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CHANGES IN INSTRUMENTAL RESPONSE SPEED FOLLOWING REWARDED ENDBOX PLACEMENT

by

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Chapter 1

Historical Background

In the development of the major theories of learning a clear distinction between "expectancy" theorists and "S-R" theorists is visible. The basis of this distinction is in the answer to the question of what is learned, the former group proposing that the organism learns the positions of stimuli in the external environment or "expectancies," and the latter group proposing that the organism learns responses to specific stimuli. Both positions arrive at the same prediction in the typical experimental paradigm, that if a response is terminated with reward then the response is increased in vigor or probability of occurrence. For this reason experiments were devised to distinguish between the two theories, experiments in which it was thought that the theories arrived at different predictions. The general class of these experiments is called Latent Learning.

The characteristic of a latent learning experiment is that Ss perform a response first under low or irrelevant motivational conditions or low or irrelevant incentive conditions. In a subsequent stage relevant motivational or incentive conditions are instated and the performance of the response is compared to the previous performance, or to the performance of other Ss without the preliminary training. Latent learning is demonstrated if the subsequent performance is elevated with respect to the previous performance or to the performance of the control group.

A separate question of the necessity of reinforcement for learning became almost inextricably confounded with that of what is learned.

Logically there is no reason that these two should not be orthogonal, yet historically the necessity of reinforcement to learning has been imputed to the S-R theorist whereas the expectancy theorist has conceived that contiguity is sufficient for learning. For this reason the typical latent learning experiment involves at least part of one question while the primary focus might be on the other. A brief discussion of two varieties of latent learning experiments will demonstrate this, and also indicate the effect of the experiments upon more recent theorizing. The following set of experiments is a selection from Thistlethwaite (1951), and MacCorquodale and Meehl (1954).

In one design satiated Ss receive trials in a T maze which has food on one side and water on the other. The Ss are subsequently reprived of either food or water and given a test trial in the T maze. Latent learning is demonstrated if the animals approach the relative incentive on the test trial. Of nine experiments, seven are positive, and two are negative.

In a second design Ss receive non-rewarded trials in a T maze in which the endboxes are highly distinctive. The S is then fed in one of the endboxes and given a test trial. Latent learning is demonstrated if S approaches the endbox in which it was prefed. Of seven studies of this type four are positive, three are negative.

In both of these designs the emphasis is upon the organism's learning the locus of stimuli within the maze, in the first case the locus of the non-relevant incentive, in the second the locus of the discriminable endboxes. Neither design permits an unequivocal statement that latent learning either does or does not exist. Clearly the failures to demonstrate the phenomenon are as embarrassing to the expectancy theorist

as the demonstrations are to the traditional S-R theorist. Perhaps because of this mutual embarrassment attention has shifted from the simple demonstration of latent learning to an investigation of the conditions which are favorable to its occurrence. There is no doubt that under some conditions latent learning will occur.

These results have had an effect upon theorists of both inclinations, although these effects are perhaps most profound for the S-R theorist. First, it would seem that the question of the necessity of reinforcement for learning has been abandoned. This is because the ingenious theorist who wishes to maintain that reinforcement is necessary can always point to some source of stimulation in every experiment that is potentially reinforcing. The question is perhaps experimentally meaningless because apparently a situation cannot be devised that does not contain some such stimulation. Second, these experiments have indicated the theoretical necessity of clearly distinguishing between learning constructs and performance constructs. The theory must be able to predict that under specified conditions learning can occur but will not be demonstrated in performance unless an adequate motivational state is also present. Within the S-R formulation this has required the formulation of mediating responses which have motivational properties.

The fractional antedating goal response and its interoceptive stimulus feedback, $\underline{r}_g - \underline{s}_g$, is basic to this formulation, providing both energisation and direction to behavior. When $\underline{S}$ eats, the consummatory response, R_g, occurs and a fraction of this response, which can occur in the absence of the consumed object, conditions to the stimuli present at the time of R_g. This fraction of the response is termed $\underline{r}_g$. Because the object and its visual or olfactory stimulation is always present at the

time of the consummatory response $\underline{r}_g$ will be conditioned to its visual or olfactory stimulation. Because $\underline{S}$ has eaten when hungry and has drunk when thirsty the $\underline{r}_g$ for food is more likely to occur when $\underline{S}$ is deprived of food, the $\underline{r}_g$ for water is more likely to occur when $\underline{S}$ is deprived of water. In the explication of maze behavior the most important characteristic of the $\underline{r}_g$ - $\underline{s}_g$ is its generalization from the stimuli present at the time of the consummatory response to stimuli which are present in the maze before the incentive is reached. In the T maze, therefore, eating or even the sight of food in the endbox will result in the generalization of the $\underline{r}_g$ - $\underline{s}_g$ for food to stimuli in the maze which are similar to the endbox stimuli.

This formulation can now be applied to the first latent learning design. In this design satiated $\underline{S}$s receive trials in a maze which contains food on one side and water on the other. When $\underline{S}$ turns towards one side the proprioceptive feedback from that response and the perseverative traces of stimuli in that arm of the maze are present at the time that $\underline{S}$ enters the endbox and perceives the food. An $\underline{r}_g$ - $\underline{s}_g$ for food is elicited by the food and conditions to these stimuli. Similarly, the proprioceptive feedback from the opposite response and the perseverative traces of stimuli on the other arm are conditioned to the $\underline{r}_g$ - $\underline{s}_g$ for water. On subsequent occasions the appropriate $\underline{r}_g$ - $\underline{s}_g$ is present at the time of each choice response, resulting in the conditioning of the response towards food to the $\underline{r}_g$ - $\underline{s}_g$ for food and of the response towards water to the $\underline{r}_g$ - $\underline{s}_g$ for water.

On a subsequent occasion the $\underline{S}$s are deprived of food or water and given a test trial. For the $\underline{S}$ deprived of food the $\underline{r}_g$ - $\underline{s}_g$ for food is more likely to occur and to this has been conditioned the response of

turning and approaching the food. For the S deprived of water the $r_g - s_g$ for water is more likely to occur and to this has been conditioned the response of turning and approaching the water. Therefore, the hungry S approaches the food and the thirsty S approaches the water.

In the second variety of latent learning experiment the S-R theorist proposes further mediating responses which are elicited by the distinctive endboxes, and which condition and generalize in much the same way as the $r_g - s_g$. However, there has not been any great acceptance of these other constructs, possibly because of the inconsistency of the results which suggests that the positive findings might be attributable to extraneous factors which as yet are not readily apparent.

Thus the major change in the S-R position is the increasing dominance of the mediating response, r_g. This concept has become central to the explanations of magnitude of reward studies, secondary reinforcement, discrimination learning, extinction, and many other phenomenon. The thesis problem explores some of the conditions under which r_g might be presumed to be a determiner of instrumental approach behavior. The primary purpose is to make explicit the role of r_g as it is employed in the explanation of approach behavior. In addition, because of the control and counterbalancing techniques, the design offers information which should be relevant to the expectancy formulation.

Chapter 2

Introduction to the Problem

The model for instrumental approach behavior proposed by Spence (1956) states that a hungry rat running through a straight-alley apparatus which has a terminal reward is performing two responses. One is the instrumental approach response, R_a, which occurs throughout the apparatus. The second is the consummatory response, R_g, which occurs only in the endbox upon receiving the food. A subset of the consummatory response, $\underline{r}_g$, can occur in the absence of food. This subset occurs initially in the presence of the endbox stimuli and is conditioned to them, the rules for this conditioning being those of classical Pavlovian conditioning.

