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THE EFFECTS OF INCENTIVE AND FRUSTRATIVE CUES
ON THE ACQUISITION OF AN ALLEYWAY
RUNNING RESPONSE IN RATS

THESIS

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By

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The motivational properties of Longstreth's (1970) definitions of incentive and frustrative cues were tested using 32 rats in a two phase straight alleyway experiment. During pretraining, incentive cue Ss were presented a visual cue prior to reinforcement; frustrative cue Ss experienced the visual cue simultaneously with reinforcement. Ss encountered the same cue in mid-alley during 40 CRF training trials. Significant inhibition developed as frustrative cue Ss passed through the cue and postcue segments. Significant incentive effects occurred midway through training only in the postcue segment. Differential resistance to extinction was not found. The results did not support all of Longstreth's assumed functions. The motivational effects were interpreted using Spence's and Amsel's instrumental learning paradigms.

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The learning of instrumental responses depends upon the interaction of states of the organism with systematic events occurring within the organism's immediate environment. One dimension of organismic state is primary motivation, the unlearned source of drive impelling the organism to action as a result of hunger, thirst, pain, hormonal changes, or sexual deprivation. While the organism has a repertoire of species-specific, innate behaviors for resolving these drive states, other response sequences can be established by experimental procedures that manipulate these drive states. The learning of new responses or habits is dependent upon some state of primary motivation and much research literature is devoted to the parameters of learning as determined by primary motivation.

However, as one consequence of learning instrumental responses, organisms have been shown to learn a source of motivation independent of primary motivation. This second source of motivation is variously referred to as learned motives, derived motives, incentives, or secondary motivation. The term incentive motivation is adopted here to refer to this variable, which is defined by Bolles (1967) as "the capacity to anticipate reinforcement, and this expectancy facilitates instrumental behavior (p. 331)."

Incentive motivation has been conceived of in the following ways: 1) as a subject variable, 2) as a procedure associated with the conditions of reinforcement and 3) as a hypothetical construct.

Incentive motivation as a subject variable is perhaps best expressed in terms of Tolman's expectancy variable. During the course of conditioning, the organism comes to expect or anticipate consequences of his behaving. These expectancies interact with a deprivation tension state to be evidenced as performance. No explanatory mechanism is advanced beyond this description; and at least one current expectancy theorist (Bolles, 1972) contends that no further explanation is necessary. All the explanation required is that the expectancy is postulated to induce instrumental responses.

Mechanisms by which reinforcement is considered to act are approached in various ways by different theorists. But empirically, the meaning of reinforcement is defined as an experimental variable which controls responding. A reinforcer may be manipulated in instrumental learning situations by altering its quantity or quality, by delaying its introduction, or by delivering it according to various schedules. Quantities of reinforcement are specifiable in terms of

physical attributes while quality is inferred from the organism's preferences of one reinforcer over another. For both positive and negative reinforcers, performance is represented as a negatively accelerated positive function of increases in the quantity and quality of reinforcers. The same function holds for the effects of delays in the appearance of reward after the response begins or has ceased. Relative to long delays, short delays in the introduction of reward facilitate performance. This relationship of reinforcement delay to performance yields the delay of reinforcement gradient. Lastly, scheduling of the intermittent occurrence of the reinforcer produces characteristic behavioral effects depending upon whether fixed interval, variable interval, fixed ratio, or variable ratio schedules are imposed (Kimble, 1961). In each of these three classes of reinforcement manipulations, performance is altered in predictable ways.

As interpreted by Hull, these performance differences are a result of the different degrees of primary drive reduction which accompany reinforcement changes. The strength of a response is considered a multiplicative function of the momentary motivational (drive) state (as determined by the animal's conditions of reinforcement) and

the independent habit strength (a function of the number of reinforcements). But rapid changes in performance with alteration of reinforcement as demonstrated by Crespi (1942) could not be accounted for by considering primary drive change alone, so a parallel source of incentive motivation learned within the instrumental setting had to be introduced. In short, primary motivation is necessary but not sufficient to account for performance.

In his 1952 system Hull introduced the incentive factor K , a construct which is meant to account for rapid performance shifts due to motivational changes. The K factor is sensitive to changes in the physical characteristics of the reinforcer as they affect changes in the vigor of consummatory responses. The conditionable part of the consummatory response, r_g , becomes associated with stimuli in the experimental environment; later occurrences of these stimuli evoke the r_g which both guides responding by its stimulus consequences, s_g , and which reinforces responding in the direction of these environmental stimuli. However, Hull created a conceptual paradox for himself by assigning these two functions to r_g and he never did resolve the dilemma (Bolles, 1967).

Spence (1956) reworked part of the conceptualization of the r_g - s_g mechanism, and redefined it as a classically conditioned response elicited by the reinforcer and conditioned to environmental stimuli in the goal box. The vigor of r_g is a direct function of the number of goal object (reinforcer) encounters, the physical properties of the goal object, and an unspecified number of response-linked variables. In an instrumental learning task the r_g is elicited by stimuli separate from the goal box. These stimuli determine the vigor of the r_g to the degree to which they resemble the goal box stimuli. The stimulus consequences, s_g , of the goal response act to increase the total stimulus complex controlling responding. This r_g - s_g construct is motivational because a representation of goal events is elicited prior to their actual occurrence, and behavior eventuating in the goal object is potentiated and guided by this representation. Although originally couched in terms of peripheral mediating events, the r_g is still a useful explanatory device in terms of its functional properties, and has generated many investigations of these properties (Bolles, 1970). One of its implications which will be considered later is that this learnable motivation

component for an instrumental task can be established independent of the criterion task.

In announcing his incentive factor, Spence did not address himself to the question of how the stimulus dimension to which the r_g is classically conditioned might be varied to affect incentive motivation. However, a body of evidence about the incentive property of stimuli associated with goal objects has accumulated, in response both to implications of Spence's motivational construct and to empirical relations found in instrumental and operant conditioning experiments.

Eninger (1953) demonstrated that rats could learn a black-white discrimination in one-third as many trials in a T maze if the alleyways leading to the baited goal box were the same color as the goal box. Alleyways contrasting in color to the goal box resulted in considerably slower learning of the discrimination. Eninger interpreted his results in a Hullian need-reduction framework, but referred to the brightness (color) as operating in a "derived incentive" role.

In a modified alleyway experiment, Lawrence and Hommel (1961) required rats to make a simultaneous black-white "choice box" discrimination which resulted in a uniform ten second delay in a second chamber. Each delay chamber led

into a third chamber, a goal box differentiated by color or structure for each experimental group. For one group a white or black choice box eventuated in a baited goal box of the contrasting color. For the other group a black or white choice box provided discriminative cues to a baited goal box of distinct shape and floor texture to differentiate it from the unbaited goal box. The goal boxes for the controls were both neutral gray. The results showed that the group running to black or white goal boxes learned the black or white choice box discrimination better than the group running to the structurally distinct goal box. Apparently a cue to food in one modality is a better discriminative stimulus even if a contrast effect is introduced for the goal box than if numerous cues which involve more than one sense modality are provided. The controls failed to learn any discrimination and fixated on either a white or black choice. The results provided the authors with empirical evidence which could not be explained in terms of secondary reinforcing principles. In referring to these results, the authors admitted to their loss for an adequate explanation. They advanced the hypothesis that the goal boxes are positively or negatively "valenced" as a consequence of being baited or not, and that the subject "notes" certain stimulus aspects of the choice

box which lead eventually to the baited goal box. Their tentative solution suggests a cognitive connection was established between discriminative stimuli and reward and non-reward, but this hypothesis was not developed.

