CONTRIBUTIONS OF STIMULUS-INCENTIVE AND RESPONSE-INCENTIVE CONTINGENCIES TO ACQUISITION AND MAINTENANCE OF RESPONSES

by

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PREFACE

This thesis presents a detailed study of a fundamental theoretical question: Is a contingency or association between a conditioned stimulus and an incentive stimulus (CS:IS) the main basis of learning, or does a contingency between the response and an incentive stimulus (R:IS) also contribute something to learning? In the two experiments conducted to explore this question, I was able to come to certain conclusions not previously known or explicitly stated. These are: (1) Auto-shaping can be achieved in the rat when the CS and the manipulandum are the same stimulus object. (2) Probability of response is highly resistant to omission training while frequency of response is drastically and immediately reduced at the introduction of the omission procedure. (3) There is no difference between the respective effects of CS:IS and CS:R:IS contingencies on the temporal distribution of response. (4) The usual greater frequency of response produced by instrumental training than by autoshaping is the manifestation of a different spatial distribution of responses.

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CONTRIBUTIONS OF STIMULUS-INCENTIVE AND RESPONSE-INCENTIVE CONTINGENCIES TO ACQUISITION AND MAINTENANCE OF RESPONSE

Two experiments were performed to compare the effects of stimulus-incentive (CS:IS) contingency, stimulus-response-incentive (CS:R:IS) contingency, and stimulus-no-response-incentive (CS:$\overline{R}$:IS) contingency on the acquisition and maintenance of an instrumental approach response by rats. Results from the first experiment showed that (1) the CS:IS contingency and the CS:R:IS contingency did not produce different temporal distribution of responses, (2) the CS:R:IS contingency produced higher rates of responses than the CS:IS contingency, (3) the CS:$\overline{R}$:IS contingency did not produce complete extinction of already established responses. Results from the second experiment showed that the CS:R:IS contingency does not produce higher rates of response but rather a different spatial distribution of responses; responses were more centered on the CS panels than the responses produced by the CS:IS contingency. It is concluded that (1) the response-reinforcement principle is not necessary to explain the observed differences in the consequences of the CS:IS and CS:R:IS contingencies, and (2) the contribution that the R:IS contingency makes to response rate depends on an increase in the incentive value of the CS and not on "response-reinforcement".

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CONTRIBUTIONS DES CONTINGENCES STIMULUS-INCENTIF ET REPONSE-INCENTIF A L'ACQUISITION ET AU MAINTIEN DE LA REPONSE

Deux expériences ont été effectuées dans le but de comparer les effets des contingences stimulus-incentif (SC:SI), stimulus réponse-incentif (SC:R:SI) et stimulus-absence-de-réponse-incentif (SC:$\bar{R}$:SI) sur l'acquisition et le maintien d'une réponse instrumentale chez des rats. Les résultats de la première expérience ont démontré que (1) la distribution temporelle des réponses produites par la contingence SC:SI était semblable à celle produite par la contingence SC:R:SI, (2) la contingence SC:R:SI a produit un taux de réponses plus élevé que la contingence SC:SI, (3) la contingence SC:$\bar{R}$:SI n'a pas produit l'extinction complète des réponses déjà apprises. Les résultats de la seconde expérience ont démontré que la contingence SC:R:SI ne produit pas un taux de réponse plus élevé mais a plutôt l'effet de changer la distribution spatiale des réponses; les réponses sont alors plus centrées sur le SC que les réponses produites par la contingence SC:SI. Ces résultats permettent de conclure (1) qu'il n'est pas nécessaire d'invoquer le principe du renforcement de la réponse pour expliquer les différences observées dues aux conséquences de la contingence SC:SI et de la contingence SC:R:SI et (2) que la contribution de la contingence R:SI au taux de la réponse dépend d'une augmentation de la valeur incentive du SC.

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GENERAL DISCUSSION

INTRODUCTION

Reinforcement, the procedure of subjecting an animal to an appetitive or aversive incentive stimulus (IS) in a certain situation, usually has a marked effect on the subsequent behavior of the animal in that situation. The particular behavioral modification produced by reinforcement may be attributed to the contingency between the presentation of the incentive stimulus and either what the animal is doing at the time or what the animal is observing at the time. Correspondingly, some workers (e.g., Hull, 1943; Skinner, 1938) have interpreted learned behavior modifications in terms of response-incentive contingencies (R:IS), while others (e.g., Bindra, 1974; Mowrer, 1960; Pavlov, 1927) have regarded the contingencies between some critical or conditioned stimuli (CS) and the incentive stimulus (CS:IS). The former idea is frequently called the response-reinforcement principle, and the latter the incentive-motivational principle. Still others (e.g., Bolles, 1972; Estes, 1972; Mowrer, 1947; Rescorla & Solomon, 1967; Spence, 1960) have thought it necessary to invoke both the principles, that is both R:IS and CS:IS contingencies, for adequately explaining the phenomena of learning.

Since the beginning of this century the response-reinforcement principle has remained the most dominant idea in discussions of learning. Until recently, many workers in the field of learning seemed to accept, explicitly or implicitly, the assumption that response reinforcement is a necessary and sufficient condition for learning. Curiously, this assumption continued to be staunchly held throughout the mid-century despite the many reports of latent learning and sensory-preconditioning, which demonstrate learning without response reinforcement, as well as several reports of spontaneous response substitution and learning without responding, which demonstrate learning without the occurrence of the response that finally emerges from the training procedure (for a review, see Kimble, 1961).

Recently, however, the response-reinforcement principle has been called into question by several investigators whose own experimental work was carried out within the broad assumptions of this principle. Two points have been raised. One is that the response-reinforcement principle does not seem to be adequate for explaining many types of behavior modifications that occur during training with certain explicit response-reinforcement contingencies. Breland and Breland (1961) reported that sometimes, in the course of instrumental training, responses that were not reinforced occurred repeatedly and responses that were shaped or maintained by reinforcement failed or ceased to occur. For example, pigs starved to death by preferring the manipulandum that delivered the food to the food itself. Falk (1971), Segal (1972), and Staddon and Simmelhag (1971) reported that certain persisting irrelevant responses could be acquired and maintained during the inter-reinforcement interval of an instrumental training schedule, at the very moment when probability of reinforcement was at its lowest. Among these phenomena, called adjunctive behaviors (Falk, 1971) or induced operants (Segal, 1972), are polydipsia (Falk, 1969), air-drinking (Mendelson & Chillag, 1971) pica (Villareal, 1967), and wheel running (Segal, 1969). These phenomena and their implications have been reviewed by Segal (1972). At the minimum, these findings suggest that some additional principle is required to supplement the response-reinforcement principle; in other words, the response reinforcement principle may not be a sufficient condition for several types of learned behavior modifications.

The second point arises from the findings that specific and stable responses, which are "operants" or "instrumental" responses in the sense that they are "emitted" and are not unconditioned "elicited" responses, may be shaped in the absence of any explicit response-incentive (R:IS) contingency. For example, the mere exposure of an animal to a conditioned stimulus-incentive stimulus contingency (CS:IS), as in the classical conditioning procedure, is sufficient to initiate and maintain operant pecking in the absence of an explicit positive R:IS contingency (Brown & Jenkins, 1968; Zener, 1937), or even in the presence of a negative R:IS contingency (Williams & Williams, 1969). These findings indicate that, at least under certain conditions, the CS:IS contingency alone may be sufficient for the emergence and maintenance of new responses; in other words, the response reinforcement may not be a necessary condition for certain instances of learned behavior modification.

The general question raised by the type of experimental results described above is this: What are the contributions of CS:IS and R:IS contingencies to the development of stable responses in different types of training procedures? Here we examine this question in the light of available findings and theoretical ideas.

The Plan

Our plan here is to classify training procedures in terms of the possible involvement of R:IS and CS:IS contingencies, and then to examine the critical evidence bearing on the contributions of the two contingencies in producing the training outcomes of some of the more common procedures. The classification scheme is presented in Table 1. For convenience we deal with procedures involving appetitive incentive stimuli only.

Each cell in Table 1 refers to a class of training paradigms, defined by the arrangement of a certain CS:IS contingency (columns) and a certain R:IS contingency (rows). Either or both of the contingencies may be positive (CS:IS or R:IS), indicating an increase in the probability of reinforcement above the prevailing (background) probability of reinforcement (incentive stimulation) before CS or R. Either or both of the contingencies may be negative ($\overline{CS}$:IS or $\overline{R}$:IS), indicating a

Table 1

Classification of some Appetitive Training Procedures According to the Stimulus-Incentive and Response-Incentive Contingencies. (See note below.)

		CS:IS CONTINGENCY		
		POSITIVE	UNSPECIFIED	NEGATIVE
R:IS CONTINGENCY	POSITIVE	1. CS:IS and R:IS Instrumental training with signaled reward.	2. CS:IS? and R:IS (a) Simple instrumental training ("Shaping") (b) Superstition Procedure II (Morse & Skinner, 1958).	3. $\overline{\text{CS}}$:IS and R:IS Instrumental training with with signaled penalty.
	UNSPECIFIED	4. CS:IS and R:IS? Autoshaping (Brown & Jenkins, 1968).	5. CS:IS? and R:IS? (a) Superstition Procedure I (Skinner, 1948) (b) Random control (Rescorla, 1967).	6. $\overline{\text{CS}}$:IS and R:IS? Conditioned Inhibition (Rescorla, 1969).
	NEGATIVE	7. CS:IS and $\overline{\text{R}}$:IS (a) Negative auto-maintenance (Williams, 1969) (b) Omission (Sheffield, 1965).	8. CS:IS? and $\overline{\text{R}}$:IS Response-penalty training.	9. $\overline{\text{CS}}$:IS and $\overline{\text{R}}$:IS (a) Intertrial Interval (b) Extinction.

Note: IS is assumed to be an appetitive incentive stimulus. CS:IS or R:IS means an increase in the probability of IS presentation above the prevailing background probability of IS presentation. $\overline{\text{CS}}$:IS or $\overline{\text{R}}$:IS means a decrease in the probability of IS presentation below the prevailing background probability of IS presentation. CS:IS? or R:IS? means that the change in the probability of IS presentation is unspecified. See text for further explanation.

decrease in the probability of reinforcement below the prevailing probability before CS or R. And either or both of the contingencies may be unspecified (CS:IS?), indicating either no change in the probability of reinforcement (null contingency) or the operation of some unintended, adventitious contingency.

A couple of examples would help to clarify the table. Consider Cell 2, where the assumed contingencies are CS:IS? and R:IS. This contingency constellation describes two known procedures: (a) shaping by trainer, and (b) superstition training, type II. In shaping by trainer, there is no specified CS and thus no specified CS:IS contingency but there is a specified response and a specified positive R:IS contingency. In superstition training, type II, there is a specified stimulus, but no specified CS:IS contingency, and there is a specified response and a specified positive R:IS contingency (Morse & Skinner, 1958). Next consider Cell 5, where both contingencies are unspecified. This contingency constellation describes (a) superstition, type I, and (b) a random procedure. In superstition training, type I, there is no specified CS and thus no specified CS:IS contingency, and there is no specified response and thus no specified R:IS contingency (Skinner, 1948). In the random procedure, there is a specified stimulus, but no specified CS:IS contingency, and since there is no specified response there is no specified R:IS contingency (Rescorla, 1967).

Of the several training paradigms represented in Table 1, we have selected four for detailed examination in order to assess the relative contributions of CS:IS and R:IS in the type of modifications of behavior produced in these procedures. The four paradigms are: "autoshaping" (Cell 4), "omission" (Cell 7), "superstition" (Cell 5) and "shaping" (Cell 2); the last two will be discussed together. The current work with these procedures offers the most direct evidence on the question of the relative contributions of CS:IS and R:IS contingencies to learned modifications of behavior.

The Autoshaping Procedure

In the autoshaping procedure, there is a positive CS:IS contingency and an unspecified R:IS contingency (see Table 1). The probability of IS is increased (for a brief period) following the presentation of the conditioned stimulus (CS) and IS is presented without regard to the behavior of the animal. This means that the presentation of IS is stimulus-contingent and supposedly response-independent. As in discrimination training, a response given during the presentation of the positive discriminative stimulus, is followed (with or without a delay) by the presentation of the IS, but unlike discrimination training, the absence of the same response may also be followed by the presentation of the IS. Since IS is not contingent on any response, no response is specified and the investigator may simply observe what, if any consistent responses emerge with this type of training.

Basic Findings

Brown and Jenkins (1968) observed that non-restrained hungry pigeons developed the response of approaching and pecking an intermittently presented key-light (CS) which had been consistently followed by access to grain. Their most successful procedure was the forward pairing (light-food) of a relatively short light presentation (3 sec. or 8 sec.) against a background (intertrial) of no light or of a light of a different color. The least successful procedures were a backward pairing of light and food, presentation of the light only, or presence of a constantly illuminated light, and a forward pairing of a light that was turned off during a trial against a background of illuminated light. In all but one experiment, a peck during the CS period terminated the CS and operated the food tray. The main interest of these experiments was on the time required (in terms of the number of trials) for "autoshaping"--the emergence of the first response--before that response could be influenced by any accidental R:IS pairing. The mean trial of the first peck for forward CS-IS pairing was 45 and all 36 subjects emitted their first peck within 119 trials. With backward CS-IS pairing, only 2 of the 12 subjects emitted their first peck within 160 trials (at respectively the 50th and 57th trial). In one of their procedures, where key-pecks had no effects either on the CS duration or on the time of food delivery (fixed-trial condition), responding throughout the 8-sec. trial was readily acquired by all 12 pigeons and maintained at high rates in 5 of them. Thus Brown and Jenkins demonstrated both autoshaping and maintenance of high rate of response in the absence of any explicit R:IS contingency.