The conditioned $\underline{r}_g$ can be generalized from the endbox stimuli to similar stimuli which are present in the apparatus before the endbox. Spence (1947) has pointed out three sets of stimuli which can provide a basis for this generalization. One set is the intramaze and extramaze stimuli present in the endbox. A second set is the stimulus feedback from the instrumental response R_a. A third set is the perseverative traces of stimuli which have impinged upon the organism before its entry into the endbox. The vigor of the generalized $\underline{r}_g$ depends first upon the vigor of the $\underline{r}_g$ conditioned to the endbox stimuli and second upon the similarity of these endbox stimuli to the stimuli which occur prior to the endbox.

In the straight-alley apparatus the dependent variable is R_g, the speed of the instrumental approach response. This is assumed to be dependent upon the strength of R_a and the vigor of the generalized $\underline{r}_g$. In

the typical experimental paradigm each R_a is followed by R_g, and an important question, both theoretically and empirically, is if this sequence of the two events is necessary to the increased speed of the instrumental response. Theoretically the question is whether this sequence is necessary for the generalized $\underline{r}_g$ to influence the speed of R_g.

One study directed at this question was reported by Stein (1957). Four groups of food-deprived rats received nine trials in a homogeneous black alley. One group (Group C:2) received 2 pellets in the endbox following each run. The other three groups were removed from the empty endbox and placed into the home cage. Subsequently, Group S:2 received nine placements into the black endbox which was baited with 2 pellets, and Group S:10 received nine placements into the black endbox baited with 10 pellets. Group D:2 received nine placements into a dissimilar white control box which was baited with 2 pellets. Group C:2 received nine placements into the home cage. All groups were then given a tenth run and it was found that Rs on this tenth trial could not be distinguished from that on the ninth trial.

A second study was reported by Swift and Wike (1958). Four groups of food deprived rats were given 10 minutes exploration of a homogeneous black straight-alley. Subsequently Groups I and II were given three black endbox feedings each day, 16 days for Group I and 3 days for Group II. Groups III and IV were given equivalent feedings in a white control box. All groups then received six food terminated trials in the black alleyway. The four groups did not differ in running speed.

In both of these designs the intent was to provide differential magnitudes of generalized $\underline{r}_g$ in the runway on the test trial. Stein hoped to accomplish this by manipulations of endbox-runway similarity and the

magnitude of the R_g. Swift and Wike manipulated endbox-runway similarity and the number of occurrences of R_g. In each case the predictions from the model were not confirmed.

This nonconfirmation implies that one of these three statements might be true:

1. The placements did not increase the magnitude of generalized $\underline{r}_g$.
2. The placements did increase the magnitude of generalized $\underline{r}_g$ but the simultaneous occurrence of R_a and $\underline{r}_g$ is not sufficient for $\underline{r}_g$ to influence the speed of R_a.
3. The placements did increase the magnitude of generalized $\underline{r}_g$ and the simultaneous occurrence of R_a and $\underline{r}_g$ is sufficient for $\underline{r}_g$ to influence the speed of R_a but more complex factors entered into the experiment which nullified the increase in R_a.

On the basis of additional observations both Stein and Swift and Wike concluded that the third statement was correct. It was presumed that while eating $\underline{S}$ made responses which interfere with the running response, and that these responses condition to the endbox stimuli. These responses then generalize to the stimuli of the runway and compete with R_a, thus obscuring the effect of the generalized $\underline{r}_g$. This conclusion has empirical support in the studies which have investigated the effects of delay in reinforcement upon running speed. These experiments suggest that responses made in the endbox before the reception of the reinforcement can generalize to the runway and interfere with the running response (Spence, 1956). In Stein's experiment, however, there was no delay between the placement into the endbox and the reception of the food. Furthermore, it would be necessary that the effect of the competing response be exactly enough in each case to cancel the effect of the differential

magnitudes of generalized $\underline{r}_g$. These considerations suggest that the other alternatives be further explored.

The first alternative is that the placements did not increase the magnitude of generalized $\underline{r}_g$. This suggests that the stimuli present in the endbox at the time of R_g and the stimuli present in the runway on the test trial were not sufficiently similar for any $\underline{r}_g$ to generalize. Two sets of stimuli can be isolated as being in the runway on the tenth run. One set is the stimulus feedback from the running response. These stimuli could not elicit $\underline{r}_g$ because they were not present at the time of R_g, $\underline{S}$ having been placed into the endbox. If these stimuli form a major portion of the stimulus complex present in the runway then very little $\underline{r}_g$ could occur unless running stimuli were present at the time of R_g. This suggests that it would be possible to demonstrate the increase in running speed only if the feedback stimuli from running were present at the time of the consummatory response.

A second set of stimuli present on the tenth run is the intramaze stimuli of the runway. In Stein's experiment it would seem that the runway stimuli should be highly similar to those of the endbox because the endbox was merely an extension of the runway, having the same dimensions and coloring. However, there is a possibility that $\underline{r}_g$ was conditioned to only a subset of these endbox stimuli, a subset that was quite dissimilar to the runway stimuli. The endbox had a glass foodcup at its far end. Stein reports that "$\underline{S}$ [was placed] in the loaded goal box with its head always oriented directly over the foodcup . . . after the first or second feeding all $\underline{S}$s consumed the pellets immediately on being placed into the goal box and appeared to emit no "gross" responses other than those involved in the consummatory act " (1957, p. 270). These conditions perhaps

prevent any reception of endbox stimuli other than those specific to the glass foodcup and the end wall of the apparatus. It is reasonable that very little $\underline{r}_g$ would generalize from these stimuli to those of the runway. If this analysis is correct it should be possible to demonstrate an increase in running speed if $\underline{S}$ received food not at the very end of the box but at its center, this making more probable the reception of endbox stimuli during the consummatory act.

The second alternative is that $\underline{r}_g$ did generalize to the runway but the simultaneous occurrence of $\underline{r}_g$ and R_a is not sufficient for $\underline{r}_g$ to influence the speed of R_a. The action of $\underline{r}_g$ has been presumed to be non-specific, $\underline{r}_g$ combining with and enhancing all response tendencies. This alternative suggests that $\underline{r}_g$ may be a specific energiser, combining with only a subset of response tendencies.

At least one response can be isolated with which $\underline{r}_g$ might combine specifically. It is possible that $\underline{r}_g$ will combine only with those responses whose stimuli elicit the $\underline{r}_g$. It would appear that this statement can not be experimentally distinguished from the statement that the feedback stimuli from the running response provide the major source of generalized $\underline{r}_g$. Both suggest that in order for the running response to be increased in vigor the stimulus feedback from running should be present at the time of the consummatory response.

Another possibility is provided by the development of the expectancy construct by MacCorquodale and Meehl (1954). In the Principle of Mnemonization (p. 237) it is stated that "The occurrence of the sequence S_1 - R_1 - S_2 (the adjacent members being in close temporal contiguity) results in an increment in the expectancy ($S_1R_1S_2$)". In the Principle of Inference (p. 242) it is stated that "The occurrence of the temporal contiguity

S_2S^* [for example, feeding the hungry animal in the presence of S_2] when $(S_1R_1S_2)$ has non-zero strength, produces an increment in the strength of a new expectancy $(S_1R_1S^*)$". The effect of this is to increase the reaction potential of the response R_1, which is demonstrated in an increased speed of R_1.