Renner (1963) studied the interaction of drive level, cues to food, and delay of reinforcement using rats in an alleyway apparatus. The cues to food were presented in a delay chamber resembling the baited goal box. The chamber was positioned immediately before the goal box in the straight alleyway. Cues to food did not alter the temporal gradient of reinforcement which was a function of deprivation and reinforcement delay, except when reinforcement was delayed more than five seconds. Although subjects had received noncontingent direct placement into the baited goal box prior to acquisition training, the effect of this pretraining was not immediate during instrumental training. The facilitative effect of the cues did not become evident until about midway through the seventy acquisition trials. This effect might be the result of the fact that the delay chamber cues elicited both frustration and food expectancy simultaneously in the acquisition trials. Additionally, the five DP training trials might not have been sufficient to condition the environmental cues to the reinforcer. The

fact that cues play no role in facilitating runway performance involving little or no delay in reinforcement, and the finding that cues do not augment low drive to increase running speed, may be failures in design which mask the relationship of cues to food with other response variables.

One drawback in the first studies cited above is the failure to separate the acquisition of incentive motivation from acquisition of the instrumental learning wherein both are thought to interact. Spence (1956) implied that the classically conditioned K factor could be established independently using the same discriminative stimuli and reinforcer operative during instrumental learning. To test this hypothesis Trapold and Winokur (1967) established a three stimulus combination as a cue to food during noncontingent pretraining. In subsequent learning of operant bar pressing, acquisition of the response occurred faster if an element of the stimulus complex was introduced during bar press training. Extinction is enhanced if an element of the stimulus which is paired with nonreward in pretraining is introduced following the criterion trial. Furthermore, generalization to other elements of the stimulus complex during instrumental learning is enhanced or retarded if one element of the complex has been paired with reward or

nonreward respectively in pretraining. Trapold and Winokur concluded that K can be preconditioned or preextinguished using a classical conditioning procedure so that the subject enters the instrumental training phase with a readily evokable incentive mechanism. Similar results showing facilitation of bar press learning under the control of cues to reward and nonreward were found by Trapold and Fairlie (1965) and Hyde, Trapold and Gross (1968).

A methodological difficulty in testing the motivational effect of cues in the straight alleyway is how to establish in a separable procedure the predictive relationship of the neutral stimulus to the reinforcer. Pairing a tone with rewarded direct placements in the goal box did not facilitate running when the tone was sounded in the start box in two studies (Bolles, Grossen, Hargrave & Duncan, 1970; Wigdor, 1971), although in the former study resistance to extinction was affected by the tone. In some earlier alleyway studies cited above the learning of the predictive cues was not carried out independent of the criterion learning, so adopting their designs was not warranted.

This study tested the effectiveness of a visual cue to food in altering alleyway running, utilizing a pretraining phase to establish the cues to food. During the pretraining

the cue was established in one of two ways: either as a temporally and spatially antecedent stimulus event prior to food or as a stimulus event contemporaneous with food. These two cues, introduced as part of the stimulus complex of the alleyway during task training were postulated to function as an incentive cue and a frustrative cue respectively as suggested by Longstreth (1970). According to Longstreth's formulations, both cues act to increase drive. Moreover, the associative effect of the incentive cue is to elicit responses towards the cue while the frustrative cue elicits responses in avoidance of the cue. The effects on running in various segments of the alleyway were investigated to discover the functional relationship of the cues as motivational variables with instrumental learning.

The following five hypotheses were advanced:

If a cue is established as an incentive cue, the occurrence of that cue should facilitate responses leading to the reward.

If a cue is paired with reward, any occurrence of that cue prior to reward should result in interference in the acquisition of responses resulting in reward, and that cue may be regarded as a frustrative cue.

Running speed for the alleyway segment between the start box and the cue should be overall faster for the incentive stimulus group than for the frustrative stimulus group. Running speeds should be equal for both incentive and frustrative cues groups in the alleyway segment between the cue and the goal box.

Running speeds for both experimental groups on the criterion trial (trial forty) should not show significant differences.

No differential resistance to extinction should be evident between the two cue groups.

Method

Subjects

The subjects were 32 female Sprague-Dawley rats 90 days old at the beginning of experimentation. Eight subjects were randomly assigned to each of the experimental and control groups. However, the data from one experimental animal was eliminated after the animal was injured due to a mechanical failure which resulted in avoidance of the goal box.

Apparatus

The apparatus was a 4 foot straight alleyway segment with interior dimensions of approximately $3\frac{1}{2}$ x 4 inches. The start box (SB) was approximately $3\frac{1}{2}$ x 4 x 12 inches, and the goal box (GB) was approximately $3\frac{1}{2}$ x 4 x 24 inches. A clear plastic sheet covered the alleyway segment, and doors of clear plastic covered the SB and GB. Guillotine doors were placed between the SB and the alleyway and the alleyway and the GB. The interior of all parts of the apparatus was painted a neutral gray. Four photoelectric cells were placed as follows: 1) immediately outside the SB, 2) 24 inches beyond the SB door, 3) 39 inches beyond the SB door and 4) 60 inches beyond the SB door. The action of S leaving the SB started the first timer. The second timer started, and

the first timer stopped, as the animal passed the second photocell. The same arrangement started the third timer and stopped the second as the animal ran through the GB. All timers were standard Lafayette models. All electromechanical components were placed in a separate room. Two U-shaped inserts $3\frac{1}{2} \times 4 \times 12$ inches were constructed from stiff poster board. One insert was flat black, the other flat white. The inserts covered both walls and floor of the alleyway when in position. Two other inserts, of the same colors, were constructed for placement in the GB. All the GB walls and the floor were covered when the insert was in position. A food cup was placed in the GB against the wall opposite the door. All sections of the apparatus were illuminated by two 100 watt bulbs placed in reflectors midway between the SB and GB and 3 feet to one side of the apparatus.

Procedure

Acclimation phase. All subjects were gentled before experimentation and trained to feed on .045 gm. Noyes pellets in their home cages. Seven days prior to experimentation the animals were placed on a 24 hour food deprivation schedule and allowed to feed ad lib for one hour per day. Water was

freely available. Prior to experimentation all subjects were allowed 2 minutes of exploration in the alleyway apparatus devoid of the inserts or reinforcement.

Pretraining phase. For Experimental Group 1 (incentive cue group) the insert was placed immediately in front of the GB entry. The alleyway was blocked so S could move only into the neutral gray GB. During pretraining half the incentive cue Ss were given 14 trials in which the black alleyway insert was paired with reward and an equal number of trials in which the white alleyway insert was paired with nonreward. A total of 28 pretraining trials were given each S with the order of the alleyway cues to reward and nonreward randomly determined. The colors of the inserts were counterbalanced for the remaining four Ss in the incentive cue group so that the white insert was associated with reward on 14 trials and the black insert was paired with nonreward on the other 14 trials. Presentation of the inserts was random.

On a given trial the black or white insert was placed in the alleyway and reinforcement of two .045 gm. Noyes pellets placed in the GB if required for that trial. With the GB door closed S was placed in the alleyway segment, delayed 5 seconds, and then allowed to move into the GB. The

GB door was then closed. S remained for 5 seconds in either the unbaited GB or in the baited GB. Five trials were given per day with Ss under 23.5 hour food deprivation.

Control Group 1 (incentive group controls) was given 14 pretraining trials with the black insert positioned immediately in front of the GB and 14 trials with the white insert immediately before the GB. On 7 trials the black insert was paired with GB reward (two Noyes pellets) and on 7 trials the white insert was paired with the same quantity of reward. Therefore the probability of reward following either of the inserts was .50. The order of presentation of the black and white inserts was randomized, as was the order of rewarded and nonrewarded trials. The Ss were placed in the 12 inch segment and run into the GB under the same conditions as the incentive cue group with the exceptions noted above.

