation state (Experiment 1, Phase 1). As patterning is typically not shown in such a small squad, it is proposed that odors from the first subgroup accumulated and were subsequently utilized by animals in in the second, motivationally different, subgroup. This

contention is further supported by the fact that the first small subgroups failed to establish patterned responding but the first animal in each of the second subgroups did display appropriate patterning. Further, when the last subject in each of the second subgroups was rotated to the first position in his respective subgroup (Experiment 1, Phase 2), patterning was maintained by these rotated subjects indicating that they were capable of using odors from the motivationally different animals that now preceded them. Similar results were obtained when all subjects received a sucrose-milk reward and the squad size was as small as two animals (Experiment 2, Phase 2). That subjects receiving the more traditional reinforcers (i.e., FD subjects received food pellets and WD subjects received water) displayed minimal disruption when shifted from the FD to the WD condition (Experiment 4, Phase 3), strongly suggests that a common reinforcer is not a necessary factor for odors to be effectively utilized across deprivation states.

Although patterned responding was maintained by each of the forementioned rotated subjects (Experiment 1, Phase 2), some disruption in the overall patterning of subgroups resulted from fluctuations in the performance of animals that followed the rotated subjects. These results suggest that individual, natural animal odors may play some role in the runway behavior of the rat. Referring back to the Prytula et al. (1981) data, the lack of disruption displayed

by each of the rotated animals might be explained by the fact that those subjects in the last position (Position 8) had the strongest odor cues from which to establish patterning. In view of this interpretation, R and N odors from preceding rats, regardless of individual, natural animal odors, were more salient for this subject. In other words, those animals experiencing the strongest odor cues become sensitized to the R and N odors, thus allowing them to potentially disregard natural animal odors. In contrast, subjects run in the initial squad positions (Positions 5, 6, and 7) would not experience adequate accumulation of R and N odors to result in sensitization. In this case, the R and N odors may be more easily masked or confounded by any novel, individual, natural animal odor(s). However, as the initial subjects of a subgroup are advanced to the terminal position prior to rotation, they experience adequate accumulation of odor cues, becoming sensitized, resulting in a lack of disruption when actually rotated.

Further indicative of the contention that natural animal odors may serve to obscure R and N odors is the fact that <u>both</u> FD and WD subjects receiving a sucrose-milk reward failed to develop patterned responding when tested under the RND running sequence (Experiment 2, Phase 1). In short, it is proposed that subjects experiencing runway training in a FXD sequence are confronted with a fixed accumulation of natural animal

odors. Thus, the accumulation of these odors remains constant (i.e., predictable) on all trials allowing R and N odors to become more salient and utilized earlier in training. Conversely, subjects tested in an RND sequence are confronted with a novel accumulation of natural animal odors on each day of runway training, potentially causing R and N odor cues to remain less salient for a prolonged period of time. As was noted, when subjects were given extended RND training, FD animals developed appropriate patterned responding (Experiment 3, Phase 1). Although FD subjects established such patterned responding when receiving food pellets (Experiment 3, Phase 1) as opposed to sucrose-milk (Experiment 2, Phase 1), it whould be emphasized that this was under extended RND training. Hence, it appears that it is not the reinforcer employed, but the extended training that enables these FD subjects to establish patterning.

The fact that FD subjects did eventually display patterned responding when tested under the RND sequence and WD subjects failed to establish such patterning under both the RND (Experiments 3 and 4, Phase 1) and the FXD sequences (Experiment 4, Phase 1) supports the third contention resulting from the present research. Namely, that odors exuded by WD subjects are less intense and/or salient than those exuded by FD subjects. Further indicative of this contention are the relatively overall

slower speed scores displayed by WD subjects (Experiment 3, Phases 1 and 2; and Experiment 4, Phase 1) and the diminution of speed scores when the running order remains unchanged and the deprivation state is shifted from FD to WD (Experiment 4, Phase 3). In contrast, when the deprivation state is held constant and the running order sequence is shifted from FXD to RND (Experiment 3, Phase 3), patterned responding appears to be enhanced (i.e., faster to R and slower to N). However, as this particular phase lasted only 2 days, no concrete interpretations concerning this possible enhancement can be made. In particular, the increment and decrement in speed scores was evident for both FD and WD groups and could be due solely to the shift in running sequence. If this phase had been extended, it is quite possible patterning would have returned to the previous Phase 1 level of patterning for both groups.