MacCorquodale and Meehl are not explicit about the compositions of S_1 and S_2 in the expectancy $(S_1R_1S_2)$. The addition of assumptions about this composition suggests that the increment will be easier to obtain if endbox and starting box are dissimilar. The complex S_1 includes the intramaze cues of the starting box and the proprioceptive stimuli attendent upon handling and placement into the box. The stimulus complex S_2 includes the intramaze cues of the endbox and the proprioceptive cues of the running response. However, when S is placed into the endbox the proprioceptive cues are characteristics of S_1, the cues of handling and placement. Therefore, if there are no differences between the intramaze cues of S_1 and S_2 the temporal contiguity S_1S^* has occurred. The theory proposed by MacCorquodale and Meehl makes no prediction about the effects of this contiguity upon the expectancy $(S_1R_1S_2)$. If this analysis is relevant it should not be as easy to obtain the increase in running speed in a homogeneous apparatus (as was employed by Stein) as it would be in an apparatus in which starting box and endbox were dissimilar.

A recent study by Seward, Jones and Summers (1960) is relevant to this analysis. Four groups of food-deprived rats were given nine non-rewarded runs in a heterogeneous apparatus, with starting box and runway painted black and an unpainted endbox. Group EF was given three feedings in the unpainted endbox, Group NF was given three feedings in a grey control box, and Groups EO and NO were each given three non-rewarded placements

into the appropriate box. On a subsequent test trial Group EF increased in speed.

It would appear that under some conditions running speed can be increased by preliminary feeding placements. However, the procedure described by Seward et al. did not eliminate the occurrence of the instrumental response either shortly before or at the time of the eating response. Therefore, this experiment does not provide a clearly unconfounded test of the necessary conditions for demonstrating the increase in running speed.

Chapter 3

Method

Experimental design

These introductory considerations have prompted a design in which manipulations are made in two dimensions: (1) the color of the endbox, and (2) the placement of S into the endbox. The experiment may be conceived in three stages: (1) the Ss are given nine non-food terminated runs through the apparatus. For one half of the Ss the endbox is black and for half the endbox is white. For all Ss starting box and runway are black. (2) The Ss are given nine placements into the food baited endbox. One-third are placed over the foodcup at the terminal end of the endbox (Groups BE and WE), and one-third are placed over the foodcup in the center of the endbox (Groups BC and WC). The remaining one-third are placed at the beginning of the endbox and the food is placed at the terminal end so that S must approach it (Groups BR and WR). (3) All Ss are given a tenth run through the apparatus.

Predictions

Under the hypothesis that the conditioning of r_g to endbox stimuli and subsequent generalization of r_g to the runway is sufficient to obtain the increase in running speed in the runway the major comparison is between Group BC and Group WC. Because the black runway is more similar to the black endbox than the white endbox, runway running speed on Trial 10 relative to Trial 9 should be greater for Group BC than for Group WC. This comparison is again emphasized because it reveals a clear differential prediction between this hypothesis and the hypothesis based on the

extension of expectancy theory. The latter predicts that Group WC should show the greater difference.

Two other comparisons are also important but because they both involve Group BC they are not independent of the first. One is that Group BC should demonstrate an increase in running speed from Trial 9 to Trial 10. The second follows because Group BE is a control-replication of Group S:2 in the experiment of Stein, and to this extent no difference between Trials 9 and 10 is to be expected. The efficacy of the center placement over end placement could be assessed by a comparison of the Trial 9 to Trial 10 differences between Group BC and Group BE.

The same arguments which give rise to the predictions about Groups BC and WC lead to the same predictions for Groups BR and WR. The r_g generalization hypothesis predicts that Group BR should demonstrate a greater relative increase than Group WR, and the extension of expectancy theory predicts the reverse. Under a third hypothesis, which is that the stimuli from the running response should be present at the time of the consummatory response in order to obtain an increase, only Groups BR and WR should demonstrate an increase on Trial 10.

Subjects

The Ss were 60 male hooded rats, approximately 100 days old. Thirty were obtained from Rockland Farms, New City, New York; 10 from the Windsor Biology Gardens, Bloomington, Indiana; 20 from the laboratory maintained by the Psychology Department of the University of Michigan. Rats from each source were distributed as evenly as possible in each group. Apart from this restriction Ss were randomly assigned to groups as they were received.

Apparatus

The apparatus was a 3-unit runway housed within a 3-unit wooden

enclosure. This enclosure was 8 ft. high and 4 ft. wide, each section being 2 ft. long. It was painted flat black and the floor was covered with black rubber matting. A 75-w. Lumline light was attached to the ceiling of each section. A portal 5 in. high and 4 in. wide placed in the center of the inner walls permitted passage from one section of the runway to the next. A guillotine door over each of these portals could be operated from outside the enclosure. The runway consisted of a starting box, 12 in. long, 4 in. high and 4 in. wide, an alleyway, 24 in. long, 4 in. high and 4 in. wide, and an endbox, 18 in. long, 4 in. high and 4 in. wide. Starting box and alleyway were black, one endbox was black and one endbox was white. Each section of the runway was covered with unpainted 1/4 in. hardware cloth.

Circular holes, 1 in. in diameter, pierced the walls of the runway 1 in. from the end of the alleyway and 6 in. from the end of the endbox, permitting infra-red filtered photoelectric beams across the runway. The floors were mounted on springs having a vertical displacement of 1/8 in. Four noiseless leaf microswitches placed under the floors, in conjunction with the photoelectric beams, permitted four time measures to be taken: leaving the starting box, reaching the end of the alleyway, entering the endbox, and traversing the first 12 in. of the endbox. These times were recorded on four Lafayette clocks, calibrated in .01 sec. The photobeam at the end of the alley was also in circuit with the end-unit light, so that the endbox was only illuminated after the beam was broken.

Procedure

The Ss were maintained on a 23-hr. food deprivation schedule by feeding for 1 hr. each day beginning 7 days before the experiment. On each of these days S was handled a minimum of 15 min. On the last two

days S was handled in the experimental room. On the seventh day a squad of three rats was placed into unpainted individual plywood detention boxes in the experimental room. Beginning 1/2 hr. later, Ss received 9 runs through the apparatus, about 15 min. apart. Each S was placed into the starting box and 5 sec. later the door was opened. The retrace doors were lowered as S traversed the runway, this progress being recorded on the clocks outside the enclosure. The S was removed from the endbox either after the last photobeam was broken or 10 sec. after the entrance into the endbox, whichever was longer. On each of these nine trials an unbaited black foodcup was attached to the end of the endbox. Three groups were run with the black endbox in place, three groups with the white endbox. One-half hour after the ninth run Ss were given 9 placed feedings in the endbox, the foodcup containing a 0.05 gm. food pellet. Two groups were placed over the foodcup at the end of the box (Groups BE and WE), two groups were placed over the foodcup at the center of the box (Groups BC and WC), and two groups were placed at the beginning of the box and ran to the foodcup at the end (Groups BR and WR). One-half hour after the feedings S was given a tenth run through the apparatus.

Chapter 4

Results

All analyses are based on a reciprocal transformation (100/sec.) of the clock reading. Complete data for each S are presented in the Appendix. Group means for all four measures, Starting Speed, Runway Running Speed, Endbox Entry Speed, and Endbox Running Speed over Trials 7, 8, 9 and 10 are given in Table 1. These data were analyzed by a repeated measurements analysis of variance, the correlated variables being Trials and the interactions with Trials (Lindquist, 1953). The major analysis is over Trials 9 and 10, and the measure of most importance is that of Runway Running Speed. An analysis of Trials 7, 8 and 9 was performed to test for the existence of a trend across these three trials which could perhaps vitiate the comparison of Trials 9 and 10.

Primary Analysis: Runway Running Speed

Running speed for the six groups over the first nine trials and the tenth test trial is depicted in Fig. 1. Performance increased over the first few trials but appeared to have leveled off by Trial 9.