For Experimental Group 2 (frustrative cue group) each S was placed in the 12 inch neutral gray alleyway segment immediately before the GB. Ss were allowed to move only into the GB which was fitted with either a white or black insert. For four Ss the black GB was consistently paired with reward (100% reinforcement with two Noyes pellets) and for the other four Ss the white GB was consistently paired with reward

(100% reinforcement with two Noyes pellets). Twenty-eight trials were given each S, 14 trials with the black GB and 14 trials with the white GB. The order of presentation of the color in the GB was randomized.

Each S was placed in the gray segment, delayed 5 seconds, and allowed to move into the GB. The door was closed when S entered the GB. Subjects remained in the GB for 5 seconds. Five trials per day were given each S which was on 23.5 hour food deprivation.

The Control Group 2 (frustrative cue controls) consisted of eight subjects which ran from a 12 inch neutral gray alleyway segment after a 5 second delay into the GB lined with a black insert for 14 trials and a white insert for 14 trials. The order of insert color was randomized. Each S received 50% reinforcement of two Noyes pellets in the black GB and 50% reinforcement of two Noyes pellets in the white GB. Time within the GB was restricted to 5 seconds. Five trials per day were given each S. All Ss were on a 23.5 hour food deprivation schedule.

Training and Extinction. For both the incentive and frustrative groups and the controls forty training trials were given the 23.5 hour food deprived Ss, with all Ss

running unobstructed from the SB to the GB. For the Ss in the two experimental groups each encountered on all trials the insert of the same color paired with reinforcement in pretraining. The insert was placed at the alleyway midpoint, extending from 24 to 36 inches beyond the SB. For the two control groups half the controls in each group ran through the alleyway with the black insert in the same position, and the other half of the Ss in each control group ran through a white insert similarly placed. The colors of the inserts were not changed throughout the 40 trials. All Ss were immediately reinforced with two Noyes pellets allowing a maximum of 5 seconds time in the GB. Five trials were given per day. The average intertrial interval was 5 minutes during training. After criterion was reached 20 extinction trials, 5 per day, were given. If an animal failed to traverse any segment within 60 seconds, the trial was terminated. Running times for the alleyway segments equipped with photoelectric cells were recorded for all Ss during training and extinction.

Results

The running times for each of the experimental and control groups were converted into speeds (inches per second) prior to statistical analysis. Running speeds for the precue, cue and postcue segments in addition to the total speed (all segments combined) were considered in blocks of four trials. A separate analysis of variance with repeated measures was applied to the ten blocks of training trials for running speeds in each segment and for total speed. The data on the five blocks of extinction trials were also subjected to separate analyses of variance. For those segments with significant overall group main effects or group-trials interactions, simple analyses of variance were computed for each of the ten blocks of acquisition trials or five blocks of extinction trials. A Neuman-Keuls procedure was used to test for differences significant at the .05 level among the set of four group means when warranted by a significant F ratio.

Running speeds for the four groups in the precue segment showed a significant increase across trials ($F = 54.39$, $df = 9$ and 243 , $p < .001$), but a nonsignificant difference among groups ($F = 1.33$, $df = 3$ and 27 , $p > .05$). The performance curves have the general shape of the negatively

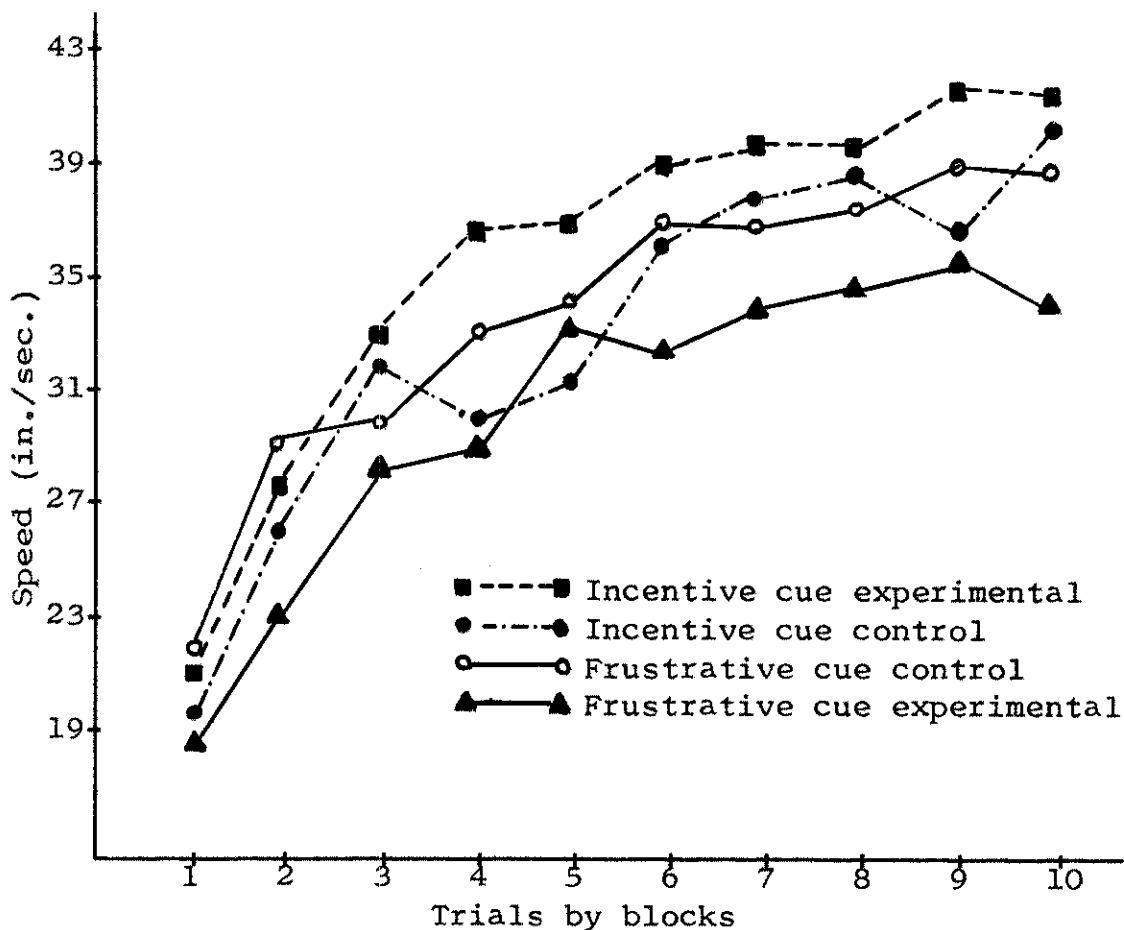


Fig. 1. Mean running speed in precue segment during acquisition training.

accelerated increasing monotonic function characteristic of rats running in a straight alleyway apparatus as shown in Figure 1.