In order to show that the emergence and repeated performance of a response in the autoshaping procedure is dependent on CS:IS contingency, it is necessary to have a control group in which CS and IS are presented but not in the forward pairing. The absence of autoshaping in the case of backward pairing (Brown & Jenkins, 1968) shows that CS:IS contingency contributed to autoshaping in the forward pairing conditions. A more general control procedure is that of employing a "truly random group," in which the CS and IS are presented independently (Rescorla, 1967). With such appropriate controls, reliable autoshaping has been demonstrated in several species. These include pigeons (Williams & Williams, 1969), rats (Peterson, Ackil, Frommer, & Hearst, 1972; Myer & Hull, 1974; Stiers & Silberberg, 1974), chicks (Wasserman, 1973b), and squirrel monkeys (Gamzu & Schwam, 1974). Other claims of autoshaping but that lack the proper control procedures include dogs (Smith & Smith, 1971), rats (Powell, Saunders, & Thompson, 1968; Hardy, Hochstetter, & Parker, 1974), bobwhite quails (Gardner, 1969), rhesus monkeys (Sidman & Fletcher, 1968), fish (Squier, 1969) and children (Zeiler, 1972).

Before considering the conditions that determine what the outcomes of an autoshaping procedure will be, it is important to draw attention to one feature of this procedure. What is called the "conditioned stimulus" in the autoshaping procedure (e.g., the key-light in the Brown & Jenkins' experiment), serves not only as the conditioned or positive discriminative stimulus (CS or S^D) which signals food, but also as the manipulandum in relation to which the response is performed and measured. Thus, the same location in the training situation provides the training stimulus complex which serves as the CS or SD, and the eliciting stimulus complex (ES) which elicits or contributes to the approach and pecking response. This identity or proximity of the locations of CS and ES appears to be an important condition for successful autoshaping. In the usual mammalian training situation, the CS (or S^D) and the ES (or manipulandum) are separated temporally or spatially, or both. In the training situation usually employed with birds, however, the locations of CS and ES are the same. It is no surprise then that the phenomenon of autoshaping was first clearly demonstrated in birds, and for some time it was doubted that it could be demonstrated in rats and other mammals.

Efficacy of the Procedure

The conditions that determine the efficacy of the autoshaping procedure are related mainly to the salience of the CS, that is, its spatial and temporal discriminability, and to the salience of the CS:IS relation.

Brown and Jenkins (1968) found that lengths of key-light of 3-sec. and 8-sec. conditions did not differ in the production of the first peck. Ricci (1973) used conditioned stimuli that were 30 and 120 sec. long; these stimuli were simple or divided into four equal components of different colors. Birds began to peck significantly sooner on the 30-sec. stimulus than on the 120-sec. stimulus. There was also a tendency to peck sooner in the four-component stimulus under both CS-duration conditions. However, there was no significant difference in the mean rates of pecking after 15 sessions between groups given trials with different CS durations.

Terrace, Gibbon, Farrel and Baldock (in press) varied the average intertrial interval between 5 sec. and 400 sec. and found a correlation coefficient of -.97 between the value of the log of mean inter-stimulus interval and the log of median number of trials before the first pecking response.

There is thus a tendency for the emergence of the pecking response to be facilitated by shorter conditioned stimuli and longer intertrial intervals. Both these conditions increase the temporal salience of the conditioned stimulus.

The spatial salience of the CS is also an important factor in the determination of the response; when the stimulus that signals the incentive stimulus stands out from the background of the experimental chamber, responding develops quite readily. For example, if the houselight of the experimental chamber is turned off, the illumination of the key-light may spread in the dark chamber, thereby increasing the visual stimuli that are positively correlated with incentive. Wasserman (1973a) has shown, in such a situation, that the pigeon does not acquire the key-light response or does not maintain it but rather displays different sorts of "superstitious" responses or movements directed toward a variety of features of the experimental chamber. A circumscribed stimulus with sharp contours--a clear figure on the background--makes an effective CS in autoshaping.

Is the sensory modality to which the CS belongs an important variable? In an experiment reported by Hearst and Jenkins (1974), Jenkins used as a CS a white noise that came randomly from one of two loudspeakers, each one located behind a constantly illuminated response panel. Jenkins found that pigeons moved toward the sounding speaker in the autoshaping condition on a significant numbers of trials but not in the random control condition. However, the percentage of trials on which pecking responses occurred in the autoshaping condition was much lower and more variable than with a visual CS (Brown & Jenkins, 1968). Hearst and Jenkins suggest that auditory signals are less efficient than visual signals in eliciting approach and contact responses: "possibly, the sound acted as a signal for when to approach the visually salient keys but the approach was to the key, not to the sound source itself." (Hearst & Jenkins, 1974, p. 9). Since a sound, even when it comes from a localized source, spreads and envelops the animal (like the diffused light in the experiment described above), the lesser efficacy of a sound may reflect not a modality difference but one of dispersion.

That such S^D properties can be acquired by a sound has been shown by Schwartz (1973). He used a tone that was spatially separated from the illuminated response key and got responding on the key, but after a very special sequence of training. He trained pigeons on a response-independent multiple schedule where a VI component was announced by a green key and an extinction (EXT) component announced by a red key. Pigeons came to peck the green key during the VI component and not to peck the red key during the EXT component. Then, in a second condition, the EXT component was announced by a green key, like the VI component. All pigeons stopped pecking. In a third condition, a tone was added to the VI component (TONE and GREEN) with the hope that it could acquire a signal value. It did not; pecking was not resumed. The first condition was then repeated (GREEN VI, RED EXT), and pecking resumed. In the next condition, the tone was added again to the green component, but this time the EXT component stayed red. Pecking persisted. Then, as in the third condition, the tone was the only signal for food, both components being green; this time, pecking was not suppressed. Apparently the tone had become an SD. Thus, once responding had been maintained in the presence of the tone, it could subsequently be generated by the tone. But the initial emergence of the response was not possible with spatially separated tone-source and response key. Schwartz also observed that each time the tone was presented in a new procedure, all pigeons oriented toward the tone, but that behavior faded after the first few sessions. These findings are consistent with the idea that the emergence of responding in relation to an auditory stimulus is determined by signal salience, as determined by its location-specificity.

Apart from the signal-salience of the CS, the precise CS:IS contingency is also an important determiner of the efficacy of an autoshaping procedure. Gamzu and Williams (1971) have shown that the mere temporal association (or simple contiguity) between the stimulus and the incentive is not sufficient to develop responding. What seems to be essential is a contrast between the stimulus that signals incentive and some stimulus or stimulus complex that signals the nonpresentation of incentive.

Instead of using the CS to signal the precise time of presentation of the incentive as did Brown and Jenkins (1968), Gamzu and Williams (1971) made the presentation of the reinforcer equally probable at each second of the CS duration (illumination of a disk). The duration of CS was 8.6 seconds, and successive CS presentations were separated by a mean intertrial interval of 30 seconds. The probability of incentive (grain) presentation was .03 at each second of CS duration, which means an average of once every 33 seconds. An average of 13 reinforcements was given during the 50 daily trials. The four pigeons used as subjects began to peck after a few sessions and maintained or increased responding in the subsequent sessions. However, when Gamzu and Williams presented the incentive at the same probability during the intertrial interval as during the illumination of the key, all pigeons soon stopped pecking during the illumination of the key. There was also no pecking during the intertrial interval. When the prior differential condition was reinstated after 15 non-differential sessions, pecking rapidly recovered its previous levels. Another group of naive birds exposed to 14 daily sessions of non-differential condition failed to develop key-pecking. These results clearly contradict any statement that the probability of response is solely determined by the response-reinforcer contingency. If this were the case, then responding on the illuminated panel should have persisted during the non-differential condition, when the only procedural change was the presentation of grain during the intertrial interval.

Clearly, the contiguous presentation of the stimulus (key-light) and the reinforcer was not sufficient to develop or maintain pecking on the key-light. The CS:IS relation, to be effective, must be contrasted against a no-CS no-incentive $(\overline{CS}:\overline{IS})$ background. In other words, the probability of presentation of the incentive must be higher in the presence of the CS than during its absence to obtain responding on that stimulus. For Gamzu and Williams, it is the "informational properties of the stimulus, rather than its mere association with feeding, that are responsible....for acquisition or sustained maintenance of behavior" (Gamzu & Williams, 1971, p. 925). The Gamzu and Williams (1971) procedure is similar to a two-component multiple schedule of response-independent reinforcement. The first component, of a fixed duration, was associated with an illuminated key, and the second component, of a variable duration, was associated with the absence of illumination of the same light. The differential condition in the above described experiment of Gamzu and Williams would be then a MULT VT 33, EXT and the non-differential condition a MULT VT 33, VT 33. Gamzu and Schwartz (1973) used a more regular multiple schedule, where both components were of equal duration and associated with a light of a different color. In the differential procedure, the two components were of a different schedule (VT 33, EXT or VT 33, VT 100) and in the non-differential procedure, the two components were identical (VT 33, VT 33 or VT 100). They found that responding was increased or maintained only in the differential procedures, and that rates of pecking were usually higher during the component of the color associated with a higher density of reinforcement. In the non-differential procedures, where reinforcement frequency was doubled, rates of response in both components decreased slowly over sessions; there was little difference in rates between components in the last three sessions of the non-differential conditions.

There is a noteworthy difference between some of the results obtained in the Gamzu and Schwartz (1973) experiment and the ones obtained by Gamzu and Williams (1971). Gamzu and Williams reported nearly no responding in either component during the non-differential condition. In the Gamzu and Schwartz experiment, the non-differential procedure did reduce responding in both components but did not suppress it over 24 daily sessions. As Gamzu and Williams proposed, there may be a stimulus generalization factor: using two lights of a different color may be less of a contrast than using the illumination and the non-illumination of the same light as did Gamzu and Williams (1971). It is also possible that a multiple schedule where the high value component is of a short and fixed length (that is, more salient), and the other component is longer and variable (as in Gamzu & Williams, 1971) will produce more contrast than a multiple schedule with two long and identical components (Gamzu & Schwartz, 1973).

The above evidence clearly indicates that, for autoshaping to occur, there must be differential training, a contrast between the environmental stimulus conditions present when an incentive stimulus is available at a certain probability and the environmental stimulus conditions present when the incentive stimulus is available at a lower probability. The differential training is made easier when the difference between the two stimulus conditions is made salient.

Form of the Response

According to Moore (1973), as well as Hearst and Jenkins (1974), the form of the response in the autoshaping procedure is determined largely by the nature of the unconditioned incentive stimulus. Jenkins and Moore (1973) studied the form of the pecking response to an illuminated key-light that preceded the presentation of food or water. The results showed (1) that the form of the response in water-deprived pigeons on a key-light preceding water presentation was similar to the consummatory drinking response, and (2) that the form of the response in food-deprived pigeons on a key-light preceding food presentation was similar to the consummatory eating response (Jenkins & Moore, 1973, Experiments I and II). In their most relevant experiments (Jenkins & Moore, 1973, Experiments IV and V), pigeons were deprived of both food and water to control the possible effects of deprivation on the form of the response and were concurrently trained on two different key-lights (in color, form, and location). One stimulus was paired with water and the other stimulus was paired with food. Trials with each stimulus were mixed in random order. Again most key-responses were of appropriate consummatory form: food CS's were "eaten" and water CS's were "drunk."

Rackham (1971;cited by Hearst and Jenkins, 1974) exposed male pigeons for 100 daily sessions, each consisting of one presentation of a key-light that preceded accessibility to a female pigeon, by the removal of a partition for 30 minutes. Accessibility to the female elicited courtship and mating behavior in the male. After a few pairings the male pigeons began to exhibit courtship behavior in the presence of the CS and directed this behavior to the CS. These results show that autoshaped responses can take the form of the unconditioned response to the incentive. However, this is not necessarily the case.

In a cool chamber, Wasserman (1973b) exposed three-day-old chicks to pairings of a key-light with a brief period of heat stimulation from an overhead infrared lamp. Heat as an incentive stimulus has the advantage of not being precisely localized and of eliciting behavior such as immobility, wing extension, and twittering, which are incompatible with pecking. Nonetheless, chicks in a regular forward pairing condition began to peck at the key after a median of 8 trials and pecked at least once on about 70% of the trials. A random condition group, in which occurrence of CS and IS were scheduled independently of each other, did not peck very much (first peck after a median of 33 trials). Also, chicks shifted from the random condition to the paired condition showed an increase in pecking at the illuminated key-light, whereas chicks shifted from the paired to the random condition showed a decrease in pecking. The author described the pecks as being generally forcefully directed at the key. An interesting finding was that the response drifted to a new topography after a few sessions: "The chicks approached even closer to the key and pushed their beaks into it, shaking their heads from side to side. The total pattern of behavior can perhaps be described as "snuggling"

(Wasserman, 1973b, p. 877). This shows that CS:IS contingency is sufficient to engender pecking, a response that is topographically different from the usual response to thermal stimulation; also approach and contact with a localizable incentive stimulus (heat lamp) is not necessary for the emergence of approach and contact to the conditioned stimulus. It has been pointed out that "snuggling" is an unconditioned response of young chicks to a warmth-giving mother hen (Hogan, 1974), but this fact does not detract from Wasserman's demonstration that approach and contact responses, different from the responses that occurred when the heat lamp was turned on, developed in relation to the CS in the absence of an R:IS contingency (Wasserman, 1973b).