The analysis of Trials 9 and 10 (Table 2) yielded a Trials x Stimuli x Placement interaction significant at the .05 level ($F = 3.65$, $df = 2/54$). The significance of this interaction permits further analysis of separate group comparisons. A separate analysis of variance (using the within-Ss mean square from the complete analysis) was performed on the major comparison, runway running speed for Group BC against Group WC. The difference between the Trial 9 to Trial 10 differences for these two groups was significant at the .01 level ($F = 7.32$, $df = 1/54$). Another (non-

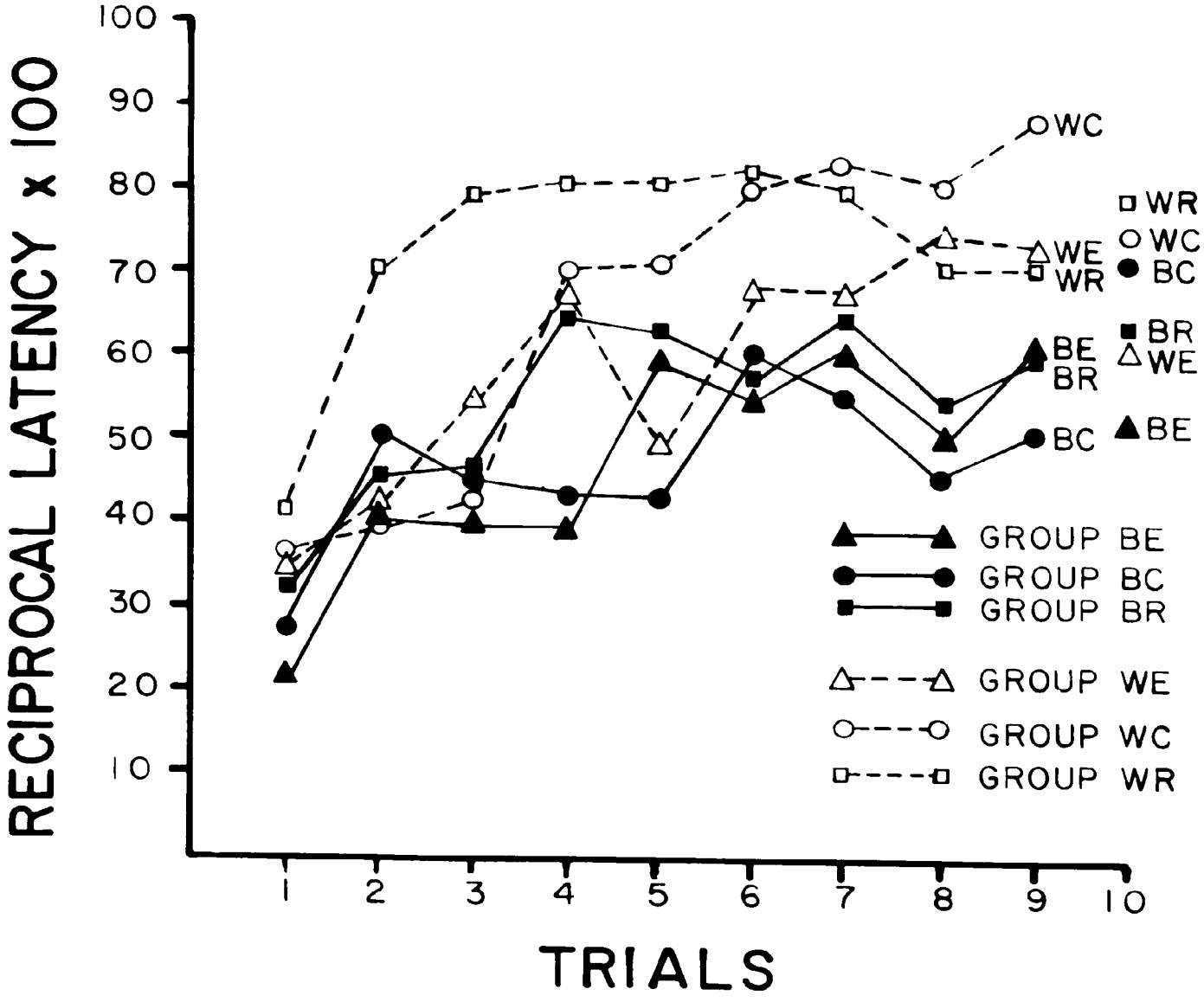


Fig. 1 Runway Performance on the Nine Non Rewarded Trials and the Tenth (Test) Trial

Table 1

Group Means on Trials 7, 8, 9 and 10 for Each of the Four Measures (Reciprocal Latency x 100)

	BE	BC	BR	WE	WC	WR
Start						
7	7.1	11.6	16.1	8.4	24.1	12.8
8	7.1	10.7	10.7	25.8	23.4	16.5
9	11.1	14.9	10.9	23.0	10.0	15.4
10	12.8	17.6	11.7	14.6	18.4	16.3
Runway						
7	63.8	58.2	65.2	70.2	85.6	84.4
8	51.8	47.1	56.6	79.1	84.7	72.5
9	69.4	56.5	66.8	77.1	92.7	74.2
10	58.5	76.0	68.7	68.1	79.5	80.8
Enter						
7	14.2	18.5	19.7	11.6	40.6**	14.6
8	18.2	39.7	11.8	31.2	73.5**	20.4
9	12.1	18.5	12.5	7.0	34.5**	12.9
10	27.7	37.6	26.2	18.8	21.3**	19.2
Endbox						
7	146.8	103.9	72.5	67.5	86.1	110.1
8	141.6	115.7	106.4	116.9	101.2	111.3
9	157.5	107.1	108.3	79.6	99.1	77.5
10	99.2	161.6	160.5	94.1	114.3	146.4

** One S in Group WC had entry speeds on Trials 7, 8 and 9 very different from the other 59 Ss. If the results for this S were disregarded the means for this group on Trials 7, 8, 9 and 10 would be 9.2, 8.7, 9.1, 23.2.

Table 2

Analysis of Variance on Reciprocal Latency x 100
Over Trials 9 and 10 for Runway Running Speed

Source	df	RUNWAY	
		MS	F
Between Ss	(59)		
Stimuli (S)	1	4886	4.69*
Place (P)	2	878	< 1
S x P	2	131	< 1
Error (b)	54	1042	
Within Ss	(60)		
Trials (T)	1	18	< 1
T x S	1	575	1.58
T x P	2	371	1.02
T x S x P	2	1331	3.65*
Error (w)	54	365	

* $P < .05$

Table 3

Analysis of Variance on Reciprocal Latency x 100 Over Trials 7, 8 and 9 for Runway Running Speed

Source	df	RUNWAY MS	RUNWAY F
Between Ss	(59)		
Stimuli (S)	1	19,034	8.94**
Place (P)	2	76	< 1
S x P	2	195	< 1
Error (b)	54	2128	
Within Ss	(120)		
Trials (T)	2	936	2.65#
T x S	2	457	1.30
T x P	4	141	< 1
T x S x P	4	283	< 1
Error (w)	108	353	

** $P < .01$
# $P < .10$

Table 4

Analyses of Variance on Reciprocal Latency x 100 Over Trials 9 and 10 for Starting Speed, Endbox Entry Speed and Endbox Running Speed

		START		ENTER		ENDBOX	
Source	df	MS	F	MS	F	MS	F
Between Ss	(59)						
Stimuli (S)	1	291	1.14	368	< 1	27,968	2.68
Place (P)	2	42	< 1	1616	1.30	2778	< 1
S x P	2	212	< 1	116	< 1	970	< 1
Error (b)	54	256		1246		10,432	
Within Ss	(60)						
Trials (T)	1	32	< 1	2359	3.16	18,008	4.85*
T x S	1	15	< 1	1570	2.10	2100	< 1
T x P	2	200	< 1	301	< 1	17,798	4.79*
T x S x P	2	158	< 1	98	< 1	7354	1.98
Error (w)	54	287		746		3712	