The results of the analysis of variance of running speeds in the cue segment indicated a significant difference among groups ($F = 3.19$, $df = 3$ and 27 , $p < .05$), a significant interaction (Group X Trials, $F = 1.89$, $df = 27$ and 243 , $p < .01$) and a significant trials effect ($F = 135.29$, $df = 9$

and 243, $p < .001$). As indicated in Figure 2, the incentive cue and frustrative cue groups evidenced an apparent divergence of their mean performance beginning between trial

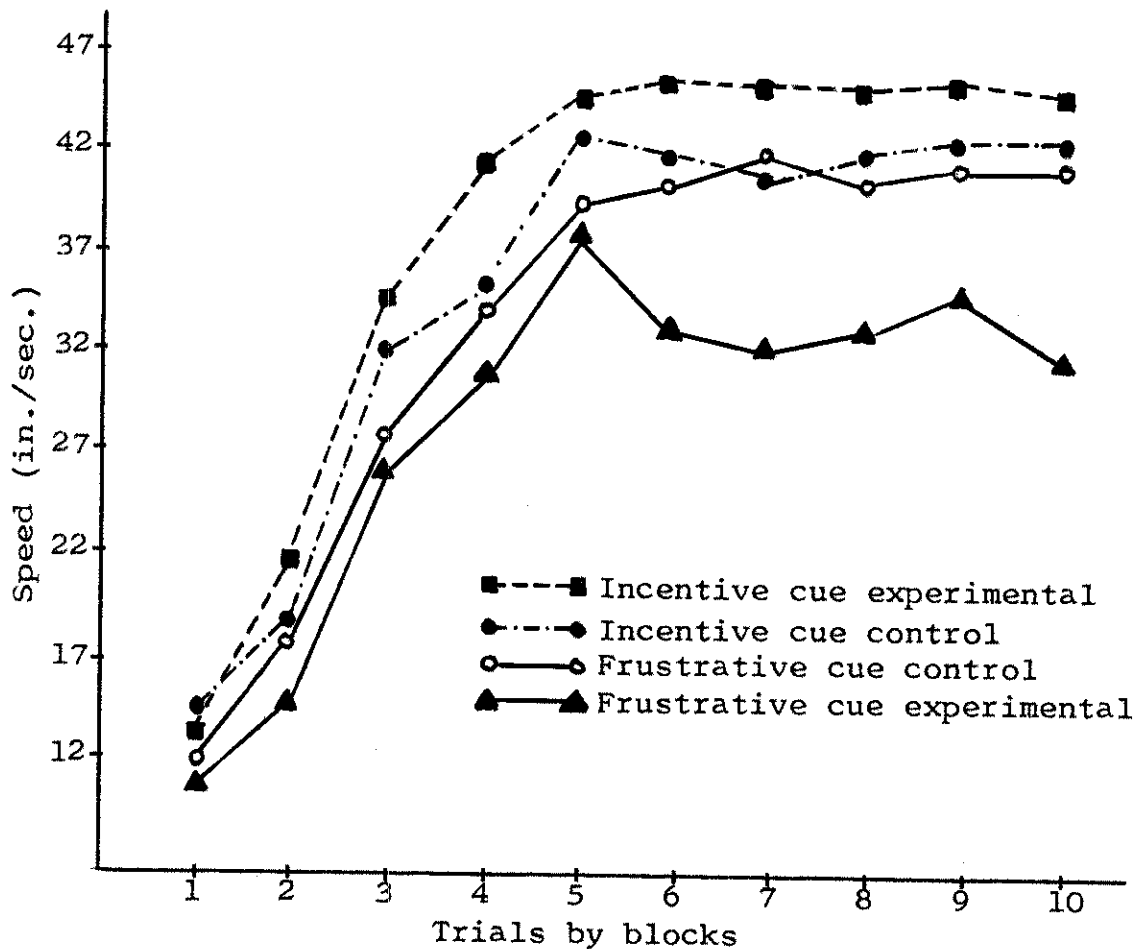


Fig. 2. Mean running speed in cue segment during acquisition training.

blocks 5 and 6. For trial block 6 a significant difference was obtained for group means ($F = 4.12$, $df = 3$ and 27 , $p < .05$) and differences remained significant throughout the remainder of trials. Neuman-Keuls tests revealed the

incentive and frustrative groups maintained significant differences for trial blocks 6 through 10 with the frustrative cue group running slower than the incentive cue group for the last half of the training trials. However, only for trial blocks 9 and 10 did the frustrative group demonstrate significantly slower running speed than its control group. Statistical evidence did not support a conclusion that the incentive group ran significantly faster than the controls or that the control groups differed in criterion performance.

Running speeds for the incentive and frustrative cue groups differed earlier in training when speeds were measured in the postcue segment. The analysis of variance resulted in significant F ratios for trials ($F = 105.70$, $df = 9$ and 243 , $p < .001$), for the interaction ($F = 1.53$, $df = 27$ and 243 , $p < .05$), and for groups ($F = 7.23$, $df = 3$ and 27 , $p < .001$). For trial block 3 the simple analysis of variance was significant ($F = 4.00$, $df = 3$ and 27 , $p < .05$). All F ratios for subsequent blocks of trials were significant at the .05 level and the Neuman-Keuls test revealed the difference between the mean speeds of the incentive and frustrative groups attained statistical significance at trial block 3. This difference was maintained throughout the remaining trials with the frustrative group running slower than the

incentive group. Only for the trial blocks 6, 7, and 8 did the incentive group run faster than the two control groups. And similar to its performance in the cue segment the frustrative group's mean speed was significantly less than the two control groups on trial blocks 9 and 10. The performance curves are shown in Figure 3.

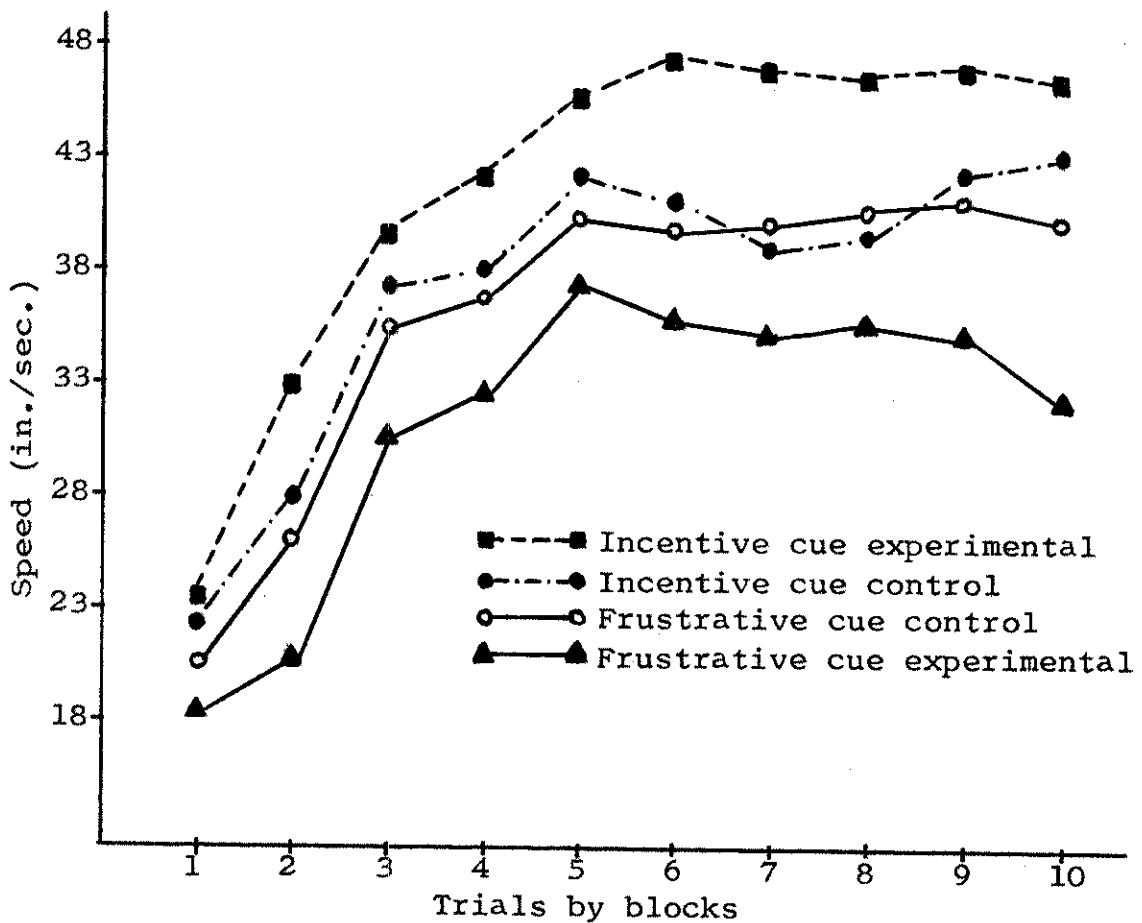


Fig. 3. Mean running speed in postcue segment during acquisition training.