Gamzu and Schwam (1974) found, in the squirrel monkey, an autoshaped response to an illuminated key-light that was different in form from the consummatory response to food pellets. According to Gamzu and Schwartz, "initial key responses were always made with palm facing down, and although the fingers were bent, the topography of this response was decidedly different from the hand movements involved in reaching for a pellet--scooping it up with the palm turning upward and bringing it to the mouth. Subsequently, some of the monkeys pressed the key with their noses." (Gamzu & Schwam 1974, p. 364). The authors suggested that the source of the difference between the form of the key response and the form of the consummatory response could be the higher variability of the motor patterns used by the squirrel monkeys to ingest the food. However, another experiment by the same authors (Schwam & Gamzu, Note 4) pointed out that the physical nature of the CS- manipulandum may be an important factor in determining similarity or dissimilarity between the response to the CS and the unconditioned response to IS. Schwartz and Gamzu obtained and autoshaped response similar to the "grasping component of consummation" by replacing the key-light used in their former experiment (Gamzu & Schwam, 1974) by an omnidirectional lever positioned in a recess housing in the wall. This could mean that the physical characteristics of the CS in relation to IS are important in determining the form of the response. Species difference may be another factor contributing to the difference between the Moore and Jenkins findings on one hand and the Gamzu and Schwartz finding on the other. It may be that in birds, species-typical consummatory responses are much more closely tied to particular motivational states than is the case in mammals, particularly in primates.

Bindra (1974) has offered a general account of the determination of the form of the response in a training situation. For Bindra, the instrumental (e.g., approach and contact) and the transactional (e.g., consummatory pecking) components of the autoshaped response are determined by, respectively, the distal and contact stimulus properties of the conditioned stimulus. According to him, the animal would approach the area of highest momentary appetitive incentive value (or least aversive incentive value), so that in the autoshaping situation the animal would move toward and make contact with the distal CS (light-key) when food is not available; the consummatory component is elicited by the contact stimuli arising from contact with the CS in the absence of the IS, and from contact with the IS when it is available. Thus, the instrumental--approached-contact--component of the response in relation to the CS would be similar to the instrumental component of the response in relation to the IS, as long as the CS "is presented in the same situation and in roughly the same spatial and temporal relation to which the unconditioned stimulus is normally presented...." (Bindra, 1974, p. 205). The transactional--consummatory--component of the response in relation to the CS would be similar to the transactional component of the response in relation to the IS, to the extent that the CS resembles the unconditioned stimulus in physical characteristics. Thus, if the animal is able to make contact with the light, it would also display some consummatory acts that may resemble, to some degree, those elicited by the contact stimuli of food (acts such as gnawing, licking, biting), but because the light source lacks the stimulus features of an edible object, the whole consummatory action would not occur until food is presented." (Bindra, 1974, pp. 204-205.) Whether such an account would cover the various types of responses reported in autoshaping studies could be determined by varying the resemblance between the stimulus features of CS and IS.

The above evidence from studies of autoshaping suggest the following conclusions. (1) The CS:IS contingency is a necessary condition for emergence and maintenance of an autoshaped response; this is shown by the failure of the "random" procedure in producing it. (2) There is no clear indication that the R:IS contingency is necessary (or sufficient) for the acquisition or maintenance of an autoshaped response. (3) The similarity between the form of the autoshaped response and the form of the consummatory response can vary considerably; the degree of similarity of the two responses seems to depend upon the spatio-temporal arrangement of CS and IS and upon the physical resemblance between CS and IS.

The Omission Procedure

In the omission procedure, there is a positive CS:IS contingency and a negative R:IS contingency (see Table 1); the absence of a specified response during CS presentation results in presentation of the IS on that trial ($\bar{R}$:IS). The training procedure may be described as a concurrent schedule CS:IS and $\bar{R}$:IS. First used in classical conditioning (Konorski, 1948; Patten & Rudy, 1967; Sheffield, 1965) for testing any possible role of the response-incentive pairings in the acquisition of anticipatory conditioned responses, it has been recently revived to determined how far a negative response-incentive contingency ($\bar{R}$:IS) can interfere with the consequences of a CS:IS contingency in an autoshaping situation (Gamzu & Schwam, 1974; Williams & Williams, 1969).

Basic Findings

Patten and Rudy (1967) applied the omission procedure to anticipatory licking responses in albino rats to test the possibility that classically-conditioned licking responses are under control of an R:IS contingency. On the contrary, the results showed that, in spite of the omission procedure, all subjects acquired the response and maintained it at a high level.

Williams & Williams (1969) used the omission procedure (that they named negative auto-maintenance) to determine if the auto-shaped pecking response of the pigeon was immune to influence of any $\bar{R}$:IS contingency. In one of their experiments, 13 birds were exposed to light-grain pairings. The pecking response to the illuminated key terminated the key-light and prevented the presentation of grain. If there was no response, the light remained illuminated for 6 seconds and then grain was presented for 4 seconds. Intertrial pecks had no effect. Most birds developed and sustained pecking over a thousand trials. Birds already trained on a positive response contingency (R:IS) persisted in pecking when they were shifted to the omission procedure. Other experiments with pigeons (Schwartz, 1972; Schwartz & Williams, 1972a, 1972b; Wasserman, 1973b) have confirmed and extended the results of Williams & Williams (1969). The level of responding under the omission procedure generally tends to be lower than that under the autoshaping procedure, but a good level of responding is nevertheless maintained. This indicates that the CS:IS contingency can override the effects of an $\bar{R}$:IS contingency, but that the latter has some deleterious effect on performance.

Wasserman (1973b) found that three-day old chicks exposed to light-heat pairings in a cool chamber acquired and maintained the pecking response on an illuminated light-key even if these pecks prevented the heat-lamp presentation at the termination of the 8-sec. illumination. The chicks responded on from 25% to 55% of the trials. This finding is noteworthy because there was no topographic similarity between the pecking response and the response evoked by the heat stimulus.

The above findings do not support the idea that the maintainance of responding in an autoshaping procedure is attributable to any response-incentive (R:IS), contingency because the primary effect of the omission procedure used was to destroy any positive response-incentive (R:IS) contingency that may otherwise have adventitiously operated in the autoshaping procedure. It has been argued that responding under the omission procedure was maintained by some "hidden" secondary reinforcer (Herrnstein & Loveland, 1973; Hursh, Navarick, & Fantino, 1974), such as the CS offset which could become an S^D for the impending reinforcement on trials without a response. This could not have happened in Williams and Williams' (1969) omission procedure, because on the occasions that the CS offset was produced by the response there was no reinforcement. Further, Schwartz (1972) found that, even when he made the

CS offset contiguous to the US offset and made the length of the CS unaffected by responding (fixed-trial procedure), pigeons were successful in developing and maintaining pecking at levels similar to those reported by Williams and Williams (1969). The fixed-trial procedure was also used with success in omission training by Wasserman (1973) and Schwartz and Williams (1972a). These results leave little doubt that the stimulus-incentive contingency (CS:IS), responsible for the initial emergence of the response (Brown & Jenkins, 1968), has also an important role in the persistence of responding. Negative response contingencies ($\bar{R}$:IS) fail to eradicate responding of an autoshaped response, at least in birds. This cannot yet be generalized outside of avian species, for there is at least one report of an autoshaped response in the squirrel monkey that did not persist under the omission procedure (Gamzu & Schwam, 1974). The authors suggested that this failure to get persistent responding was caused by the dissimilarity in topography between the key response and the grasping response leading to ingestion. However, even after having successfully designed a manipulandum (an omnidirectional lever in a recess housing in the wall) that forced topographic similarity between the autoshaped response to the manipulandum and the grasping component of the consummatory response, Schwam and Gamzu (in preparation) did not obtain persistence of the autoshaped response under omission training. However, in both those experiments, the approach component of the autoshaped response (orientation and contact) was maintained under the omission procedure.

Basis of the Inefficacy of the R:IS Contingency

Is the relative impotence of the negative response-incentive contingency ($\bar{R}$:IS) to eradicate an autoshaped response, or some of its components, due to an insensitivity of the animal to a negative response contingency? The answer appears to be no, because the pigeon will prefer pecking at a key that has no negative response contingency than at one that does. This was shown in one of the control experiments by Williams and Williams (1969), in which an irrelevant key was added to the "omission" one. The two keys were illuminated together but were differentiated by their hue (red or green). Both keys were illuminated for 6 seconds and followed by grain presentation only if no peck occurred on the omission key. A peck on the omission key made both keys inoperative and prevented grain presentation. Pecking on the irrelevant key had no effect at all; that is, the irrelevant key procedure was similar to the fixed trial procedure in autoshaping experiments (Brown & Jenkins, 1968, Experiment 4). All six pigeons used as subjects came to peck on the "irrelevant" key and, when the colors identifying the keys were reversed, the pigeons shifted responding on the other key. This indicates that the pigeon's pecking preferences were influenced by the contingency difference between omission and irrelevant keys. Thus the birds were not insensitive to the omission procedure.

In a slightly different context, it has also been found by Schwartz and Williams (1971) that spaced-responding in a differential reinforcement of low rates schedule (DRL) could be obtained only if there was an irrelevant key that could receive the "overflow" of pecking. First, the pigeons acquired the pecking response on a 6-sec. illuminated key-light with the autoshaping procedure. They were then shifted on to a new procedure where pecking during the first 6 sec. of key illumination had the effect of turning off the light and preventing food delivery. If no peck occurred for 6 sec., the first subsequent peck turned off the CS and allowed the food to appear. If no peck occurred for 6 seconds, the first peck turned off the CS and produced the presentation of the food. Over 45 sessions (2000 trials), only one pigeon out of four succeeded in improving its performance, that is, to restrain pecking during the 6-sec. CS period, and even then only on 7% of the trials. When an irrelevant key of a different color was illuminated contiguously with the DRL key, three pigeons out of four learned to peck the irrelevant key during the first six to eight seconds of its illumination and then shifted to the DRL key for a reinforced peck.

These results support the hypothesis that the CS:IS contingency induces pecking and makes it highly resistant to disruption by the omission training, even though the pigeon's behavior is demonstrably sensitive to the negative R:IS contingency. That is, instead of not pecking, they may peck elsewhere, specially when the opportunity is offered by an alternative "irrelevant" key light. It is worth noting with Schwartz and Williams (1971) that "other apparently possible forms of effective collateral behavior, such as turning away from the key, or pecking at the houselight, did not develop." (Schwartz & Williams, 1971, p. 159.) This means that the directedness of the response at a particular location is an important factor in determining what collateral behavior would emerge.

The lower rate of responding in the case of the omission procedure, as compared to the rate in the autoshaping procedure, may be explained by the effect of one factor or by the combined effects of two factors (see Hearst & Jenkins, 1974; Williams, in preparation): (1) fewer CS:IS pairings and (2) response-contingent removal of IS (extinction). When the animal responds on 50% of the trials, this means that the CS is presented without reinforcement on 50% of the time; on these non-reinforced trials, the response-contingent removal of reinforcement may cause the partial extinction of the response. To test this idea, one may compare the performance in an omission procedure to a yoked-control procedure that keeps the same proportion of CS-US pairings. Schwartz and Williams (1972a) made that comparison (within-subjects design) with two different kinds of trials that were presented successively and differentiated by the color of the key: (1) omission trials were given on a red key and (2) yoked positive trials on a white key. On the positive trials, the key-light was followed by the reinforcer at the same probability as the preceding omission trials. For example, if a pigeon pecked the red-omission key on 75% of the trials, then the green-positive key was presented alone on 75% of the trials and was followed by reinforcer on 25% of the trials. All eight pigeons preferred the yoked "irrelevant" key, as indicated by th higher percentage of trials at which they pecked on it, by the rate of pecking on it, and by the choice made when both keys were presented. Pigeons' preference shifted appropriately when the stimuli correlated with the two conditions were reversed.

Schwartz and Williams (1972a) concluded that the "observed differences in performance must reflect the effective influence of the different response-reinforcer contingencies that were correlated with the two keys" (Schwartz and Williams, 1972a, p. 355). However, we do not know whether performance was affected more by the negative response-reinforcer contingency ($\overline{R}$:IS) of the omission procedure or by the positive response-reinforcer contingency (R:IS) of the irrelevant key. Also it is possible that the differences between the two keys were not only in the response-reinforcer contingencies. Even if the number of CS:IS pairings was the same on the two keys, it is possible that the CS:IS relation was not exactly the same in the two cases. For example, we know that when the omission key is contacted on 75% of the trials, the pairings for both keys with IS is on 25% of the trials.

Now, if the pigeon is pecking on the irrelevant key on 80% of the trials, it means that 80% of 25% of the trials are reinforced, that is 20% of the trials. We can then be sure that the pigeon observed the CS:IS pairing of the irrelevant key on 20% of the trials. We do not know if the pigeon observed equally often the CS:IS pairings of the omission key, because in each trial in which these pairings occurred, by the procedural definition, the pigeon had not bothered to peck. Thus it is possible that the observation of CS:IS concomitance is made more probable when the CS is pecked and that this is the main reason why the birds maintain their responding under the autoshaping procedure, and perform at a lower level under the omission procedure. The contingency between the response and the incentive stimulation may have nothing to do with the obtained differences.

Form of Response

Recent evidence from omission experiments indicate that the form of the response under omission training may be different from the form of response under the autoshaping procedure (Schwartz and Williams, 1972b; Stiers and Silberberg, 1974). Schwartz and Williams (1972b) found two populations of key-pecks of different durations with the autoshaping and omission procedures. Their analysis showed that the initial key-pecks, in either a fixed-trial or omission procedure, were of short duration (below 20 msec.) but, with continued training, the fixed-trial procedure produced many longer key-pecks (above 40 msec.), in addition to the short ones, while the omission procedure continued to produce only short pecks. Moreover, a continuous-reinforcement schedule (CRF) led to the development of long duration key-pecks; in FI 20 and FR 25 schedules, long duration pecks were also preponderant, the distribution of FR being less variable than on FI. Finally, short-duration pecks were found to be insensitive to differential reinforcement while long-duration pecks were sensitive to it. Thus it seems that the first pecks made under the autoshaping procedure are short and that further training adds longer pecks to the shorter ones. The omission procedure, though unable to prevent the acquisition or to suppress the shorter ones, prevents the longer ones from appearing.