* $p < .05$

Table 5

Analyses of Variance on Reciprocal Latency x 100 Over Trials 7, 8 and 9 for Starting Speed, Endbox Entry Speed and Endbox Running Speed

		START		ENTER		ENDBOX	
Source	df	MS	F	MS	F	MS	F
Between Ss	(59)						
Stimuli (S)	1	1947	3.37#	3654	< 1	24,640	1.4
Place (P)	2	83	< 1	9711	1.02	7071	< 1
S x P	2	259	< 1	2517	< 1	16,718	< 1
Error (b)	54	577		9546		17,058	
Within Ss	(120)						
Trials (T)	2	85	< 1	4348	3.27*	4774	1.8
T x S	2	382	1.97	1010	< 1	2970	1.1
T x P	4	310	1.64	1258	< 1	233	< 1
T x S x P	4	317	1.64	59	< 1	3917	1.5
Error (w)	108	193		1328		2613	

# $P < .10$
* $P < .05$

Table 6

The Number of Ss in Each Group for Which Endbox Entry Speed on Trial 10 Was Greater or Less Than Speed on Trial 9

		BE	BC	BR	WE	WC*	WR
10	9	6	9	7	5	6	7
9	10	4	1	3	5	3	3

* One S in Group WC did not change from Trial 9 to Trial 10.

orthogonal) comparison was that of the difference in running speed between Trial 9 and Trial 10 for Group BC. The increase from Trial 9 to Trial 10 was significant at the .05 level ($F = 5.21$, $df = 1/54$). The third comparison was between the Trial 9 to Trial 10 differences for Group BC against Group BE. The difference between these two groups was significant at the .025 level ($F = 6.29$, $df = 1/54$).

The analysis also indicated that the Stimulus main effect was significant at the .05 level ($F = 4.69$, $df = 1/54$). This can be attributed to the slower running of black endbox groups.

The analysis of Trials 7, 8 and 9 yielded a Trials main effect significant at the .10 level ($F = 2.65$, $df = 2/108$). Inspection of Table 1 reveals that this is not to be attributed to an increasing trend across the three trials but to a depression of Trial 8 relative to both Trials 7 and 9. The Stimulus main effect was significant at the .01 level ($F = 8.94$, $df = 1/54$), again indicating that the black endbox groups were slower.

Supplementary Analyses

(1) Endbox Entry Speed

The analysis of Trials 9 and 10 (Table 4) indicated that the Trials main effect was not significant. However, an inspection of the individual data indicated that this analysis was perhaps inadequate for these data because one S in Group WC ran so fast on Trial 9 that that one score by itself was one-quarter as large as the sum for all 60 scores on that trial (263 out of 976). This had a marked effect on the variance of that cell such that the ratio of that cell variance to the smallest cell variance (obtained in Group WE) yielded a value of 98.04.

A Sign test was performed on the number of Ss for which speed increased on Trial 10 (Table 6). Forty of the 60 Ss increased in speed

on Trial 10 (one S in Group WC did not change). The tabled values for for Sign test indicated significance at the .01 level (Dixon and Massey, 1951).

The analysis of Trials 7, 8, and 9 (Table 5) yielded a Trials main effect significant at the .05 level ($F = 3.27$, $df = 2/108$). Inspection of Table 1 reveals that this can be attributed to a decrease in Trial 9 relative to Trial 8, and not to an increasing trend over the three trials.

(2) Endbox Running Speed

The analyses of Trials 9 and 10 (Table 4) yielded both a Trials main effect ($F = 4.85$, $df = 1/54$) and the Trials x Placement interaction ($F = 4.79$, $df = 1/54$) significant at the .05 level. This interaction indicates that the Trial 9 to Trial 10 effect is different across placement conditions. On the basis of the a priori hypothesis that the two end placement groups should not differ from Trial 9 to Trial 10, whereas the other four groups should increase in speed, the center and running groups (Groups BC, WC, BR and WR) were combined for a separate analysis (using the within-Ss mean square from the complete analysis). The increase in endbox running speed from Trial 9 to Trial 10 for these four groups was significant at the .005 level ($F = 12.26$, $df = 1/54$). A similar analysis was performed on the combined Groups BE and WE. The decrement from Trial 9 to Trial 10 was not significant ($F = 1.29$, $df = 1/54$).

The analysis of Trials 7, 8 and 9 (Table 5) indicated that the Trials main effect was not significant.

(3) Starting Speed

The analyses of Trials 9 and 10 (Table 4) and of Trials 7, 8 and 9 (Table 5) indicated that the Trials main effect was not significant

in either one ($F < 1$). A Sign test was performed on the number of Ss for which increases in speed were found on Trial 10. This number, 37 out of 60, was found not significant ($P < .10$).

Chapter 5

Discussion

In the analysis of this experiment the measure of greatest theoretical interest is that of Runway Running Speed, because this was recorded before the endbox cues were visible. The results indicate that the speed of the instrumental running response can be influenced by consummatory behavior if the stimuli present at the time of the response are similar to those present at the time of the consummatory behavior. Two sets of stimuli were manipulated, intramaze cues and, indirectly, feedback stimuli from the running response. The three groups (Groups BC, BR and WR) for which one of these stimuli was present both at, or shortly before, the time of the consummatory response and at the time of the running response had a mean running speed on Trial 10 higher than the mean running speed on Trial 9. Only in Group BC did this increase reach statistical significance, although the Trials x Stimuli x Placement interaction indicated that the overall pattern of the six groups was significant.

The difference between Group BC and Group WC is consistent with the model for instrumental approach behavior proposed by Spence (1956). The response analysis specifies two responses which occur in the straight-alley apparatus, the instrumental response, R_a, and the fractional goal response, $\underline{r}_g$. The speed of the instrumental response is jointly determined by the associative strength of R_a and the vigor of generalized $\underline{r}_g$. This analysis presumes that the nine preliminary runs increased the associative strength of R_a and the subsequent feedings resulted in the conditioning of $\underline{r}_g$ to the stimuli present at the time of the consummatory

response. In the center placement groups the feedings result in the conditioning of $\underline{r}_g$ to the stimuli of the black or of the white endbox. In the runway on the tenth trial the stimuli of the runway are present, these stimuli being similar to the conditioned stimuli for Group BC but not similar to the conditioned stimuli of Group WC. Therefore, more $\underline{r}_g$ would generalize in the black endbox group than for the white endbox group. This should result in an increase in running speed for Group BC but not for Group WC, and this was observed.

The obtained increase for Group BC is different from the results obtained by Stein (1957) and Swift and Wike (1958). In both of these experiments $\underline{S}$ was placed over the foodcup at the end of the endbox and no increase in running speed was obtained following the feeding. In the present experiment the failure of the group fed at the end of the endbox (Group BE) to show an increase in running speed replicates the previous findings. In the account of these results it is remarkable that the end placement groups failed to demonstrate an increase in the Endbox Running Speed measure. This would appear to substantiate the argument that the conditioned stimuli for these two groups were only a subset of endbox stimuli possibly consisting only of the foodcup itself and the terminal wall of the endbox. It may be assumed that this subset of stimuli was so dissimilar to the rest of the endbox that there was little generalization from one to the other, which would account for the failure of these groups to demonstrate an increase in speed.

The Spence analysis also leads to the expectation that Group BR should show a greater increase in running speed than Group WR. In both of these groups the perseverative feedback from the running response and the perseverative trace of the endbox stimuli should be present at the

time of the consummatory response. On the tenth run the intramaze stimuli of the black runway and the stimulus feedback from running are present, and this complex should be more similar to the conditioned stimuli of Group BR than of Group WR. Therefore Group BR should have a greater increase in running speed. The difference between these two groups is not significant, but is certainly in the wrong direction.