When the total speed for the three segments was computed a significant F ratio was obtained for trials ($F = 102.31$,

$df = 9$ and 243 , $p < .001$), but a nonsignificant interaction ($F = 1.50$, $df = 27$ and 243 , $p < .06$) and a nonsignificant group effect ($F = 2.77$, $df = 3$ and 27 , $p < .06$) were found.

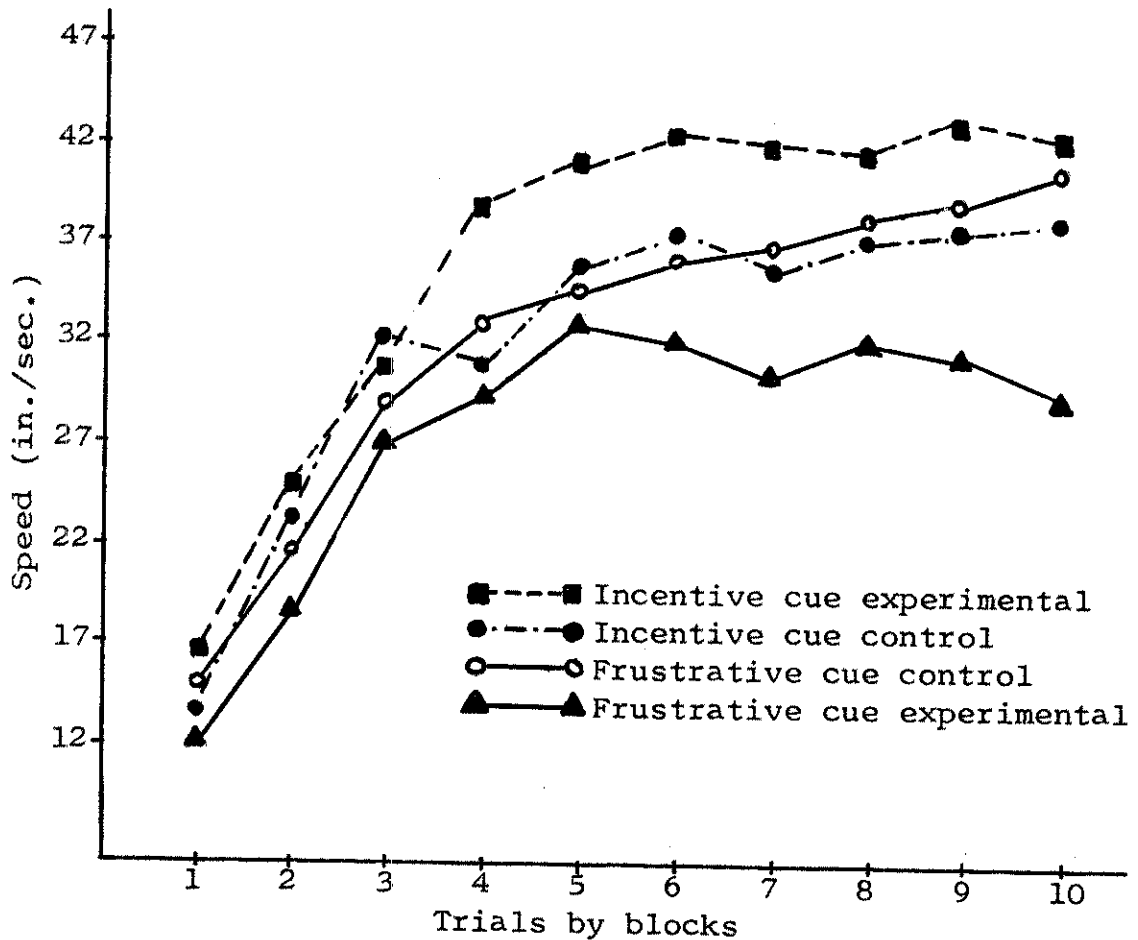


Fig. 4. Mean total running speed during acquisition training.

These nonsignificant F ratios did not reach their critical values perhaps through the effect of the precue performance levels wherein groups did not widely differ. The total variation of running speeds was not of primary importance since sequential components of the alleyway response were

analysed as subunits, thereby providing more information. Overall performance is shown in Figure 4.

The data for extinction is presented in Figures 5 through 8. A simple analysis of variance indicated that no significant mean speed changes occurred between the end of

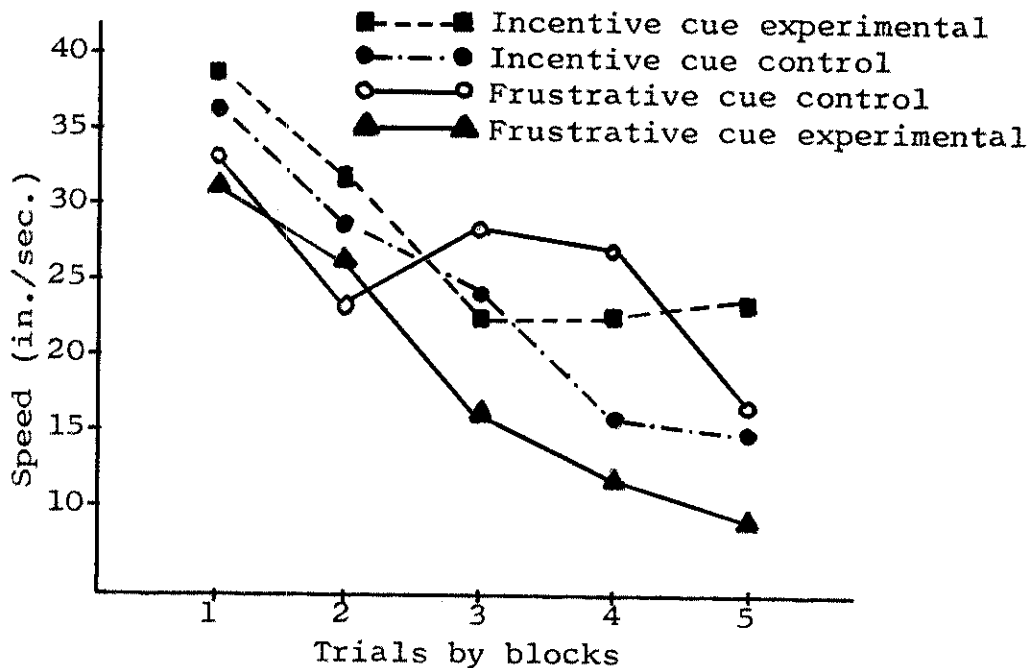


Fig. 5. Mean running speed in precue segment during extinction trials.

training and the beginning of extinction ($F = 2.27$, $df = 1$ and 60 , $p > .05$). For precue running during extinction an expected decline in speed over trials was found ($F = 42.07$, $df = 4$ and 108 , $p < .001$), with an interaction (Groups X Trials, $F = 1.93$, $df = 12$ and 108 , $p < .05$) but no group effect ($F = 1.31$, $df = 3$ and 27 , $p > .05$). The significant