Rats can also respond differently under the omission procedure as compared to the autoshaping procedure.

Stiers and Silberberg (1974), using hooded rats, found that the median contact duration and the form of the contact response to a CS-lever were different depending upon the procedure used. While most contact durations were short (around 20 msec.) in both autoshaping and omission procedures, some longer responses (over 100 msec.) occurred in the autoshaping procedure. Observational data during the last four sessions showed that the autoshaped responses were mostly lick, bite, and paw contacts. These responses were no longer present during the last four sessions of the following omission procedure but were replaced mostly by short nose contacts.

Thus, in both pigeons and rats, one can see two classes of response, which differ in their duration for which the key remains closed. According to Schwartz and Williams (1972b), Williams (in preparation) and Stiers and Silberberg (1974), one class (short pecks in pigeons, short nose contacts in rats) is controlled by the CS:IS contingency and the other class (long pecks in pigeons; lick, paw and bite contacts in rats) is controlled by the R:IS contingency.

However, it is also possible that the short pecks or the short contact responses, the first to appear, are a part of the early instrumental approach sequence and the longer pecks or the longer lick, bite and paw contact responses, which appear only when the consummatory response closely follow responding to the manipulandum (R:IS), are a part of the later consummatory sequence. If this is so, the longer, consummatory responses, which are a part of the later part of the response chain (closest in time to IS), would be the first to disintegrate with the introduction of the omission (extinction) procedure, while the shorter, instrumental responses, which are a part of the early part of the response chain, would be the last to disintegrate--as appears to be generally the case in extinction (e.g., Antonitis, 1951; Morgan and Einon, in preparation; Wagner, 1961). The short and long responses thus may represent responses at different points in the total behavioral chain, rather than responses shaped and maintained by two different contingencies. The differences between the autoshaping and omission procedure in the relative frequency of occurrence of short and long responses could then be due to the differential effect of the omission (extinction) procedure on different parts of the response chain. It is not necessary to invoke the explanation offered by Schwartz and Williams (1972b) and Stiers and Silberberg (1974).

If the proposed extinction interpretation is correct, the difference in topography found by Moore (1971) between autoshaped pecks for food and autoshaped pecks for water should disappear under omission procedure and only the approach short pecks should remain. This prediction is supported by some recent evidence in the monkey. Schwam and Gamzu (in preparation) found that a lever-pressing response acquired under the autoshaping procedure did not persist under omission procedure, even when its topography was similar to the grasping component of the consummatory response. However, the approach component (orientation, approach of the arm) remained intact. Thus the component of the autoshaped response that is similar to the consummatory response and thus determined by the presence of IS would seem to be the one that is likely to be disrupted earlier in omission training. Whether the strengthening of the consummatory component during later stages of autoshaping and its extinction during the omission procedure are determined solely by changes in CS:IS contingency is a question that remains to be investigated.

Conclusions

The above evidence from "omission" experiments suggests the following tentative conclusions: (1) A positive CS:IS contingency even in conjunction with a negative R:IS contingency, can lead to the acquisition and maintenance of an instrumental approach-pressing response; the CS:IS contingency can thus override any possible effects of the negative $\bar{R}$:IS contingency. (2) The addition of omission procedure does lead to a reduction in response level below what would be obtained with CS:IS contingency alone; however, this reduction does not require the attribution of a necessary role to the $\bar{R}$:IS contingency, for it could represent a change in the observation of the CS:IS contingency. (3) The later, consummatory components of the total autoshaped response are disrupted by omission procedure somewhat sooner than the earlier approach components; this may be the reason for the reported difference in the topography of responses in the autoshaping and omission procedures.

The Superstition and Shaping Procedures

What would happen if IS were presented without reference to any specified response, as in the autoshaping procedure, but also without reference to any specified stimulus? Using such a procedure, Skinner (1948) observed what he called "superstitious" behavior (see Table 1, Cell 5). In his experiment, food was presented at fixed intervals of 15 seconds. Each of six birds, out of eight, acquired and maintained a certain stereotyped and consistent response: "One bird was conditioned to turn counter-clockwise about the cage, making two or three turns between reinforcements. Another repeatedly thrust its head into one of the upper corners of the cage. A third developed a "tossing" response, as if placing its head beneath an invisible bar and lifting it repeatedly. Two birds developed a pendulum motion of the head and body.... Another bird was conditioned to make incomplete pecking or brushing movements directed toward but not touching the floor" (Skinner, 1948, p. 169).

Skinner (1948) attributed such superstitious actions to adventitious reinforcement of particular but unspecified responses. He also accorded an important role to environmental features and objects: "With the exception of the counter-clockwise turn, each response was almost always repeated in the same part of the cage, and it generally involved an orientation toward some feature of the cage. The effect of the reinforcement was to condition the bird to respond to some aspect of the environment rather than merely to excite a series of movements." However, it is the adventitious reinforcement aspect of his interpretation that became widely accepted as the explanation of superstitious behavior (see Herrnstein, 1966).

Staddon and Simmelhag (1971) repeated Skinner's (1948) experiment and noted carefully the exact moment of appearance of responses during the interval between IS presentation. They used three schedules: a FT 12 sec. (response independent), a VT 8 sec. (response independent), and an FI 12 sec. (response dependent). The results showed that some behaviors would occur more consistently in the early part of the interval and some others would occur more consistently in the late part of the interval; Staddon and Simmelhag called the former "interim activities" and the latter terminal responses. The terminal responses, found in most pigeons, increased over the interval and were mostly (a) orientation responses toward the magazine wall, which occurred in all pigeons and in each schedule; (b) pecking responses directed, in the response-dependent schedule, at the constantly illuminated key and, in the response-independent schedules, at some point on the magazine wall. The interim responses, that were more variable from bird to bird, had their optimum rates in the early part of the intertrial interval. The most frequent were pecking the floor, "1/4 circles," flapping wings, moving along magazine wall, and pointing beak to the ceiling; moreover, all these actions were arranged in certain sequences. Staddon and Simmelhag (1971) described the characteristics of these sequences as follows: "(a) each bird showed only a small number of typical sequences (usually three or four); (b) the sequencing was very rigid, so that although a given behavior might fail to occur during a particular interval, it never occurred out of sequence....(c) the variability of the sequences was greatest early in the interval and least at the end, in the period just preceding food delivery...." (Staddon & Simmelhag, 1971, p. 9). Also, there was little difference in behavior betwen response-dependent and response-independent schedules. Staddon and Simmelhag (1971; see also Staddon, in preparation) explained terminal responses and interim activities separately. They suggest that terminal responses occur in periods of relatively high reinforcement probability. The R:IS relation sets the occasion for the selection of a response from among those "induced" in the situation by a "principle of variation" (transfer processes, stimulus substitution, preparatory responses, situation-specific and species-typical responses, etc....). Interim activities occur in periods of relatively low reinforcement probability and are the sub-products of interactions among motivational states.

Now that we know that a contingency between a selected stimulus and an incentive stimulus is sufficient to initiate and maintain an unselected but particular skeletal response (Brown & Jenkins, 1968; Williams & Williams, 1969), the possibility arises that such a contingency may also operate in the superstition procedure. The greater variability of responses emerging in this procedure could be attributed to the greater variability of the environmental stimuli that come to serve as CS when IS is not contingent on any specific stimulus. For example, if by chance, the pigeon is observing the right upper corner of the chamber when the food hopper appears, the right upper corner is likely to become the unselected CS. That right upper corner would then acquire some appetitive incentive value, thus increasing the likelihood that the pigeon will look at the same place and approach it. This interpretation in terms of stimulus-incentive contingency alone would predict that the earlier post-reinforcement responses would be made in relation to stimuli distant from the location of reinforcement ("interim activities") and the pre-reinforcement responses would be made in relation to stimuli that are progressively close to the location of reinforcement (terminal responses).

Adventitious pairings between IS and unselected stimuli can occur even when there is an already operating selected CS:IS contingency. Wasserman (1973a) found that the presence of a house-light was a necessary condition for autoshaping to occur. Without the house-light, the light behind the key illuminated the entire chamber. The result was a suppression of pecking at the key, or, more accurately, the initiation of other behaviors directed at other features of the environment. One bird "would first turn toward the key but would then walk toward the masked house-light, extend its neck, and 'bob' its head in the upper right hand corner of the chamber." Another bird "approached the key light but did not make any pecking movements and often lowered its head toward the food hopper" (Wasserman, 1973a, p. 200).

A response like turning clockwise, a celebrated operant in the pigeon, appears to be a complex skill requiring shaping by an experienced trainee, not a simple response directed at some surrounding stimulus (see Jenkins, 1973). However, Skinner (1948) observed that this behavior can emerge without any shaping; a FT 15 sec. schedule was sufficient to produce it without any explicit training. A CS:IS hypothesis would suggest that the bird, when turning, is looking at a sequence of objects, a sequence that terminates with the presentation of grain. Maybe a moving disk turning around the pigeon before food presentation would lead to the emergence of a turning response of the pigeon. This is probable in view of Skinner's (1971) recollection of an unpublished earlier observation where a pigeon followed and pecked a spot of light that moved on the wall in a direction opposite to that of the feeder, just before food presentation.

If superstitious behavior can emerge in a situation where IS is presented without reference to any specified CS or R (Skinner, 1948), it should also emerge in a situation where a positive R:IS contingency is specified but CS:IS is not (Cell 2 of Table 1). Morse and Skinner (1958) used a VI 30 min. schedule of reinforcement of key pecking in pigeons; the shortest interval was 1 min. and the longest 59 min. This is similar to a 2-component MULT schedule where each component would have an identical schedule of IS presentation but two different (but irrelevant) stimuli announcing each component. Daily sessions varied from 6 to 20 hr. in length. The key light was orange, but turned blue for 4 min. once per hour. There was no CS:IS specified relation. The results showed that the rate of responses came to be influenced by the presentation of the short-length CS (blue key light). For some pigeons, the rate of pecking increased during the blue light period, while for some others the rate decreased, and still others stopped responding during the same period. Morse and Skinner (1958) clncluded "that incidental stimuli adventitiously related to reinforcement may acquire marked discriminative functions" (Morse & Skinner, 1958, p. 211).

In the Morse and Skinner (1958) experiment, the CS, the response and the R:IS relation (see Table 1, Cell 2) were specified, but not the CS:IS contingency. The situation that we will now consider is similar except that the CS itself is also unspecified; this is the common shaping procedure. A specified response may be shaped by making the IS contingent upon responses that are progressively more and more like the selected response. However, it may be possible to shape a selected response without using this successive-approximation version of the response-reinforcement procedure.

Moore (1973) analyzed the different methods that are currently used to shape the pecking response in the pigeon and arrived at the conclusion that "in every case both the acquisition and the maintenance of the response follow at once from the Pavlovian principles" (Moore, 1973, p. 177). Bindra (1972, 1974) also offered an interpretation of shaping in terms of CS:IS relations. To illustrate his approach, let us consider the shaping of the bar press response in the rat by the method of successive approximation. The experimenter may first decide to present food to the rat when it is in the vicinity or facing the lever. This creates a CS:IS relation in which the lever and its location on the wall would become a CS. After a few trials of that sort, the lever acquires enough incentive value (as the key light in autoshaping experiments) to make the approach the lever. We know from Peterson, Ackil, Frommer, and Hearst (1972) that illuminating the lever before presenting food has exactly the same effect, that is, to attract the rat (see also Stiers and Silberberg, 1974). If now the trainer makes reinforcement contingent upon the rat touching the lever, he would have reduced the part of the environment that serves as the CS. Thus the method of successively reinforcing more and more specific responses may in fact be one of making the effective CS more and more specific; what appears to be response differentiation training may in fact be stimulus discrimination training. The difference between autoshaping and shaping is that the shaper, instead of, say, illuminating the lever to make it more likely that the rat would look at it, simply waits until the rat looks at the lever spontaneously. The effect is the same, that is, producing more orientation and approach between lever and food, but also a spatio-temporal contingency: the spatial contingency is created by the contrast in incentive value between the lever and the other features present in the environment that are never, when observed by the rat, paired with food. The temporal contingency is created by the contrast between the time of the "trial," that is, when the rat observes the lever-food relation and the time of the "intertrial interval," that is, when the rat is occupied with other matters. The form of the shaped response will be, at first, similar to the form of an autoshaped response with food. The rat will sniff the lever, bite it (strongly enough to destroy it if made of wood or tin) and manipulate it until the switch delivering the food is activated.

The exact configuration of the lever may play an important role in determining the kind of responses that the rat will make toward it, but manipulation with the front paws is likely to occur, the rat using them extensively for manipulating and holding objects of interest like food. Thus, the shaping procedure may be efficient because it maximizes the learning of new stimulus-incentive relations by exposing the animal to the elements of that relation only when "attentive" or "interested," that is, when looking at or contacting the stimulus-manipulandum.

Conclusions

The above evidence and considerations suggest that the emergence of specific responses in the course of the superstitious and shaping procedures, which is usually interpreted in terms of adventitious response-reinforcement (R:IS), is also open to interpretation in terms of adventitious CS:IS contingencies that might operate in these procedures.