The failure of the group fed in the center of the white endbox (Group WC) to demonstrate an increase in running speed in the runway (under conditions where Group BC did increase) does not support the deduction from MacCorquodale and Meehl's Principle of Inference, nor is it consistent with the observations of Seward, Jones and Summers (1960). The latter found that a group given preliminary runs in a straight-alley apparatus which had a dissimilar endbox demonstrated an increase in running speed after endbox feedings. However, in the description of the procedure no mention was made of the way in which S was placed into the endbox, and it is possible that S was allowed to make an instrumental approach to the foodcup. To this extent the comparable group in the present experiment is Group WR and not Group WC, and the results for this group are in the same direction observed by Seward, et al.

This finding has rather suggestive implications for expectancy theory. Group WC (by analogy with Group BC) received the endbox stimuli but made no instrumental response and did not demonstrate an increase in running speed. Group WR which in addition to receiving the endbox cues also made the instrumental response in the endbox did show an increase in running speed, as did Seward's experimental group. This suggests that the reception of S_2 at the time of the consummatory response is not sufficient for the formation of the new expectancy ($S_1R_1S^*$) but that it is

also necessary to have the sequence R_1-S* occur. This is consistent with recent extensions of expectancy theory (such as Atkinson, 1954) which emphasize the final instrumental linkage in the formation of incentive motivation.

A secondary observation was that in the first nine runs the black endbox groups ran slower than the white endbox groups in the runway. It is possible to account for this finding by assuming that responses which compete with the instrumental approach response were made in the endbox before S was removed, and that these responses conditioned to the endbox stimuli. These responses would generalize more from the black endbox to the black runway than from the white endbox to the black runway, and, therefore, there would be greater interference with the running response in black endbox groups. If competing responses generalize from the endbox to the runway it would be consistent for approach responses to generalize from the runway to the endbox, which implies that the black endbox groups should run faster in the endbox. The differences between black and white endbox groups in endbox running speed are not significant but they are in the suggested direction.

When the endbox measures are considered, a significant increase in speed from Trial 9 to Trial 10 was demonstrated by the running groups (Groups BR and WR) and the center placement groups (Groups BC and WC). For Group WC when the stimuli contiguous with the eating response were not present at the time of the instrumental response (in the runway) there was no increase in speed. However, when S was in the presence of these stimuli, which was true when S was actually in the endbox, an increase in speed was demonstrated.

On the Starting Speed measure neither the Trials main effect nor

any of the interactions with Trials was significant. This failure to find increases in starting speed is compatible with the suggestion that the consummatory response does not interact with the running response specifically but with all responses present at the time. The starting box door was opened a fixed time after S was placed into the starting box and it was possible for S not to be oriented towards the runway at the time that the door was opened. It is then possible that the running response was not at that time the dominant response, and, therefore, it would not be increased in strength relative to other responses.

Except for the failure of Group BR to show a significant increase in running speed in the runway the results are consistent with the analysis of instrumental approach behavior proposed by Spence (1956). Two previous experiments (Stein, 1957, Swift and Wike, 1958) failed to demonstrate the increase in running speed following rewarded placement into an endbox which was similar to the rest of the alleyway. The present experiment suggests that this failure occurred because Ss were not receiving the appropriate endbox stimuli at the time of the consummatory response. In Group BC the placement of S at the time of the consummatory response was such as to maximize the probability of endbox reception, and in this group runway running speed was increased on the test trial.

Chapter 6

Summary

The analysis of instrumental approach behavior proposed by Spence (1956) predicts that rewarded endbox placement will increase the speed of the instrumental approach response if the stimuli present in the runway are similar to the stimuli present in the endbox. Two experiments (Stein, 1957, and Swift and Wike, 1958) performed in the context of this analysis failed to demonstrate any effect of endbox feedings on running speed. In the present experiment a number of conditions were explored in which endbox feedings might influence the speed of the instrumental response.

Six groups of food deprived rats were given nine non-food terminated runs in a straight-alley apparatus. For all six groups the starting box and runway were black, for three groups the endbox was black and for three groups the endbox was white. The Ss subsequently were given nine placements into the appropriate baited endbox. Two groups were placed over the foodcup at the end of the endbox, two groups were placed over the foodcup at the center of the endbox, and two groups were placed at the beginning of the endbox from where they ran to the foodcup at the end. All Ss then received a test run through the apparatus.

Four measures were recorded: starting box speed, runway speed (recorded before the endbox cues were visible), endbox entry speed, and endbox running speed. In starting speed there were no differences between Trials 9 and 10. In the runway the group fed in the center of the black endbox demonstrated a significant increase on Trial 10. In the

endbox measures the groups fed in the center of the endbox and the groups which ran to the end of the endbox increased in speed.

The increase in running speed in the runway demonstrated by the group fed in the center of the black endbox, and the increases of the four groups in the endbox measures was interpreted as consistent with the analysis proposed by Spence. This analysis states that the effect of the feedings was to condition the fractional goal response, $\underline{r}_g$, to the endbox stimuli, and that $\underline{r}_g$ generalized from the black endbox to the black runway. The simultaneous occurrence of $\underline{r}_g$ and the instrumental response, R_a, resulted in the increased speed of R_a. This experiment suggests that the previous failure to demonstrate the increase in running speed can be attributed to a failure to ensure that $\underline{S}$ received the appropriate endbox stimuli at the time of the consummatory response.

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APPENDIX

Reciprocal Latencies for all Subjects on Each Measure over the 10 Trials

Table 7

Starting Speed (Reciprocal Latency x 100) for Each S in Group BE over the 10 Trials

Trial \ S	1	2	3	4	5	6	7	8	9	10
1	12	2	15	10	3	3	14	4	2	14
2	5	2	4	2	2	1	11	17	7	5
3	6	1	4	1	2	12	5	10	7	2
4	14	2	7	3	3	9	13	19	5	15
5	17	2	4	4	1	6	22	40	42	6
6	12	3	1	51	1	4	11	21	8	15
7	12	3	1	2	5	13	15	8	7	5
8	14	2	2	3	6	3	8	17	3	13
9	57	1	14	4	1	4	10	7	5	8
10	23	2	37	2	6	3	10	35	2	8

Table 8

Runway Running Speed (Reciprocal Latency x 100) for Each S in Group BE over the 10 Trials

Trial \ S	1	2	3	4	5	6	7	8	9	10
1	16	18	13	7	23	31	27	45	24	24
2	32	30	40	60	30	44	34	87	26	61
3	48	71	9	33	38	47	51	85	20	56
4	22	10	4	2	38	50	77	79	90	48
5	75	47	41	65	5	56	72	100	118	59
6	68	57	19	99	7	40	77	109	31	66
7	37	72	38	94	13	77	83	112	43	69
8	67	65	41	112	5	5	65	64	34	60
9	85	53	103	97	12	51	77	112	45	58
10	29	62	114	101	55	24	76	67	23	34

Table 9

Endbox Entry Speed (Reciprocal Latency x 100) for Each S in Group BE over the 10 Trials

Trial \ S	1	2	3	4	5	6	7	8	9	10
1	22	22	21	14	18	2	22	18	12	8
2	3	15	11	96	2	8	17	17	2	27
3	18	31	8	2	4	4	20	26	3	3
4	11	22	8	59	4	60	15	8	10	4
5	7	3	34	32	7	9	41	14	90	4
6	8	3	27	19	11	5	8	4	30	12
7	1	2	4	5	9	8	2	34	75	2
8	20	5	6	13	2	6	9	7	88	26
9	4	9	40	6	1	2	24	6	22	7
10	24	6	161	19	10	2	5	18	21	11