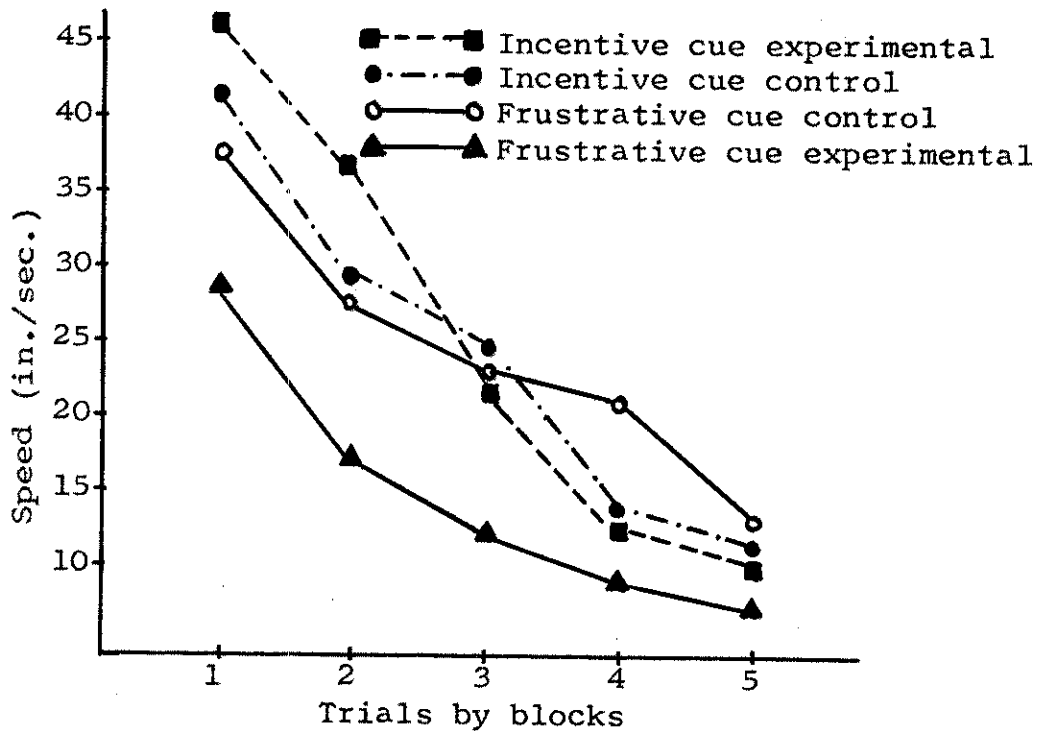


Fig. 6. Mean running speed in cue segment during extinction trials.

interaction could be accounted for by the fact that the frustrative group was significantly slower than the incentive group only for trial block 5 as revealed by the Neuman-Keuls test.

The overall effect for trials was found to be significant for the cue segment ($F = 87.67$, $df = 4$ and 108 , $p < .001$), for the postcue segment ($F = 72.02$, $df = 4$ and 108 , $p < .001$), and for the total running speed ($F = 87.63$, $df = 4$ and 108 , $p < .001$); however, nonsignificant differences among groups were found for the cue segment ($F = 2.32$, $df = 3$ and 27 ,

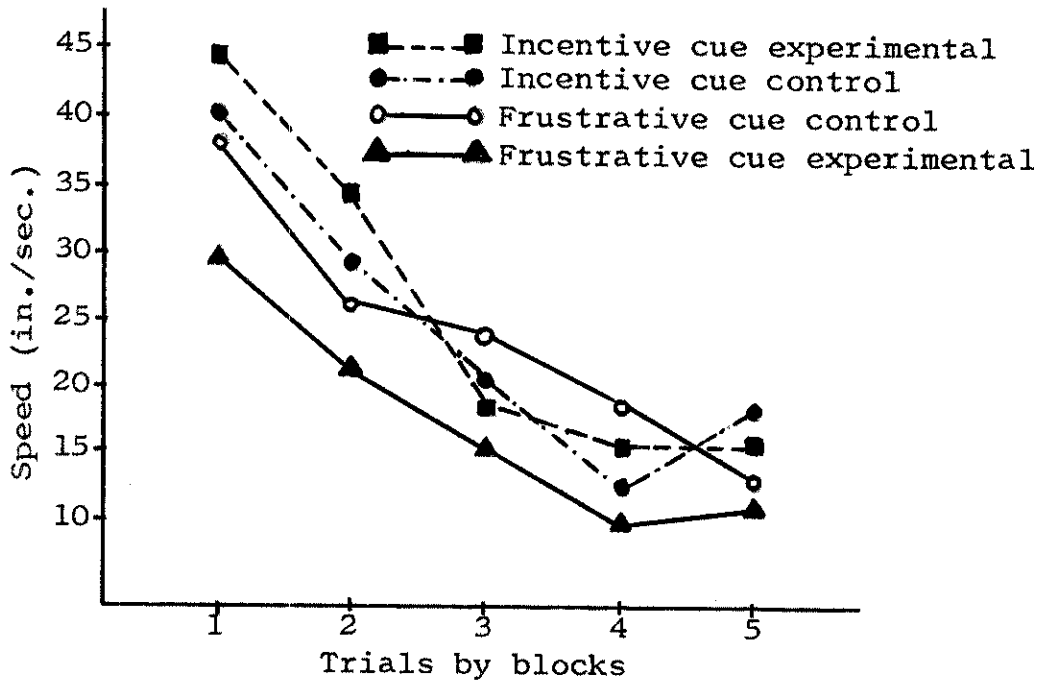


Fig. 7. Mean running speed in postcue segment during extinction trials.

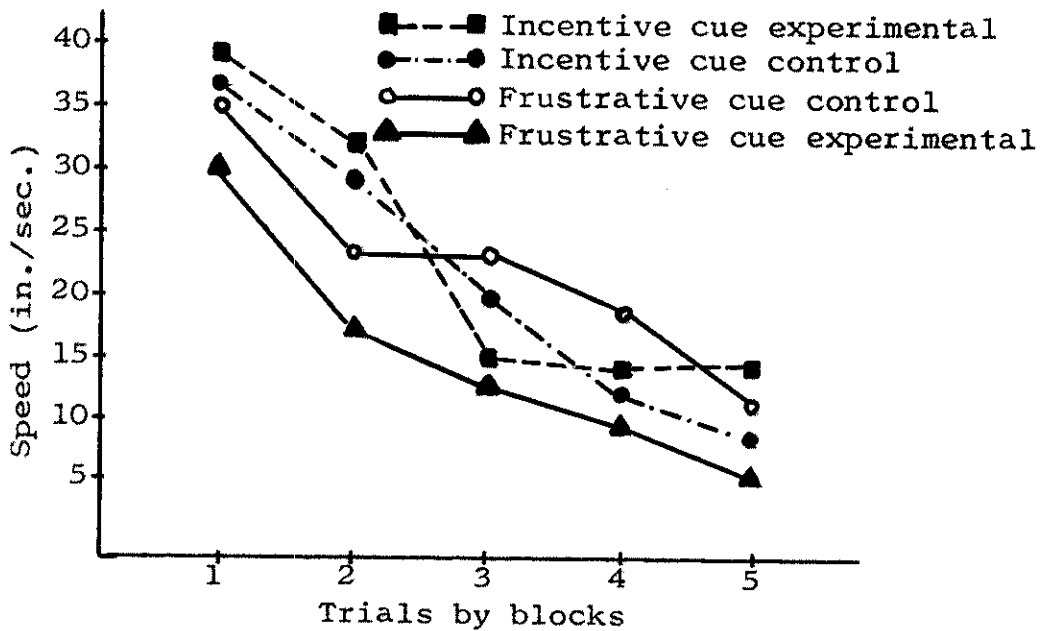


Fig. 8. Mean total running speed during extinction trials.

$p > .05$), the postcue segment ($F = 1.69$, $df = 3$ and 27 , $p > .05$) and the total ($F = 7.39$, $df = 3$ and 27 , $p > .05$).