General Conclusion and Implications

The above review was concerned with examining the relative importance of R:IS and C:IS contingencies in the acquisition of stable responses of the type commonly described as operant or instrumental responses. The review has shown that while autoshaping and omission training experiments provide firm evidence that CS:IS contingency can be sufficient for the acquisition and maintenance of instrumental responses, there is no firm evidence that a CS:IS contingency is a necessary condition for instrumental learning. And while it established that R:IS contingency is not necessary for the acquisition or maintenance of instrumental responses, there is no firm evidence that such a contingency can be sufficient for instrumental learning. Even in shaping and superstition experiments, in which the R:IS contingency has usually been reagarded as the proponderant and necessary factor, it can be shown to be dependent on the CS:IS contingencies and may be wholly interpretable in terms of such contingencies. Thus, while it is established that CS:IS contingencies are sufficient for instrumental learning, it remains to be decided whether they are always necessary. And while it is established that R:IS contingencies are not necessary for instrumental learning, it remains to be decided whether they can sometimes be sufficient.

In view of the above conclusions, it appears reasonable to explore further and in greater detail the hypothesis that CS:IS contingencies are the sole basis of learned behavior modifications even in the traditional instrumental training procedures. Such an hypothesis would include two main ideas (Bindra, 1974). The first idea is that the development of an instrumental response requires that the eliciting stimulus (ES) come to serve as the CS that is followed by the incentive stimulation in training (ES=CS:IS). The role of the eliciting stimulus--the stimulus complex that contributes to the occurrence of the first instrumental response (before it has been reinforced)--has been largely ignored in discussions of instrumental learning. But since there must be some stimulus complex that determines whether a specified response is likely to occur "spontaneously" in the training situation, the assumption of such an ES in every instrumental training situation is inescapable. When an animal observes or otherwise acts in relation to ES, the instrumental response occurs, and the incentive stimulation is presented; so that, apart from the arranged R:IS contingency, an ES:IS contingency also operates. As Bindra (1974) has put it, "....arranging a response-incentive contingency is the best way so far discovered for insuring the animal will observe the critical stimulus features which must enter into the stimulus-incentive contingency for producing the specified response...." (Bindra, 1974, p. 208). A firm proof of the hypothesis is that ES:IS is the only effective contingency would require isolation of the ES:IS contingency (e.g., observation of lever:food) from the R:IS contingency (e.g., pressing the lever:food). There seems to be no obvious experimental way of isolating these two contingencies, but it may be possible to approach the question by testing the implications of the opposing hypotheses against the details of the results of experiments in which selected features of the two contingencies are varied.

The second main idea is that at any given moment, an animal will respond in relation to those conditioned (i.e., eliciting) stimuli that have acquired greater appetitive (or lesser aversive) incentive value through their contingency with IS. A response in relation to any object or location is thus not determined by its absolute conditioned incentive value, but by its relative value in relation to other stimuli in the situation. As the conditioned incentive value of various conditioned (eliciting) stimuli may change from moment to moment, according to the temporal relation between the stimuli and

IS, the animal's behavior may vary considerably during a trial. But the essential point is that it is the differential incentive value of various stimulus components of a situation which determines the probability of response; the actual number of responses is mainly a matter of the nature of the manipulandum and ~~the~~ definition of the specified response. This implies that the greater the opportunity to learn to discriminate between the incentive value of different stimuli, the more specific would be the emerging response (or pattern of responses); further, the greater the relative incentive value of the eliciting stimulus for the specified response, the greater would be the probability of the occurrence of the response. This suggests that greater response probabilities obtained by arranging R:IS contingencies, as compared to those obtained by arranging comparable CS:IS contingencies, may be an outcome of greater discriminative advantage of ES in the former arrangement. This prediction should also be testable experimentally.

The Present Investigation

The investigation reported here was aimed at comparing the acquisition and performance of a response under two procedures, one in which the explicitly arranged contingency was CS:IS and another in which an explicitly arranged R:IS contingency was added to the CS:IS contingency. It was hoped in this way to determine what additional influence on the acquisition and performance of a response is produced by adding the R:IS contingency, and to consider how the observed contributions of the latter contingency might be interpreted. The animal used was the hooded rat and the response studied was a simple approach-contact response. Rats were thirsty and and the reinforcement consisted in the presentation of an incentive (water IS). A light served as the CS.

A comparison of the type mentioned above is difficult to make in the traditional test chamber used for instrumental training with rats. This is so because the CS (e.g., a light) which announces the impending availability of the IS is different and spatially separated from the manipulandum (e.g., a lever) in relation to which the instrumental response is usually measured. This means that all responses directed toward the CS, such as approaching, sniffing, licking, and biting, remain unrecorded, if not unobserved. But in the test chamber typically used with pigeons, the manipulandum (on which responses are made) and the CS are the same stimulus object. Therefore a test chamber was connstructed for use with rats that was similar to the one used with pigeons; that is, the CS upon which IS was contingent and the manipulandum used to measure the response were the same object; namely a wire-grid panel which, when illuminated, served as CS.

Two experiments were performed. The first was designed to compare the influence on response rate and on the temporal distribution of the response of an experimentally arranged CS:IS contingency without any explicit R:IS contingency with the combined influence on response probability of both contingencies, CS:IS and R:IS. The effects of the introduction of an omission procedure on responding under the two conditions were also examined. The omission procedure maintained the CS:IS contingency but replaced the R:IS contingency by a $\bar{R}$:IS contingency (i.e., nonoccurrence of the response was followed by IS).

On the basis of the results of the first experiment, a second experiment was designed to explore further the factors influencing response acquisition and maintenance by an analysis of the spatial distribution of the response under the CS:IS and CS:R:IS contingencies.

EXPERIMENT 1

The purpose of this experiment was to determine the effects of the three contingencies (CS:IS, CS:R:IS, and CS:$\overline{R}$:IS) on response rate and the temporal distribution of responses within a trial.

Method

Subjects

The subjects were 10 naive male hooded rats weighing 245-255 g. at the time of purchase from the Quebec Breeding Farm. They were individually housed.

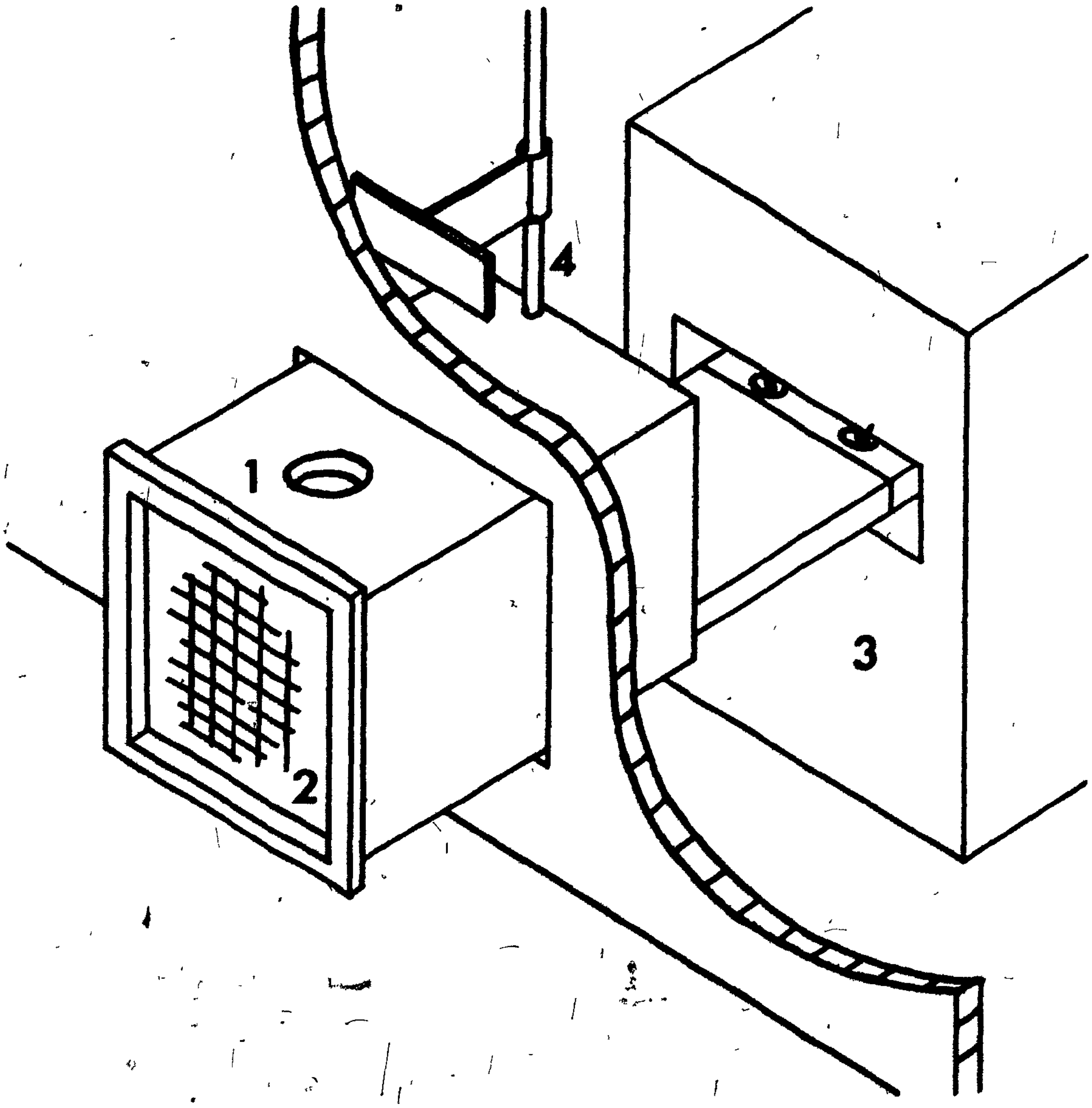
Apparatus

The experiment was conducted in an especially prepared test chamber 30.5 cm long, 30.5 cm wide, and 19.7 cm high. All the walls were made of Plexiglas; the north wall was painted black, the west wall was unpainted, and the other two walls were painted brown. The floor, placed over a rip basement, consisted of steel bars. The ceiling was an opaque white Plexiglas sheet under a neon light. A brown filter was placed between the light and the ceiling, reducing the chamber's luminance to 46 cd/m², as measured from the floor in the center of the box. The test chamber was itself placed in a sound-protected enclosure 122 cm long, 122 cm wide, and 61 cm high. A Plexiglas door on the roof of the enclosure permitted observation of the animal through a mirror placed near the clear wall of the test chamber. A ventilating fan assured proper air circulation and created a quasi-white noise of 70 dB (measured inside the test chamber), which masked the equipment sounds.

A "reinforcement drawer" was located in the middle of the black wall, its center being at 38 mm from the floor. As shown in Figure 1, the front panel of the drawer consisted of a square (31.75 by 31.75 mm) copper wire-grid placed on a white Plexiglas support and bound by a black frame. The drawer was attached to a retractable lever apparatus (Lehigh Valley Electronics, no. 123-05), with the lever replaced by the drawer. When extended into the test chamber, the drawer was 22 mm long with black sides. A lamp (28 VDC), located inside the drawer, could illuminate the wire-grid panel, bringing the luminance of the panel to 343 cd/m², as measured at a distance of 5 cm from the front of the grid. In the middle of the upper surface of the drawer was a recessed circular cavity (9.5 mm in diameter) which could hold .3 cc of water. The lighting of the panel was used as the CS and the water as the IS (US or reinforcer).

A drinkometer circuit (BRS, series 100) was connected to the front wire-grid in front of the drawer and was used to record consummatory responses and to control, through logic modules, the delivery of water for the next trial. That is, if the rat did not drink on a given trial, the solenoid delivering water was blocked at the next trial, so that the same amount of water was available to the rat on each trial.

FIGURE 1. The "drawer" in the extended position. (1) Water receptacle (IS). (2) Wire-grid panel (CS). (3) Modified retractable lever apparatus. (4) Water tube.


1
2
3
4

Automatic scheduling and recording of approach and consummatory responses (drinkometer contacts) were controlled by a set of logic modules (BRS-Foringer, series 100) and by an on -line computer (PDP-8/S).

continued on next page/

Procedure

On each of the first three days of the experiment, the animals were individually handled and allowed to explore the apparatus for 10 minutes. They were then placed on a 22 1/4 hr. water deprivation schedule. For the next five days they were exposed to the complete experimental procedure (see below) except for the presentation of the CS; water was given at each "trial" regardless of their behavior. Two subjects were discarded because of a learned fear of the movement of the drawer that prevented drinking. The remaining eight animals were then randomly distributed into two groups, a designated CS:IS "stimulus-contingent" group (SC group, n=4) and a designated R:IS "response-contingent" group (RC group, n=4).

Each daily training session lasted 30 min. and consisted of 20 trials. In each trial, the panel was illuminated (CS) for 8 sec. At the termination of the light, the drawer was extended into the chamber for 4 sec. and was then retracted into the wall. The extension and retraction time of the drawer was 2 sec. each, so that the total drawer presentation time was 8 sec.; the water receptacle was accessible during six of the eight seconds. The lenght of the intertrial interval was variable, the average being 64 sec., the shortest 48 sec., and the longest 80 sec. Intertrial intervals were randomly distributed within each session. After each session, the animal was returned to its cage and, one hour after, was given water ad lib for 15 min.; it was then deprived until the next session (22 hr. 15 min.).

Three training procedures were used. (1) Stimulus-contingent training procedure (CS:IS): IS was presented at the end of the CS period regardless of the behavior of the animal. (2) Stimulus and response contingent training procedure (CS:R:IS): the reinforcer was presented at the end of the the 8-sec. CS period only if at least one response (contact with the illuminated panel) had been made during the CS period. (3) Omission-training procedure (CS:$\bar{R}$:IS): the reinforcer was presented at the end of the CS period only if no response (contact with the panel) had been made during the CS. The SC group was given 36 daily sessions of the stimulus-contingent training and the RC group was given 36 sessions of the stimulus and response-contingent training (CS:R:IS). Both groups were then given 24 sessions of omission-training (CS:$\bar{R}$:IS).