Table 10

Endbox Running Speed (Reciprocal Latency x 100) for Each S in Group BE over the 10 Trials

Trial \ S	1	2	3	4	5	6	7	8	9	10
1	159	57	22	9	175	67	154	125	5	169
2	256	4	51	12	172	17	182	77	196	81
3	204	5	7	15	189	179	164	222	192	141
4	106	18	44	20	167	143	169	208	204	161
5	156	4	24	6	7	147	132	169	312	182
6	172	14	8	8	7	85	127	172	208	6
7	120	68	52	105	123	154	132	217	312	185
8	213	8	52	116	123	57	116	123	345	263
9	164	40	161	161	2	2	204	263	278	300
10	200	24	125	95	20	102	61	62	222	81

Table 11

Starting Speed (Reciprocal Latency x 100) for Each S in Group BC over the 10 Trials

Trial \ S	1	2	3	4	5	6	7	8	9	10
1	3	3	12	3	4	6	9	1	34	5
2	2	14	11	16	10	6	3	5	55	2
3	12	27	5	14	2	2	4	7	3	1
4	21	4	8	11	2	2	1	5	19	3
5	19	56	2	23	5	1	2	6	4	1
6	45	5	3	12	2	5	1	4	3	7
7	3	29	3	41	3	1	4	22	3	7
8	3	5	2	29	40	1	2	8	12	5
9	8	14	51	22	3	5	2	9	33	2
10	6	49	2	51	7	21	10	3	5	22

Table 12

Runway Running Speed (Reciprocal Latency x 100) for Each S in Group BC over the 10 Trials

Trial \ S	1	2	3	4	5	6	7	8	9	10
1	23	5	42	42	36	34	49	24	7	21
2	58	92	39	67	36	66	52	70	19	32
3	79	39	58	64	18	23	3	88	76	16
4	82	53	50	62	53	17	2	70	62	7
5	75	24	79	60	78	16	14	70	48	10
6	81	120	85	106	63	2	45	64	81	2
7	56	73	86	55	65	2	68	78	71	28
8	11	83	40	89	62	21	59	55	36	16
9	25	68	84	106	73	15	37	25	76	56
10	64	120	94	101	64	98	56	53	57	53

Table 13

Endbox Entry Speed (Reciprocal Latency x 100) for Each S in Group BC over the 10 Trials

Trial \ S	1	2	3	4	5	6	7	8	9	10
1	19	25	23	4	17	26	2	22	33	2
2	3	7	15	14	11	27	14	29	18	4
3	34	52	40	12	2	2	2	31	22	4
4	45	6	4	20	5	31	14	11	22	4
5	37	164	99	30	1	12	2	4	59	12
6	69	133	9	19	1	1	4	19	312	2
7	3	34	2	73	7	7	7	9	35	8
8	1	72	5	16	2	15	2	6	263	15
9	2	44	8	19	3	33	3	4	54	15
10	57	93	17	44	15	53	9	13	51	22

Table 14

Endbox Running Speed (Reciprocal Latency x 100) for Each S in Group BC over the 10 Trials

Trial \ S	1	2	3	4	5	6	7	8	9	10
1	294	185	94	71	143	14	40	3	161	68
2	217	95	156	161	7	62	19	32	161	137
3	294	192	164	161	24	9	7	13	93	48
4	137	233	179	208	45	23	11	93	128	39
5	250	14	149	192	30	3	33	61	41	56
6	270	152	200	222	7	4	10	66	23	6
7	119	200	172	227	3	18	5	137	43	115
8	192	179	217	286	22	14	12	127	19	89
9	133	250	213	154	11	42	14	135	9	110
10	250	189	74	286	312	86	149	7	111	152

Table 15

Starting Speed (Reciprocal Latency x 100) for Each S in Group BR over the 10 Trials

Trial \ S	1	2	3	4	5	6	7	8	9	10
1	10	2	14	1	2	4	38	2	15	8
2	2	6	10	5	2	38	4	1	34	6
3	4	2	5	5	2	11	13	5	4	5
4	1	8	16	4	11	9	4	5	2	5
5	3	14	26	2	12	9	3	13	25	33
6	15	17	2	2	7	5	3	40	11	15
7	2	21	5	3	3	11	27	62	11	16
8	1	18	3	2	7	24	14	19	10	9
9	1	48	4	2	8	6	13	13	2	12
10	11	14	9	8	5	10	14	6	35	5

Table 16

Runway Running Speed (Reciprocal Latency x 100) for Each S in Group BR over the 10 Trials

Trial \ S	1	2	3	4	5	6	7	8	9	10
1	6	32	21	38	10	62	41	31	57	26
2	67	31	67	19	56	68	11	30	72	37
3	45	36	51	48	53	56	11	64	98	21
4	83	64	60	59	76	27	47	118	96	60
5	53	81	90	45	36	79	35	69	109	61
6	55	66	88	7	50	74	12	105	108	77
7	54	109	30	15	55	100	21	93	110	65
8	88	88	39	16	50	3	36	93	88	65
9	62	106	26	66	64	72	32	82	93	65
10	86	75	59	78	62	81	49	74	112	10

Table 17

Endbox Entry Speed (Reciprocal Latency x 100) for Each S in Group BR over the 10 Trials

Trial \ S	1	2	3	4	5	6	7	8	9	10
1	22	8	3	12	7	17	32	9	25	2
2	3	17	23	25	8	3	22	12	182	27
3	1	14	3	2	2	12	15	20	25	45
4	14	4	5	3	13	16	15	17	80	18
5	4	4	5	1	1	2	1	18	63	36
6	31	12	24	1	4	9	2	11	34	4
7	7	54	7	13	2	8	7	12	30	57
8	1	4	3	2	7	47	34	11	4	5
9	1	20	4	20	0	22	16	21	11	10
10	24	15	8	45	44	18	54	31	19	5

Table 18

Endbox Running Speed (Reciprocal Latency x 100) for Each S in Group BR over the 10 Trials

Trial \ S	1	2	3	4	5	6	7	8	9	10
1	5	94	169	143	217	161	120	95	61	73
2	119	238	270	118	179	164	147	93	14	159
3	185	238	161	115	179	178	164	27	42	192
4	149	227	85	21	270	132	108	96	156	156
5	125	204	233	37	5	238	172	137	66	196
6	110	68	200	5	3	154	61	152	161	250
7	8	172	62	85	48	6	98	30	3	213
8	175	133	99	8	125	159	11	133	4	217
9	110	67	6	179	120	167	84	115	81	154
10	147	60	83	278	139	141	145	208	182	222

Table 19

Starting Speed (Reciprocal Latency x 100) for Each S in Group WE over the 10 Trials

Trial \ S	1	2	3	4	5	6	7	8	9	10
1	5	35	13	4	2	7	3	49	18	6
2	14	17	10	10	5	9	8	24	10	2
3	7	27	15	9	2	15	8	42	1	8
4	0	76	19	2	2	3	3	64	5	3
5	11	83	23	5	1	14	6	8	12	5
6	3	31	18	16	4	9	3	19	10	3
7	2	8	6	17	4	16	2	15	7	7
8	1	77	16	75	2	18	4	32	26	7
9	0	105	13	9	5	20	2	13	44	19
10	12	6	5	13	26	13	8	32	20	10

Table 20

Runway Running Speed (Reciprocal Latency x 100) for Each S in Group WE over the 10 Trials