The only interaction found to be significant was for the cue segment (Group X Trials, $F = 1.99$, $df = 12$ and 108 , $p < .05$), but no significant differences in mean speeds were detected with simple analyses of variance for each block of trials. While the incentive group appeared to be more resistant to extinction when the precue speeds are considered, the failure

TABLE I

PEARSON PRODUCT-MOMENT CORRELATIONS FOR DIFFERENCES BETWEEN INCENTIVE CUE GROUP SPEED AND MEAN CONTROL SPEED PER TRIAL BLOCK AND FRUSTRATIVE CUE GROUP SPEED AND MEAN CONTROL SPEED PER TRIAL BLOCK

Segment	Differences	Pearson's r	t
Cue	Incentive cue group - mean controls	.72	2.91*
Cue	Frustrative cue group - mean controls	.90	5.94**
Postcue	Incentive cue group - mean controls	.74	13.30**
Postcue	Frustrative cue group - mean controls	.69	2.66*

* $p < .05$

** $p < .001$

to find the same relationship in the other segments suggests that none of the four groups evidenced any differential resistance to extinction.

In order to establish the relationship between the control and experimental groups for the cue and postcue segments during acquisition, the mean speeds per trial block for the two control groups were averaged. The difference in speed per trial block between each experimental group and the mean control speed was computed, and the difference

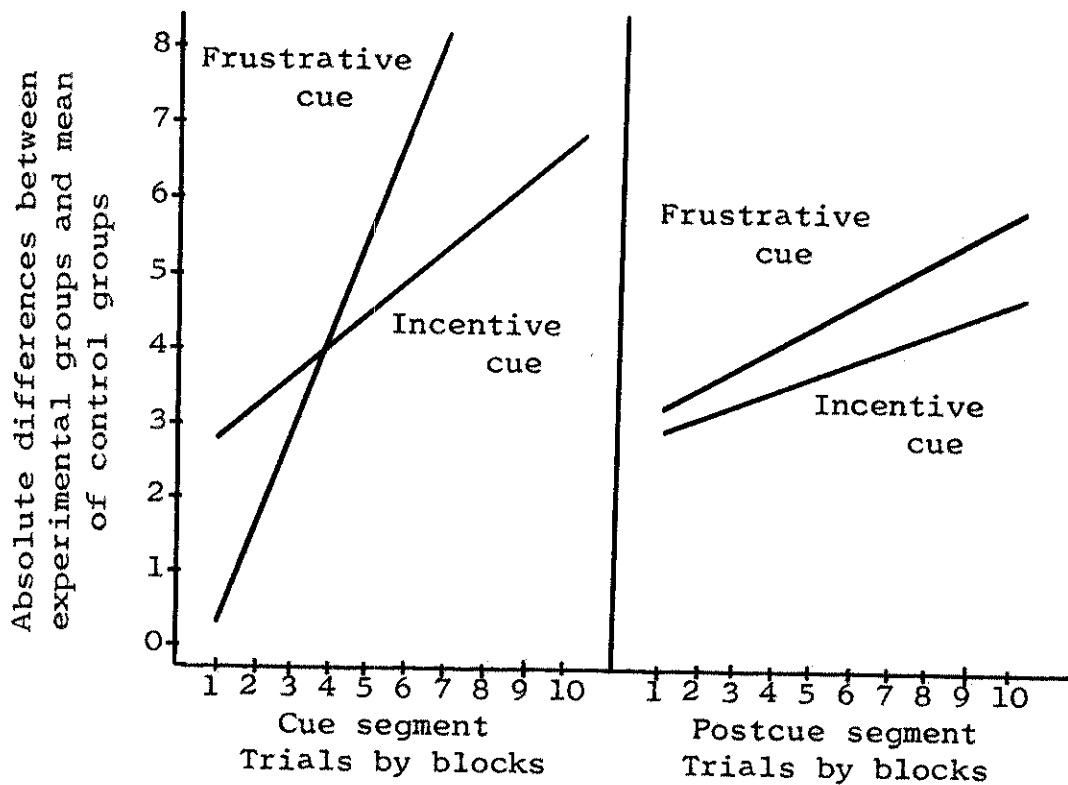


Fig. 9. Absolute differences between speed of each experimental group and mean speed of controls by blocks of trials for the cue and postcue alleyway segments.

correlated with blocks of trials. The results are shown in Table I. The correlations suggest a linear relationship between speed differences for the experimentals and controls as acquisition training progressed. The regression lines are shown in Figure 9.

Discussion

The results of this study established that during the pretraining phase the subjects in the experimental groups did attend to the cues and that the differential performance for the incentive cue and frustrative cue groups was attributable to the effects elicited by the cues in the training situation. The hypothesized directions of change of responding were supported by the results but the effects of the cues interacted with other learning occurring in the training phase. Longstreth hypothesized that both kinds of cues act to increase drive and "(strengthen) concurrent and immediately subsequent responses" (1970, p. 338). As defined by Longstreth, an incentive cue is considered to have a directive effect in that it elicits approach behavior towards the cue, while a frustrative cue results in the elicitation of avoidance responses in relation to the cue. These functions as assumed by Longstreth imply an identity in terms of drive effects and symmetrical but opposite effects in terms of associative effects. The data obtained in this study are at variance with these assumptions.

When responses occurring between the start box and the cue were considered, the groups which had experienced a cue

with contingent reward did not appreciably differ in performance from the control groups which experienced the cue in no predictive relationship to reward. Whatever effects the cue had as training progressed must be assumed to have affected all groups equally in the precue segment, but no differential effects due to pretraining were evidenced.

The effects of the cues were present in the cue segment, although they were subtle and not readily apparent. The performance curves are almost parallel for the first twenty trials, with the incentive group running faster than the controls and the frustrative group running slower than the controls. However, statistically significant differences did not occur until after the twentieth trial. If the controls are considered to provide a parametric performance curve for all the unique variables (e.g., species of rat, deprivation level, reward magnitude, ambient stimuli) operative in this alleyway segment, then the two experimental groups may be considered to deviate from the controls in some systematic and accountable way on the basis of their prior experience with the cue stimuli. As shown in Figure 9, the differences between the performance of each experimental group and the controls in the cue segment is accounted for by a linear function which may be considered to express the

growth of incentive and frustration as training progressed. Appreciable motivating and depressing effects were not reached until the last trials in training, and these effects did not make a sudden appearance and increased in magnitude over trials. Contrary to an implication of one of the hypotheses advanced prior to experimentation, the operation of the cues was not conspicuously apparent early in the acquisition phase. The subjects terminated the pretraining phase with a basic locomoting response associated with some of the ambient stimulus aspects of the apparatus. In the training situation the animal was responding to a new set of response requirements and was attending to new temporal, spatial and proprioceptive stimuli. Faced with the new learning requirements in the training phase, the components of the existing running response were altered and refined and were associated with numerous new interoceptive and exteroceptive stimuli. The frustrative and incentive cues were only one aspect of the total stimulus complex controlling responding in the training phase, and accordingly the cues exerted a proportionately small effect during the early phase of training.

In the case of the incentive cue, its signalling of reward may be considered redundant since the subject was

learning the CRF contingency of the training phase independent of the cue. The cue apparently had some motivating effect but not an appreciable amount, perhaps because it was no more salient than other alleyway stimuli. The argument for redundancy also gains support from the fact that the variability of differences associated with the incentive cue regression line was greater than that for the frustrative cue group. A redundant stimulus would be expected to show more chance variation in its effect than a non-redundant (informative) stimulus.

The frustrative cue appears to have had a more pronounced relationship to the developing alleyway response. The learning of new stimulus-response associations in the training phase may be considered to have progressed for the frustrative cue group as for the other groups: the subject learned reward was available and learned the responses required to obtain it. However, the subject entered the training phase with an expectancy that the occurrence of the cue signalled the immediate availability of reward. During the training phase the animal learned that stimuli ambient to the cue signalled the later availability of reward. Successive encounters with the cue in training resulted in the increase in conflicting expectancies. At the later

stages of training a strong expectancy of reward in the goal box was subject to interference from the previously learned expectancy that reward was located at the black or white stimulus. The last blocks of trials evidenced the statistically significant depression of response rate as a result of this conflict while the controls continued to respond at apparent asymptote.