Analysis of the data

In a first, rough, analysis of the temporal distribution of response, each trial was divided into four periods: (1) a 20-sec. pre-CS period, (2) an 8-sec. CS period, (3) a 20-sec. post-CS period, and (4) an intertrial interval (between the end of the post-CS period and the beginning of the next pre-CS period) which varied from 8 sec. to 40 sec. The two groups were compared with respect to the average response rates (rate scores) for each period, as well as with respect to the number of trials (trial scores) on which at least one response was made during the CS period. In a second, more detailed, analysis of the temporal distribution of responses were calculated for each 2-sec. interval of the pre-CS, CS, and post-CS periods, in blocks of four sessions.

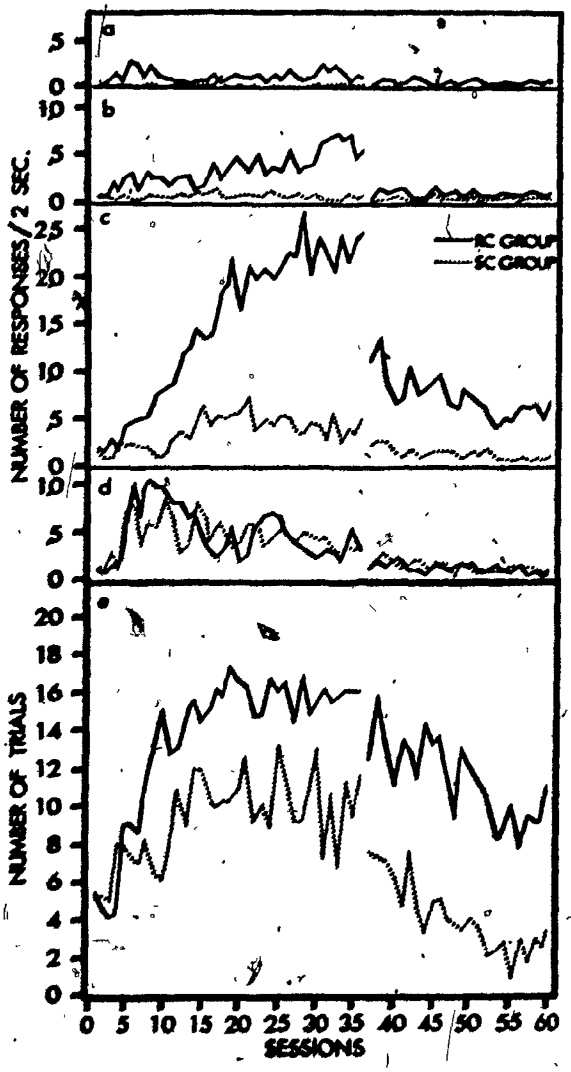
Results

Results from the 36 sessions of stimulus-contingent training (CS:IS) and stimulus-response contingent training (CS:R:IS), as well as from the 24 sessions of omission training (CS:$\bar{R}$:IS) are shown in Figure 2. Rate scores for the two presented for: (a) the intertrial (ITI) period, (b) the 20-sec. pre-CS period, (c) the 8-sec. CS period, and (d) the 20-sec. post-CS period. Results in terms of trial scores are shown in section (e).

Inspection of Figure 2 reveals that the rate scores were generally greater for Group RC than for Group SC during the intertrial period, the pre-CS period, and the CS period, but not during the post-CS period; the differences between the groups increased steadily from the intertrial period to the CS period. Rate scores showed a general increasing trend over the 36 training sessions during the the CS period in both groups, but during the pre-CS period only in RC group. During the post-CS period, the rate scores decreased, in both groups, from the maximum attained on about the 10th session.

Separate analyses of variance were carried out on rate scores for each period and on trial scores for the CS period. The same design was used in each of the five

FIGURE 2. Results from the 36 sessions of stimulus-contingent training (SC group) and response contingent training (RC group) and for 24 sessions of omission procedure (both groups). Average response rates (per 2-sec. intervals) for (a) the intertrial period, (b) the 20-sec. pre-CS period, (c) the 8-sec. CS period, and (d) the 20-sec. post-CS period. (e) Proportion of trials during which at least one response was made for the 36 training sessions and 24 omission-procedure sessions.


a
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25
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15
10
5
0
10
5
0
20
18
16
14
12
10
8
6
4
2
0
NUMBER OF RESPONSES/2 SEC.
NUMBER OF TRIALS
RC GROUP
SC GROUP
0 5 10 15 20 25 30 35 40 45 50 55 60
SESSIONS

analyses; that is, a three-way analysis of variance (Blocks x Sessions x Groups) with repeated measures on the first two factors. There were two groups and 60 sessions, nested in five blocks of 12 sessions. The first three blocks of sessions included all 36 acquisition training sessions and the last two blocks of sessions included all the omission training sessions. The results of these analyses of variance are presented in Tables 2 to 15.

No significant differences between groups or blocks were found for the ITI period analysis and the pre-CS period analysis (Tables 2 to 4); however, for the CS period analysis, a significant difference between blocks ($p < .01$) and a significant interaction between blocks and groups ($p < .01$) were found (Table 5). This difference between blocks was further examined with the Newman-Keuls test and two pairwise comparisons were found significant (Block 3 - Block 1, $p < .05$; Block 2 - Block 1, $p < .05$) (Table 6). Also, a separate Newman-Keuls analysis performed on the RC group revealed a significant difference between Block 2 and Block 1 and between Block 3 and Block 1 (Table 7). However, no difference between blocks were found for the SC Group with the Newman-Keuls procedure (Table 8). Tests of simple effects performed for each block revealed a significant difference between the two groups at Block 3 ($df=1,6$; $p < .01$) (Table 9). For the post-CS period, the overall F was not significant; however, there was a significant difference between sessions($p < .01$) (Table 10).

While the two groups were significantly different in the average asymptotic response rates during the CS period, there was no significant difference between the groups in trial scores (Table 11). However, there was a significant difference between blocks ($p < .01$) and this difference was confirmed as significant by the Newman-Keuls procedure: as with the rate scores, a significant difference was found between Block 2 and Block 1, and between Block 3 and Block 1 ($p < .05$) (Table 12). In RC group, Blocks 3 and 2 were both found significantly different from Block 1 ($p < .05$) (Table 13) but in SC group, there was no significant difference between the first three blocks (Table 14). Tests of simple effects performed for each block between the two groups did not reveal any significant difference (Table 15). Thus, both rate scores and trial scores continued to increase over training sessions in RC group but not in SC group.

Reinspection of Figure 2 indicates that the introduction of the omission procedure (the last 24 sessions) produced during the CS period an immediate decrease in rate scores in both groups but greater in the RC group. During the other periods, responses rates also diminished at the first session of omission training but then remained at the same level until the last session. The number of trials on which at least one response was made during the CS period did not show any substantial decrease at the onset of the omission procedure, but declined gradually over several sessions; however, the trial scores were still considerably above zero in both groups at the end of omission training.

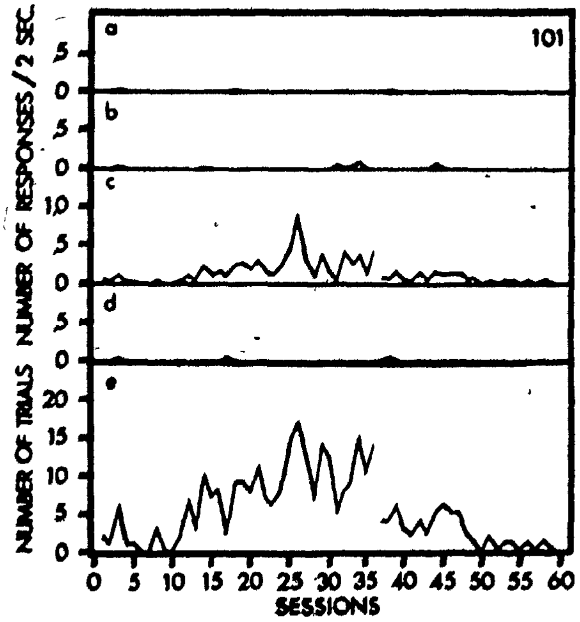
Analysis of the rate scores indicated a significant effect of omission training during the CS period for Group RC: Blocks 2 and 3 were significantly different from Block 4 and 5 ($p < .05$) (Table 8). No difference was found in SC group; t tests revealed no significant difference between groups for the two omission training blocks (Table 9). Analysis of the number of trial scores showed that Blocks 2 and 3 were significantly different from Block 4 ($p < .05$) and from Block 5 ($p < .01$) (Table 12). However, contrary to the rate scores, the origin of this difference was in Group SC; in Group RC , there was no significant difference between omission blocks (Block 4 and 5) and training blocks (Blocks 1, 2 and 3) (Table 14) while, in Group SC, Block 5 was significantly different from Blocks 2 and 3 ($p < .05$) (Table). As with rate scores, t tests revealed no significant difference between groups during the two omission training blocks (Table 15).

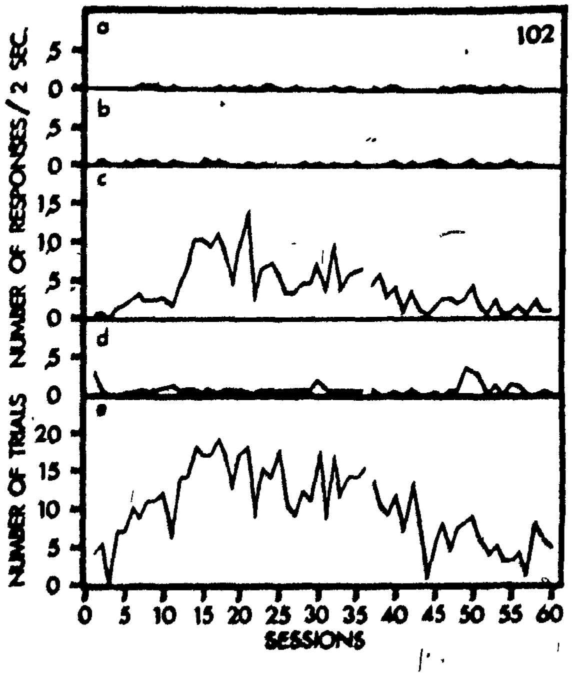
Results of each subject in SC group (Rat 101 to 104) are presented in Figure 3 and of each subject in RC group (Rat 105 to 108) are presented in Figures 4 and 5. The parameters and partitions of the figures are the same as those for the group results (Figure 2). In general, the group scores adequately represented the individual scores. In most subjects, comparison of ITI, pre-CS, and CS period showed an increase in rates from the ITI period to the CS period. The increasing trend over the pre-CS period in RC group was found in two subjects (Rats 105-108). However, during the post-CS period, the group results were not representative: only one subject in each group (Rats 104 and 105; see also 107) was responsible for greater responding after a few acquisition trials. During the CS period, three subjects (Rats 101, 102, and 103 in SC group; rats 105,107 and 108 in RC group) were representative of their group mean.

The trial scores were generally less variable than rate scores. In RC group, rats 105, 107, and 108 responded on nearly all trials after acquisition; in SC group, there was a slow acquisition of responding in rats 101, 102, and 103. Performance of rat 104 seemed more like an habituation curve and might account for the absence of any significant trend in acquisition of SC group. The trial scores were more sensitive to low level performance (see rat 106) but not sensitive to very strong performance because of the presence of a ceiling effect. Comparison of rates and number of trials in rats 105, 107 and 108 revealed a similar phenomenon: the first session of acquisition was similar for rates and number of trials but while the subjects came to respond at all sessions, their rates continued to increase for many more sessions before attaining a plateau.

The introduction of the omission procedure affected all animals. In SC group (Considering rats 101, 102, and 103), the effect was gradual on both rate scores and on trial scores. On the contrary, in RC group (Considering

FIGURE 3. Individual results of rats 101, 102, 103, and 104 (SC group). Parameters and partition of the figures are the same as those for the group results (see Figure 2).