Although the odor-intensity interpretation is plausible in light of the previously stated data, the fact remains that WD subjects did establish patterned responding when tested under the FXD sequence of Phase 2 in Experiment 3. Consequently, it should be emphasized that two procedural differences existed in obtaining the present results (Experiment 3, Phase 2) and those previously mentioned (Experiment 4, Phase 1). Specifically, the subjects in Experiment 3 (Phase 2) had experienced, albeit under the RND condition, 14 days of previous runway

training. Secondly, this group consisted of seven subjects whereas the groups in Experiment 4 consisted of only six. In view of these discrepancies, the most feasible explanation involves the use of only six subjects in conjunction with the apparently less intense water-related odor cues. It would appear that those WD groups consisting of seven subjects and tested in the RND sequence may not be able to completely discriminate among R, N, and natural animal odors when utilizing the less intense water-related odor cues (Experiment 3, Phase 1). However, with the use of seven subjects, shifting to the FXD sequence (Experiment 3, Phase 2) allows even the less intense water-related odor cues to become more discriminable with the result being the establishment of patterned responding. Recall also that patterned responding was established when a squad of eight WD subjects are tested in a FXD sequence and receive a sucrose-water reinforcer (Experiment 1, Phase 3). Of potentially greater interest is the fact that WD subjects receiving a sucrose-milk reward displayed patterned responding within only four days of FXD training (Experiment 2, Phase 2) after nondifferential responding was displayed under the previous RND training (Experiment 2, Phase 1). The rapidity of this patterning suggests that, with the use of seven subjects, the RND procedure does not preclude odor production and that some learning about the predictive value of R and N odor cues may occur. On

the other hand, when only six subjects are employed, the less intense water-related odor cues appear to result in an inadequate accumulation of odors and no learning and/or learning that odors are irrelevant stimuli takes place during prior runway training under both the RND and FXD sequence (Experiment 4, Phase 1). Hence, when shifted to the FD condition, regardless of the running sequence employed (Experiment 4, Phase 2), a blocking effect appears to be present, resulting in the retardation of the development of patterned responding. If animals are allowed to develop patterned responding utilizing the more salient FD cues, they can maintain such patterning (with a slight disruption) even when shifted to the WD condition and are utilizing the less substantial WD odor cues (Experiment 4, Phases 2 and 3). However, it should be noted that this occurs only for those subjects tested under the FXD condition and not the RND condition. The fact that disruption reoccurs for those WD subjects tested under the RND condition is further indicative of the contention that water-related odor cues are less salient allowing R and N odors to once again compete with or become obscured by natural animal odors -- especially with the use of six subjects.

With regard to the somewhat discrepant results obtained between the present studies and those supporting motivational specificity, the most plausible explanation

would be based upon procedural differences. In particular, the present studies demonstrated commonality of odor cues across deprivation states by employing independent groups of test animals. Conversely, the odor-donor technique was employed in the studies demonstrating motivational specificity. This is not to say that odors exuded under different deprivation states do not differ in some respect. Obviously, it has been demonstrated numerous times that FD run-subjects do not utilize odor cues exuded by WD startbox-placed odor-donors, and vice versa. However, strict motivational specificity of the signal value of odor cues does not appear to be tenable. Although no clear cut interpretations can be proposed, it would appear that odors exuded under different deprivation states are dissimilar, yet contain some "common element(s)" that can be effectively utilized under certain circumstances. For example, it appears that previous runway training somehow facilitates the use of odors exuded under different states. Recall that Eslinger and Travis-Neideffer (Note 2) demonstrated the development of patterned responding in all segments of the runway when utilizing the odor-donor technique; but only after the run subjects were previously trained with odor-donors experiencing the same deprivation state condition. Further indicative of the previous runway contention are the results of Experiment 2 in the present research. When run as separate squads, both FD and WD subjects failed to develop patterned responding

under the RND condition. However, when assigned to smaller squads consisting of FD and WD subgroups (Phase 2), patterned responding was readily developed under the FXD condition.