When the regression line relating trials to differences between the frustrative cue group and the controls is considered for the cue segment, the variability of differences about that line is much less than the incentive cue regression line. Whatever reaction the frustrative cue evoked shows a markedly consistent effect, opposite to that evoked by the incentive cue and greater in magnitude after the fourth trial block.

Response rates in the postcue segment showed both a carry-over of motivational effects elicited in the cue segment and the appearance of additional motivational effects evoked by goal box stimuli. As shown in Figure 9, the contribution to the differences between the experimental and control groups by the cues was less pronounced in the postcue segment than in the cue segment. During early trials the motivating cues had greater influence in the postcue segment

than in the cue segment, but increases in performance in the cue segment as a function of the motivational cues surpassed the increases in the postcue segment during later trials. These findings are to be expected, since the depressing and facilitating effects perseverated for a brief period beyond the actual stimulus but were reduced in effectiveness by the immediate goal box cues to reward.

Incentive effects in the postcue segment evidenced approximately the same rate of change and the same range of magnitude when compared to the incentive cue effects in the cue segment. However, the effects of frustration were much more attenuated in the postcue segment, indicating that expectancy conflict was more pronounced when stimuli eliciting the conflicting expectancies were both present. Although stimulus traces of the inhibiting cue were probably present as the animal traversed the last portion of the alleyway, the immediate goal box cues were more salient and minimized their inhibiting effects. That the frustrative stimulus effects were subject to more chance variation in the postcue segment is shown by the increase in variability of the differences between the controls and the frustrative cue group (Table I).

The extinction trials produced no strong conflicting evidence to refute the hypothesis that either of the experimental groups was more resistant to extinction. The data in this study indicate that removal of reinforcement makes ineffective any stimuli which previously had motivational properties when reward was still present in the goal box.

When motivating stimuli are considered in the context of an alleyway learning task, the effects of the cues are shown to be dependent upon the portion of the apparatus in which the behavior is monitored. The present findings indicate response changes occur most dramatically when the animal is experiencing the cue, and that subsequent behavior during the trial is similarly affected but to a lesser degree. The shifts of the performance curves for the experimental groups may be explained by referring to Spence's formulation that variables affecting response strength combine in the following way:

$$R = f(E) = (D + K) \times H - I_t \quad (1)$$

where R = response strength, a function of excitatory potential; D = drive induced by deprivation; K = an incentive factor determined by the number of reinforced trials; H = habit strength, dependent on the number of alleyway runs; and I_t = inhibitory effects produced by delay of reinforcement

(Spence, 1956). Since D was held constant for all subjects in this study, equation (1) can be reduced to:

$$R = f(E) = KH - I_t \quad (2)$$

By using equation (2) the results of this study can be readily interpreted. Spence conceived of the K and I_t as intervening variables which refer to quantitative aspects of the reinforcement. As used in this analysis, the I_t factor refers to an additional temporal factor introduced by the unique qualities of the alleyway cues.

The incentive group had the same number of encounters with each cue as did the controls, but twice as many reinforced encounters. The incentive group therefore entered the training situation with an r_g having a higher probability of occurrence when the cue was encountered than did the controls. Thus the pretraining provided some opportunity to the incentive group for the r_g to become conditioned to the cue stimulus in the alleyway while this process did not begin until training for the controls. Inhibition (I_t) due to unanticipated delay of reinforcement had a value of zero since the cue in both the pretraining and training phases was part of the alleyway stimulus complex and therefore occurred prior to reinforcement and consistently predicted the later availability of reinforcement.

As was the case for the incentive cue group, the frustrative cue group entered the training situation with the r_g preconditioned to the cue. In order to account for the depression in training trials' performance I_t is considered to be the inhibitory factor which has as its basis a delay of reinforcement. The frustrative cue originally signalled immediate reinforcement, but in the training phase comes to signal a delay of reinforcement (the time necessary to run from the cue into the goal box). As the animal learns the new alleyway response it also learns that a delay of reinforcement is now associated with the cue. As a result the animal's prior expectancy of reward at the cue (pretraining r_g) comes into conflict with the new expectancy (training r_g) that reward is gained by continuing to run for an additional amount of time. The conflict in expectancies is evidenced by a depression in response strength in the cue and postcue segments and is represented in the Spencian equation as I_t .

This inhibitory effect follows the same course of development as does the fractional anticipatory frustration reaction (Amsel, 1967). The fact that the inhibition in response did not occur until about the twentieth trial is

consistent with reports by Spence (1960) that the effects of frustration develop slowly, and is consistent with Amsel's hypothesis that an r_g must develop before the frustration reaction (r_f) becomes operative. This study was in part analogous to Amsel and Roussel's (1952) double alleyway experiment in which the animal encountered a frustrating event in one goal box before running into a second goal box. The analogue to the first goal box was the cue in this study but its effect on the frustrative cue group was not to increase response magnitude (the frustration effect) but just the opposite. The first goal box in Amsel and Roussel's procedure occasioned frustration only after an expectation of reward had become conditioned to it. Likewise in this study the frustrative cue was first conditioned to the immediate availability of reward but later signalled delay in reward. However, this experiment did not follow the double alleyway paradigm in one respect; that is, that no delay was imposed on the animal by the experimenter. For the conditions under which the frustrative cue was preconditioned, evocation of competing responses (e.g., stopping, searching for food, and other nonconsummatory goal box behaviors) appears to be the mechanism responsible for the response decrement in the training phase. Although the inhibitory

effect parallels its development with Amsel's frustration effect, the two can not be identified because they refer to different mediating processes.

All aspects of Longstreth's assumed functions of incentive and frustrative cues did not receive conclusive empirical support from this study. The incentive cue established according to his definition resulted in a statistically significant increase in running speed for three trial blocks in the postcue segment. This indicates responses subsequent to encountering the incentive stimulus were potentiated. However, this effect was transitory according to the statistical data. The failure to find statistically significant increases in running speed in the cue segment precludes a firm conclusion that behavior concurrent with the appearance of the cue was strengthened.

The fact that the incentive cue group always ran faster than the controls in all segments can not be ignored. The lack of statistically acceptable differences limits the degree to which the results can be generalized. The results themselves may be of value nevertheless in suggesting a methodological critique. The incentive value of the cue might have been better demonstrated if the cue were introduced into the alleyway after the alleyway response habit

had been well established. In this way the maximal effects of the incentive might have been shown since habit strength of the appropriate response would be close to asymptote.

The performance of the frustrative cue group did not suggest alterations in drive or avoidance behavior as hypothesized by Longstreth. In contrast to energizing ongoing behavior the effect of the cue appears to have been the elicitation of responses incompatible with the running response. The termination of training at forty trials may have left the animals in the frustrative cue group in an expectancy conflict similar to that described in Amsel's Stage 3 (Amsel, 1967, p. 8). A cautious speculation is advanced that with further trials the inhibitory effect would have extinguished. With the expectancy conflict resolved running speed should increase for the frustrative cue group.

With respect to the frustrative cue the experimental results are of particular interest. The decrements in running speed are opposite to the effects stated identically in both Longstreth's hypothesis and Amsel's formulations on the effects of frustration. The failure to have found the anticipatory frustration reaction and the frustration effect is made more acute when the similarities between this study

and Amsel's double alleyway experiment are considered. A replication of this design seeking to confirm the effects found for frustration, and incorporating modifications to demonstrate conclusive incentive effects, seems warranted.

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