101
a
b
c
d
e
NUMBER OF RESPONSES/2 SEC.
NUMBER OF TRIALS
SESSIONS
0 5 10 15 20 25 30 35 40 45 50 55 60


102
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b
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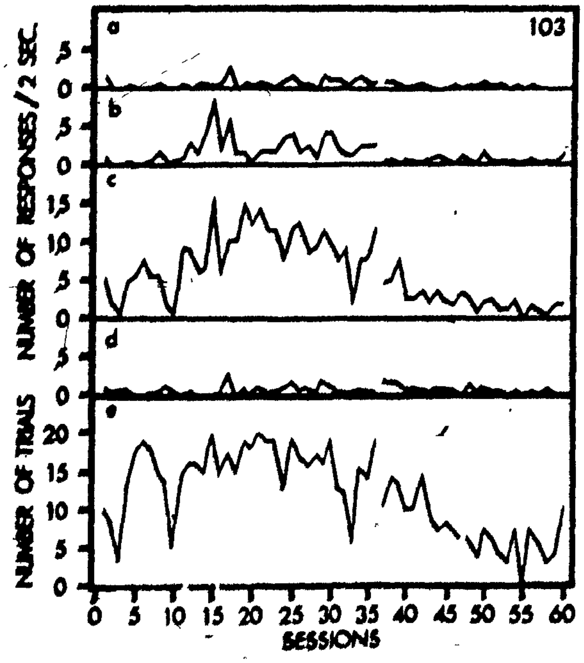
NUMBER OF RESPONSES/2 SEC.
NUMBER OF TRIALS
SESSIONS
0 5 10 15 20 25 30 35 40 45 50 55 60


103
a
b
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e
NUMBER OF RESPONSES/2 SEC.
NUMBER OF TRIALS
SESSIONS
0 5 10 15 20 25 30 35 40 45 50 55 60

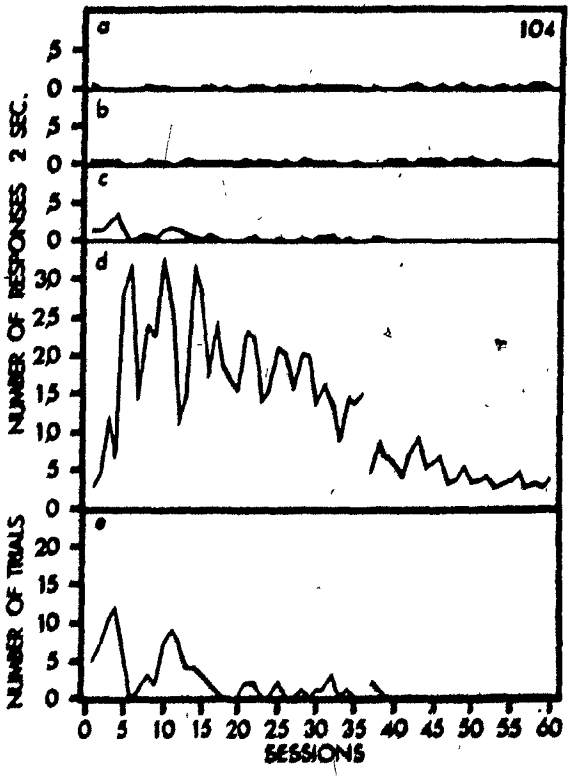
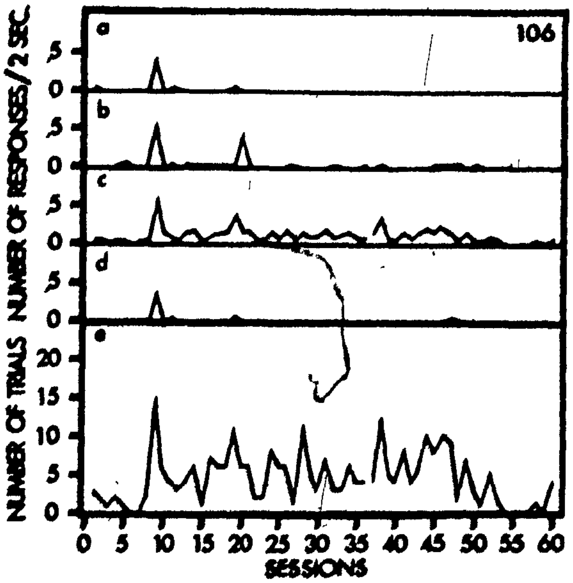

104
a
b
c
d
e
NUMBER OF RESPONSES 2 SEC.
NUMBER OF TRIALS
SESSIONS
0 5 10 15 20 25 30 35 40 45 50 55 60

FIGURE 4. Individual results of rats 105, 106, and 107 (RC group) (See Figure 3).


106
a
b
c
d
e
NUMBER OF RESPONSES/2 SEC.
NUMBER OF TRIALS
.5
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20
15
10
5
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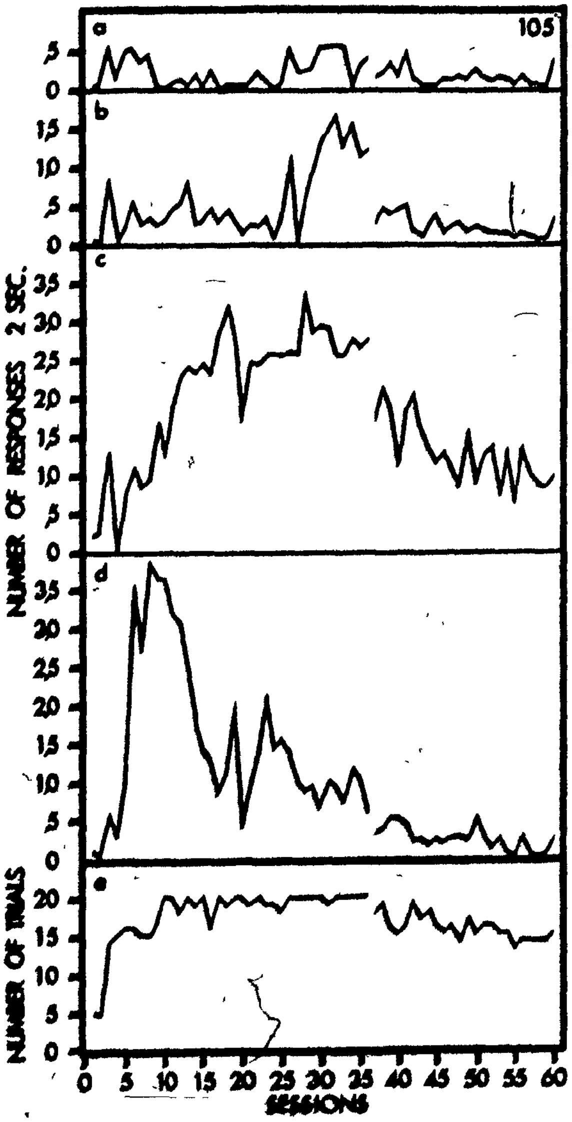
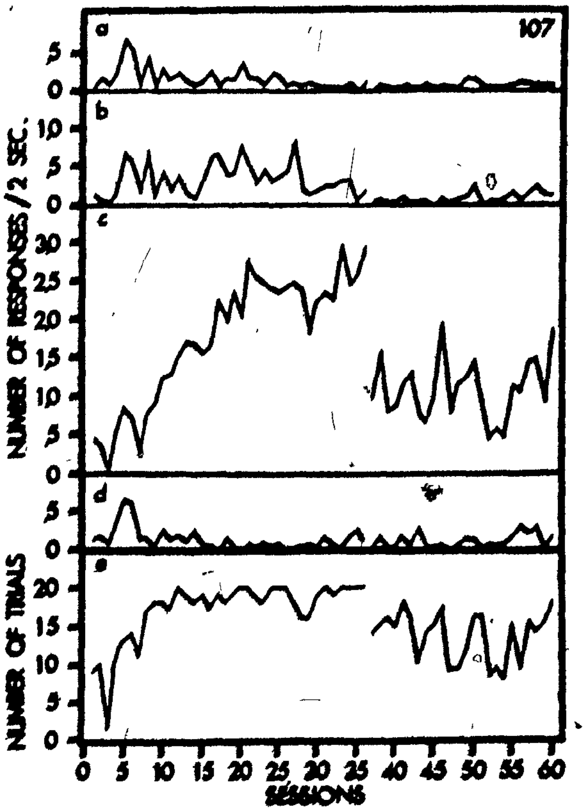
0 5 10 15 20 25 30 35 40 45 50 55 60
SESSIONS


105
a
b
c
d
e
NUMBER OF RESPONSES 2 SEC.
NUMBER OF TRIALS
.5
0
1.5
1.0
3.5
3.0
2.5
2.0
20
15
10
5
0
0 5 10 15 20 25 30 35 40 45 50 55 60
SESSIONS


107
a
b
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d
e
NUMBER OF RESPONSES/2 SEC.
NUMBER OF TRIALS
.5
0
1.0
3.0
2.5
2.0
1.5
20
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10
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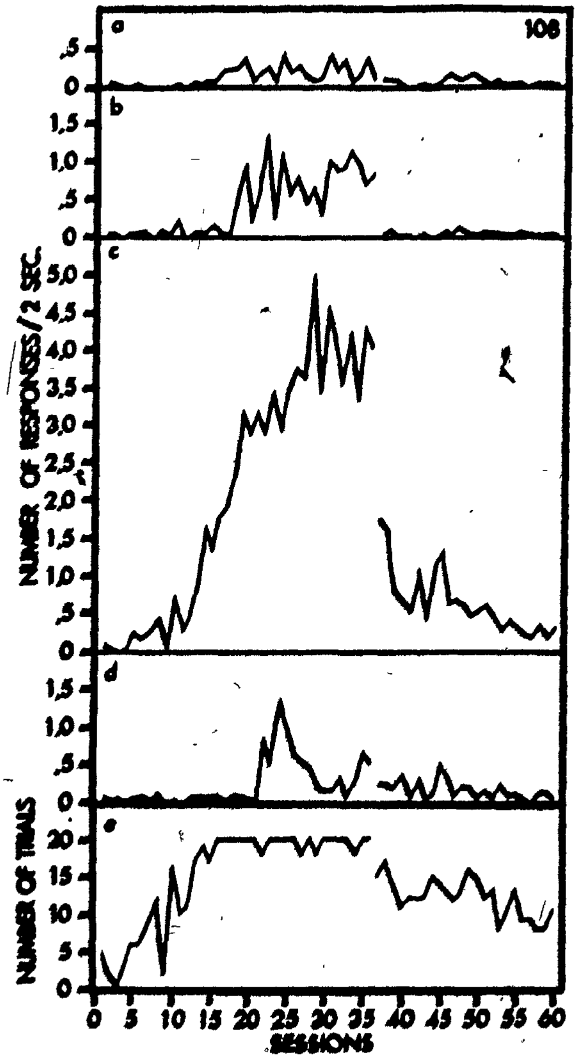
0
0 5 10 15 20 25 30 35 40 45 50 55 60
SESSIONS

FIGURE 5. Individual results of rat 108 (RC group) (See Figure 3).


a
108
,5
0
b
1,5
1,0
,5
0
c
5,0
4,5
4,0
3,5
3,0
2,5
2,0
1,5
1,0
,5
0
NUMBER OF RESPONSES/2 SEC.
d
1,5
1,0
,5
0
e
20
15
10
5
0
NUMBER OF TRIALS
0
5
10
15
20
25
30
35
40
45
50
55
60
SESSIONS

rats 105, 107, and 108), rates were immediately affected (at the very first session) but trial scores were gradually affected as in SC group. Rat 106 had a strange reaction to omission procedure: having the lowest asymptote rate during acquisition in RC Group, it should have been affected rather quickly by the omission procedure but it reacted only after 12 sessions; then, its performance slowly decreased toward extinction.

The goal of a more detailed temporal distribution analysis was to see if the scores obtained for each period adequately represented the distribution of responses within the period. Figure 6 to Figure 9 are three-dimensional representations of the temporal distribution of the scores within trial. The scores are presented on the z-scale. On the x-scale are presented, from left to right, in blocks of two-second intervals, the pre-CS period (10 units), the CS period (four units), the water presentation period (four units), and the post-CS period (10 units). The sessions are presented on the y-scale, from front to rear, grouped in blocks of four sessions. The first nine units represent the 36 training sessions and the last six units represent the 24 sessions of omission training.

Figure 6 shows SC scores; Figure 7 shows the same scores as in Figure 6 but this time as viewed from the opposite direction, in order to see some of the scores that were hidden in Figure 6. Figure 8 shows RC group scores and Figure 9 shows the same scores as in Figure 8 but as viewed from the opposite direction.

FIGURE 6. Three-dimensional representation of the temporal partition of the SC group mean scores within trial for all sessions. The scores are presented on the z scale. The highest score was 2.075. From left to right (x scale) are presented, in blocks of two-second moments, the pre-CS period (10 blocks), the CS period (four blocks), the water presentation period (four blocks), and the post-CS period (10 blocks). From front to rear (y scale) are presented all 60 sessions, grouped in blocks of four sessions. The first nine blocks represent the 36 training sessions and the last six blocks represent the 24 sessions of omission training.

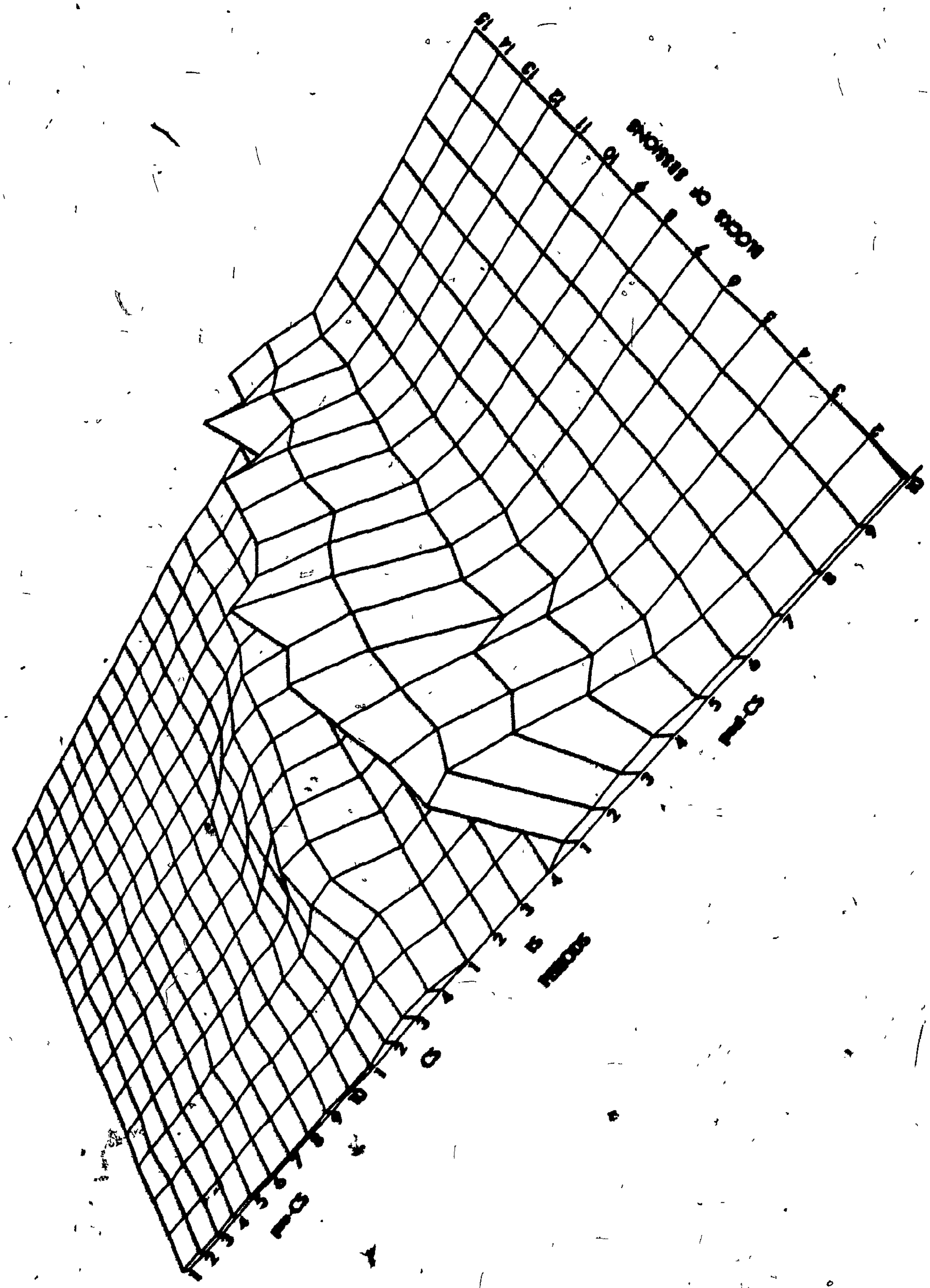

BLOCKS OF SESSIONS
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
PERIODS
PRE-CS
CS
US
PRE-CS

FIGURE 7. Back view of the three-dimensional representation of Figure 6.