A second procedure which apparently facilitates the use of different deprivation state odor cues is that of allowing both FD and WD subjects to traverse the runway. As was seen in the present research (Experiment 1, Phase 1), appropriate DA responding was established in the goal area by running two groups of runway naive subjects experiencing different deprivation states as a single squad.

Undoubtedly, there are a myriad of unanswered questions with regard to the production and utilization of odor cues. However, it is clear that research in the area of odor control of animal maze performance has gone far beyond the simple conceptualization of there being <u>just</u> reward and nonreward odor cues. We must now contend with considerations of the daily within-group running sequence, the influence of natural animal odors, deprivation state employed, the effects of previous runway training, and the specific type of reinforcer employed, to name just a few parameters -- let alone their possible interactions.

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APPENDIX: TABLE 3

TABLE 3

Experimental Design - Experiment 1

Phase 1 - All subjects received daily double-alternation (RRNNRRNN) training in the straight runway for 18 days (144 trials).

SQUAD 1			SQUAD 2		
Subgroup A	S 1	FD	Subgroup A	S 1	WD
	2	FD		2	WD
	3	FD		3	WD
	4	FD		4	WD
Subgroup B	S 5	WD	Subgroup B	S 5	FD
	6	WD		6	FD
	7	WD		7	FD
	8	WD		8	FD

- Each squad received all daily trials before the next squad received its daily session.
- Trial 1 was administered to all subjects within a squad before Trial 2 was administered, etc. The apparatus was swabbed and aired after the completion of each trial for all animals in a squad.
- The order for running squads alternated daily.
- Subgroup A always preceded Subgroup B. Within each squad the subjects were run in a fixed (1-8) order on each day.
- An R event consisted of 30-sec access to a 32% sucrose-water solution.
- An N event consisted of 30-sec confinement to an empty goalbox.

Phase 2 - All subjects received daily double-alternation training in the straight runway for 3 days (24 trials).

SQUAD 1			SQUAD 2		
Subgroup A	S 1	FD	Subgroup A	S 1	WD
	2	FD		2	WD
	3	FD		3	WD
	4	FD		4	WD

- Subjects within the A subgroups were run in a fixed (1-4) order on all days of Phase 2.
- On each day of Phase 2 the last subject (Position 8) within each B subgroup was rotated to the first position (Position 5) within his respective subgroup.

Day 1

SQUAD 1			SQUAD 2		
Subgroup B	S 8	WD	Subgroup B	S 8	FD
	5	WD		5	FD
	6	WD		6	FD
	7	WD		7	FD

TABLE 3 (con't.)

Experimental Design - Experiment 1 (con't.)

Phase 2 - (con't.)

Day 2

SQUAD 1			SQUAD 2		
Subgroup B	S 7	WD	Subgroup B	S 7	FD
	8	WD		8	FD
	5	WD		5	FD
	6	WD		6	FD

Day 3

SQUAD 1			SQUAD 2		
Subgroup B	S 6	WD	Subgroup B	S 6	FD
	7	WD		7	FD
	8	WD		8	FD
	5	WD		5	FD

- Trial administration procedures, R and N events, and order for running subgroups and squads were the same as those employed in Phase 1.

Phase 3 - All subjects received daily double-alternation training in the straight runway for 3 days (24 trials).

SQUAD 1			SQUAD 2		
Subgroup B	S 6	FD	Subgroup B	S 6	WD
	7	FD		7	WD
	8	FD		8	WD
	5	FD		5	WD
Subgroup A	S 1	FD	Subgroup A	S 1	WD
	2	FD		2	WD
	3	FD		3	WD
	4	FD		4	WD

- Subgroup B always preceded Subgroup A. Within each squad the subjects were run in a fixed (6-7-8-5-1-2-3-4) order on each day.
- Trial administration procedures, R and N events, and order for running squads were the same as those employed in Phases 1 and 2.