Trial \ S	1	2	3	4	5	6	7	8	9	10
1	61	31	29	24	21	61	35	51	7	25
2	35	52	60	60	60	42	8	49	45	55
3	36	74	65	83	45	46	22	79	35	95
4	52	76	58	100	64	74	25	76	75	93
5	12	63	68	90	38	60	15	65	112	9
6	6	86	78	116	53	61	49	81	91	132
7	44	76	12	99	65	62	22	122	89	111
8	56	76	27	139	81	64	24	89	88	147
9	40	78	68	88	55	74	51	96	88	133
10	31	80	64	91	57	31	25	90	93	119

Table 21

Endbox Entry Speed (Reciprocal Latency x 100) for Each S in Group WE over the 10 Trials

Trial \ S	1	2	3	4	5	6	7	8	9	10
1	14	10	50	2	1	30	7	21	3	7
2	5	10	5	3	0	13	7	35	57	4
3	3	60	3	12	0	33	2	5	30	12
4	3	17	30	6	1	20	2	4	39	8
5	1	18	7	8	1	40	2	10	6	5
6	0	3	19	18	2	4	2	41	4	14
7	0	2	28	10	2	4	1	33	7	29
8	1	18	7	44	4	49	1	39	19	130
9	0	10	13	3	1	28	1	3	7	4
10	0	30	8	2	1	9	9	59	61	9

Table 22

Endbox Running Speed (Reciprocal Latency x 100) for Each S in Group WE over the 10 Trials

Trial \ S	1	2	3	4	5	6	7	8	9	10
1	23	48	3	244	31	79	47	43	32	85
2	28	79	85	213	0	196	4	105	118	118
3	3	116	110	161	5	159	41	130	96	149
4	3	120	105	227	4	79	49	127	13	200
5	6	27	23	66	5	92	2	23	119	67
6	2	55	115	127	16	122	4	111	132	62
7	5	109	2	128	8	91	8	213	3	109
8	4	159	118	233	100	14	11	120	172	238
9	20	120	99	141	23	6	14	137	164	72
10	4	60	73	189	47	10	44	196	213	105

Table 23

Starting Speed (Reciprocal Latency x 100) for Each S in Group WC over the 10 Trials

Trial \ S	1	2	3	4	5	6	7	8	9	10
1	7	2	12	52	5	11	6	5	1	6
2	15	3	6	7	31	15	13	3	2	5
3	20	3	53	13	40	1	36	14	11	3
4	38	14	7	4	3	3	39	5	29	3
5	50	3	8	18	2	1	16	23	3	9
6	143	3	43	4	17	6	21	3	43	11
7	66	6	36	2	2	11	80	3	24	11
8	55	6	11	20	13	3	92	3	26	5
9	12	2	9	9	2	3	19	10	32	2
10	11	5	23	17	68	10	20	21	5	4

Table 24

Runway Running Speed (Reciprocal Latency x 100) for Each S in Group WC over the 10 Trials

Trial \ S	1	2	3	4	5	6	7	8	9	10
1	29	27	27	65	7	7	64	21	27	71
2	28	68	78	12	20	66	39	18	19	65
3	62	15	4	44	14	54	96	12	64	93
4	80	70	86	87	25	52	82	85	85	83
5	84	44	96	98	76	65	123	22	56	84
6	66	59	82	109	74	83	143	56	77	78
7	83	91	71	104	49	56	139	75	100	88
8	69	70	95	139	62	72	125	69	130	16
9	75	93	94	112	81	74	132	76	95	95
10	75	92	96	66	89	54	83	79	55	108

Table 25

Endbox Entry Speed (Reciprocal Latency x 100) for Each S in Group WC over the 10 Trials

Trial \ S	1	2	3	4	5	6	7	8	9	10
1	4	12	4	68	1	10	6	0	24	5
2	17	3	31	2	4	2	49	3	40	5
3	8	16	7	1	1	18	4	45	14	6
4	11	2	3	9	1	0	6	3	149	5
5	19	16	8	9	1	4	9	3	15	14
6	0	54	5	1	1	6	72	2	263	11
7	12	1	3	43	0	2	5	16	324	1
8	14	2	23	12	2	1	1	7	667	6
9	17	1	9	15	0	3	5	23	263	9
10	42	2	32	19	34	20	5	18	36	6

Table 26

Endbox Running Speed (Reciprocal Latency x 100) for Each S in Group WC over the 10 Trials

Trial \ S	1	2	3	4	5	6	7	8	9	10
1	256	145	110	79	2	18	30	83	154	30
2	175	263	222	4	3	5	263	9	169	263
3	119	9	159	5	11	112	244	13	7	270
4	3	145	233	6	2	59	175	3	72	250
5	8	208	72	125	1	83	12	8	100	278
6	11	161	4	154	1	72	172	5	167	222
7	179	4	79	156	0	11	94	9	182	147
8	101	78	59	114	4	77	137	86	227	130
9	204	1	17	164	3	93	303	31	36	139
10	204	10	95	154	38	72	125	36	196	213

Table 27

Starting Speed (Reciprocal Latency x 100) for Each S in Group WR over the 10 Trials

Trial \ S	1	2	3	4	5	6	7	8	9	10
1	14	11	9	2	5	10	4	16	26	3
2	2	7	16	3	13	7	8	8	5	23
3	16	7	6	8	90	17	3	30	44	22
4	10	5	24	6	54	34	5	20	7	15
5	2	4	18	14	6	13	5	24	4	13
6	3	24	31	14	2	2	17	76	7	3
7	2	18	35	8	11	6	2	8	14	24
8	1	4	47	8	12	5	8	5	17	58
9	5	3	23	6	13	8	3	30	48	15
10	9	13	27	17	16	27	7	31	8	8

Table 28

Runway Running Speed (Reciprocal Latency x 100) for Each S in Group WR over the 10 Trials

Trial \ S	1	2	3	4	5	6	7	8	9	10
1	53	50	30	59	50	35	34	25	32	65
2	43	88	64	189	81	60	7	39	103	57
3	77	88	88	72	102	71	64	68	91	111
4	78	105	103	71	79	74	82	80	74	115
5	88	93	109	85	44	76	93	93	56	123
6	45	83	94	72	76	103	99	94	89	119
7	41	99	100	87	56	85	68	108	87	123
8	13	85	111	80	44	36	66	73	95	122
9	4	88	128	82	67	83	68	54	83	85
10	9	93	99	83	65	96	62	62	58	101

Table 29

Endbox Entry Speed (Reciprocal Latency x 100) for Each S in Group WR over the 10 Trials

Trial \ S	1	2	3	4	5	6	7	8	9	10
1	2	30	5	4	3	7	2	2	54	40
2	3	119	20	10	4	6	6	5	114	19
3	10	22	5	3	2	11	1	8	4	5
4	1	4	9	2	1	3	1	8	6	6
5	3	23	6	14	2	3	1	82	2	6
6	2	16	10	2	7	3	2	111	3	16
7	5	1	56	3	2	2	1	48	24	4
8	2	1	39	2	3	5	0	10	77	65
9	1	1	45	1	1	3	0	5	5	67
10	1	4	37	4	17	29	2	24	38	36

Table 30

Endbox Running Speed (Reciprocal Latency x 100) for Each S in Group WR over the 10 Trials

Trial \ S	1	2	3	4	5	6	7	8	9	10
1	106	179	43	6	24	13	147	3	102	112
2	149	137	175	88	4	36	208	5	169	12
3	111	244	256	141	46	5	145	141	164	303
4	5	189	65	90	89	51	10	133	263	135
5	60	164	175	8	20	5	93	167	238	7
6	5	7	200	85	3	9	75	179	172	233
7	101	98	213	6	47	99	4	7	213	312
8	5	53	185	14	13	137	8	143	233	323
9	22	17	130	14	34	21	2	83	189	263
10	6	213	222	93	6	102	103	196	200	324