Experimental Design - Experiment 2

Phase 1 - All subjects received daily double-alternation training in the straight runway for 12 days (96 trials).

Group WD1: Ss 1-7
Group WD2: Ss 8-14
Group FD1: Ss 15-21
Group FD2: Ss 22-28

TABLE 3 (con't.)

Experimental Design - Experiment 2 (con't.)

Phase 2 - All subjects received daily double-alternation training in the straight runway for 4 days (32 trials).

SQUAD 1 - (n = 2)			SQUAD 2 - (n = 2)		
Subgroup A	S	1 WD	Subgroup A	S	1 FD
Subgroup B	S	1 FD	Subgroup B	S	1 WD
SQUAD 3 - (n = 4)			**SQUAD 4 - (n = 4)**		
Subgroup A	S	1 WD	Subgroup A	S	1 FD
		2 WD			2 FD
Subgroup B	S	1 FD	Subgroup B	S	1 WD
		2 FD			2 WD
SQUAD 5 - (n = 6)			**SQUAD 6 - (n = 6)**		
Subgroup A	S	1 WD	Subgroup A	S	1 FD
		2 WD			2 FD
		3 WD			3 FD
Subgroup B	S	1 FD	Subgroup B	S	1 WD
		2 FD			2 WD
		3 FD			3 WD

- Each group (Phase 1) or squad (Phase 2) received all daily trials before the next group/squad was run.
- Trial 1 was administered to all subjects within a group or squad before Trial 2 was administered, etc. The apparatus was swabbed and aired after the completion of each trial for all animals in a group or squad.
- The order for running groups/squads was randomized daily.
- During Phase 2 Subgroup A always preceded Subgroup B. Within each subgroup the subjects were run in the same fixed sequence on all days. (Note: the fixed sequence was also employed during Phase 1.)
- An R event consisted of 1 ml of a 32% sucrose-milk solution.
- An N event consisted of 30-sec confinement to the empty goalbox.

Experimental Design - Experiment 3

	Phase 1	Phase 2	Phase 3
Group WD (n = 7)	WD/RND	WD/FXD	WD/RND
Group FD (n = 7)	FD/RND	FD/FXD	FD/RND

TABLE 3 (con't.)

Experimental Design - Experiment 3 (con't.)

- All subjects received daily double-alternation training in the straight runway for 14 days (112 trials) during Phase 1, 8 days (64 trials) during Phase 2, and 2 days (16 trials) during Phase 3.
- Each group received all daily trials before the next group received its daily session.
- Trial 1 was administered to all subjects within a group before Trial 2 was administered, etc. The apparatus was swabbed and aired after the completion of each trial for all animals in a group.
- An R event for Group WD consisted of 30-sec access to plain tap water while an R event for Group FD consisted of 12, 45-mg Noyes pellets.
- An N event for both groups consisted of 30-sec confinement to the empty goalbox.

Experimental Design - Experiment 4

	Phase 1	Phase 2	Phase 3
Group F-F-F (n = 6)	WD/FXD	FD/FXD	WD/FXD
Group R-F-F (n = 6)	WD/RND	FD/FXD	WD/FXD
Group F-R-R (n = 6)	WD/FXD	FD/RND	WD/RND

- All subjects received daily double-alternation training in the straight runway for 13 days (104 trials) during Phase 1, 17 days (136 trials) during Phase 2, and 8 days (64 trials) during Phase 3.
- Trial administration and cleaning procedures were the same as those employed in Experiment 3.
- The order for running groups was cyclic over a three-day period.
- During Phases 1 and 3 (WD) an R event consisted of 15-sec access to plain tap water. During Phase 2 (FD) an R event consisted of 12, 45-mg Noyes pellets.
- An N event consisted of 15-sec confinement to the empty goalbox.