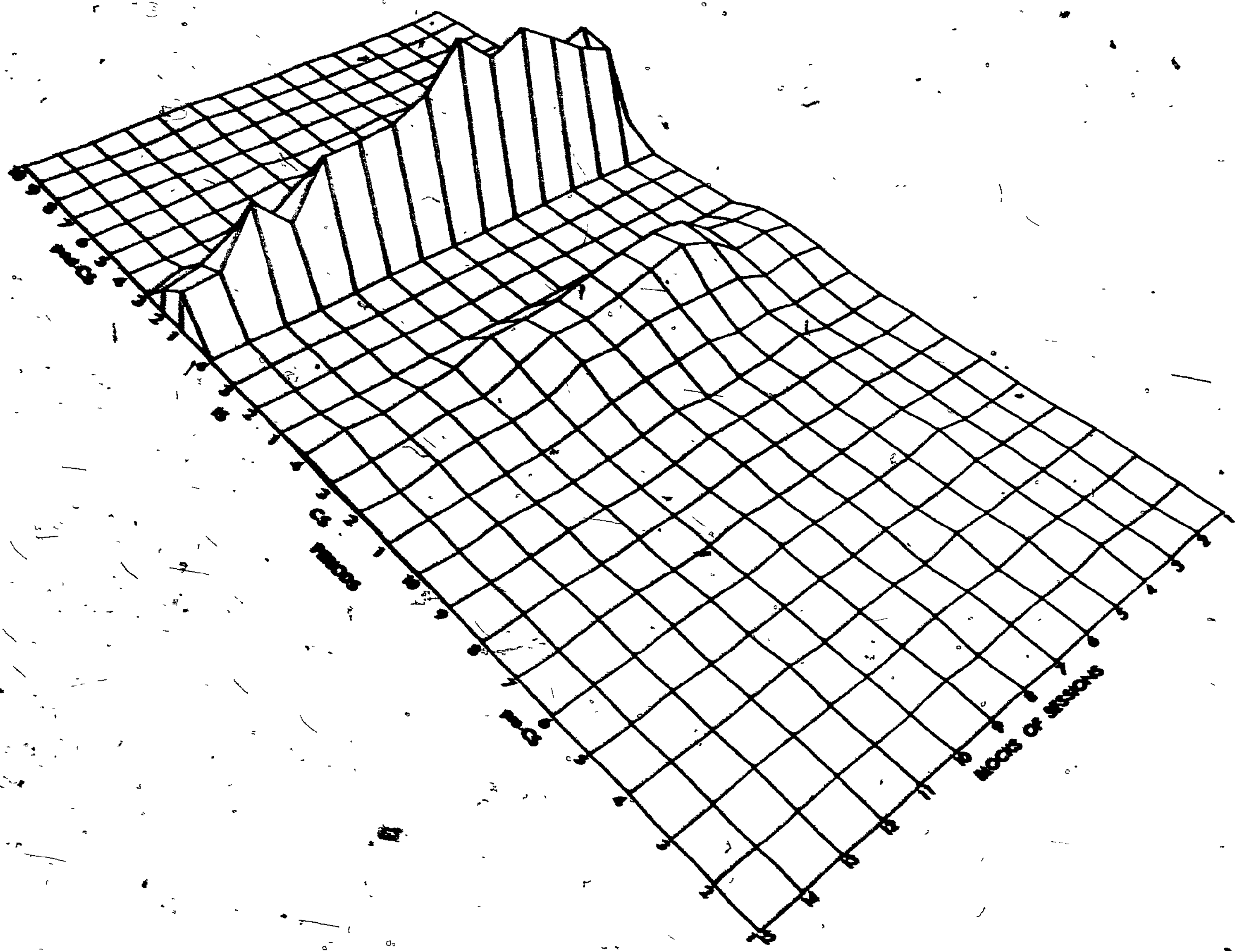

CS
PERIODS
BLOCKS OF SESSIONS
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

FIGURE 8. Three-dimensional representation of the temporal partition of the RC group mean scores within trial for all sessions. The highest score was 2.81. See Figure 6 for more explanation.

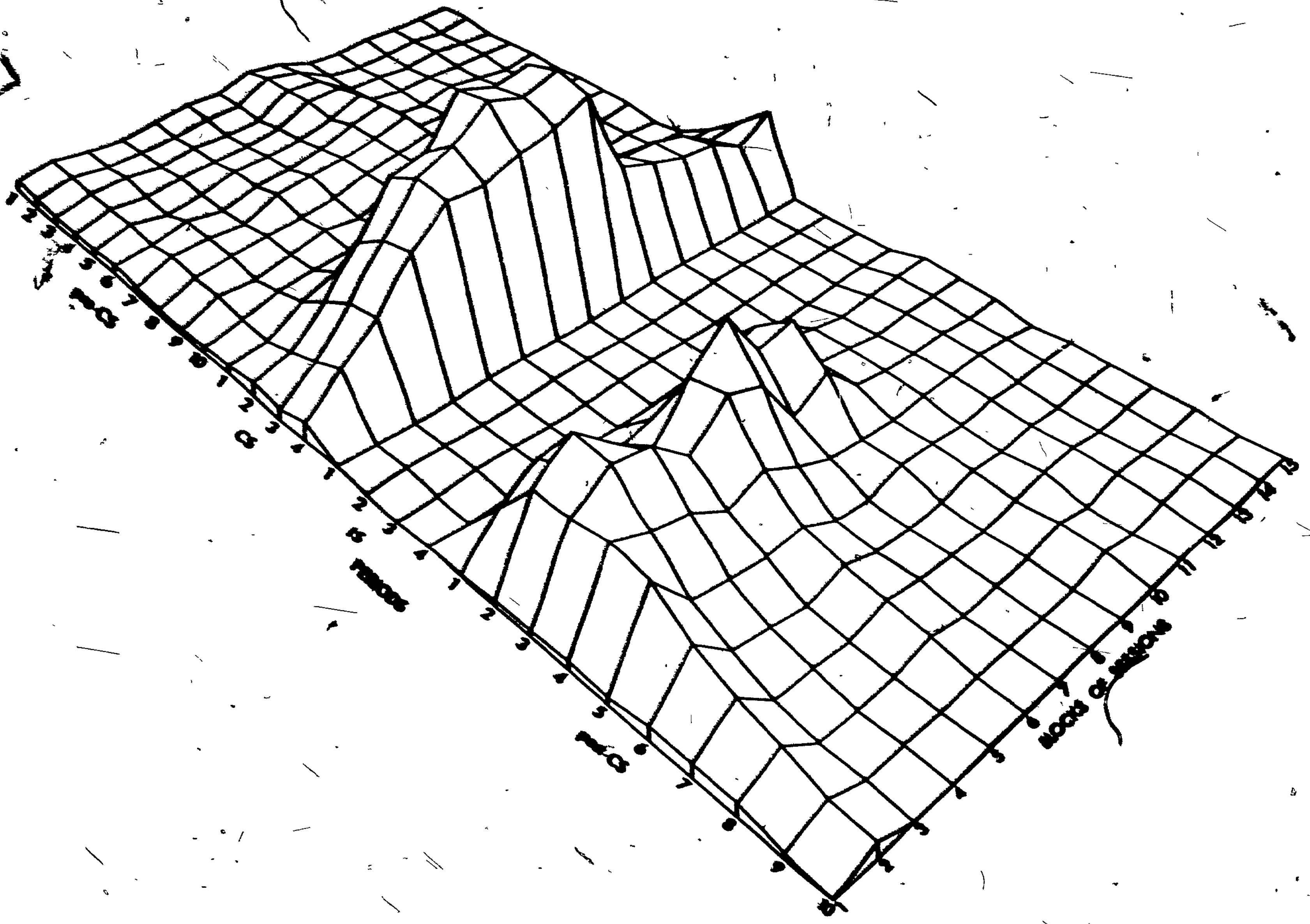
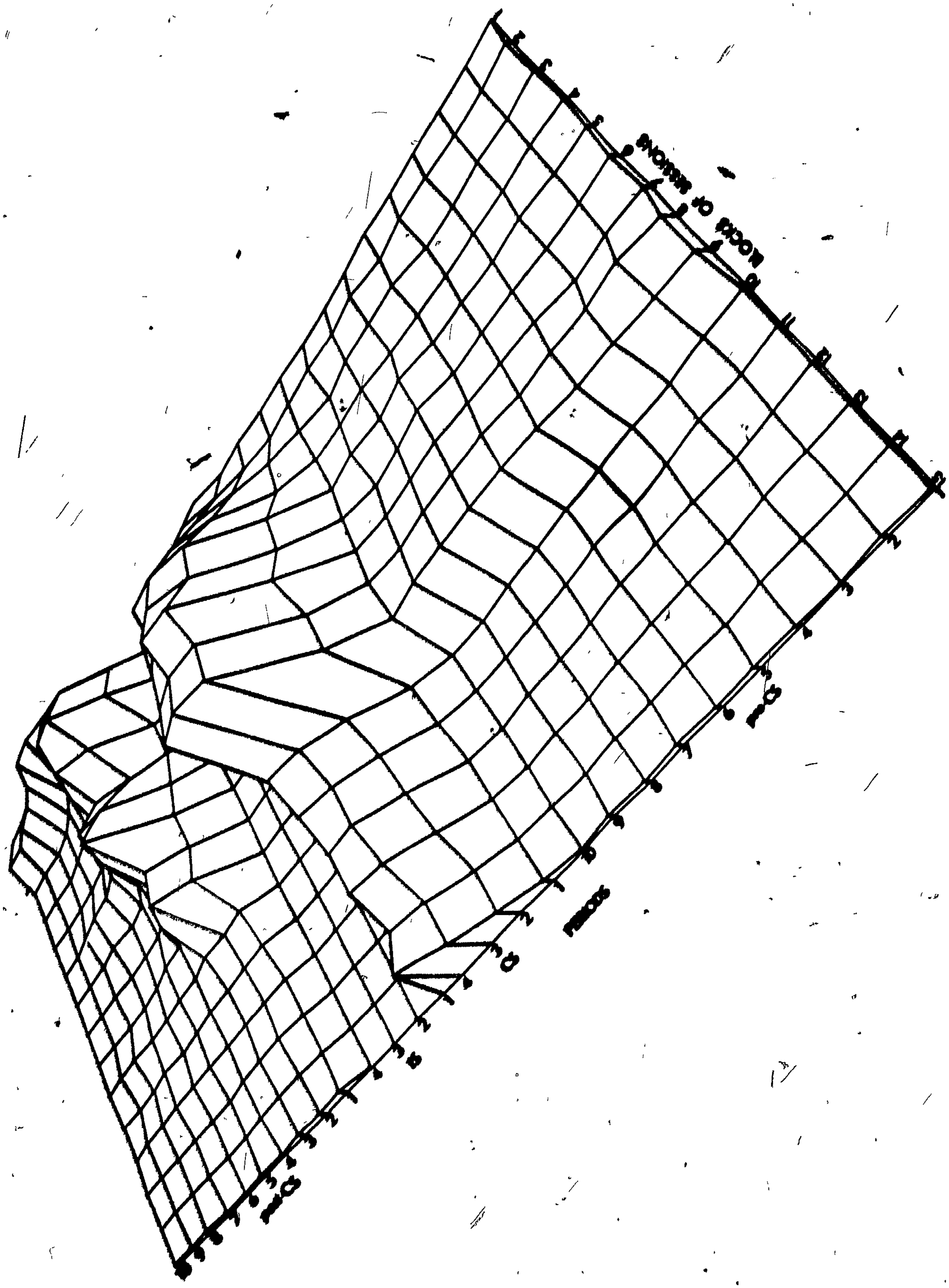

1 2 3 4 5 6 7 8 9 10
PRE-CS
1 2 3 4
CS
1 2 3 4
US
PERIODS
1 2 3 4 5 6 7 8 9 10
POST-CS
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
BLOCKS OF SESSIONS

FIGURE 9. Back view of the three-dimensional representation of Figure 8.


BLOCKS OF SESSIONS
PERIODS
CS

The results of this detailed "temporal-distribution" analysis generally confirmed the results of the earlier, rough "period" analysis. No statistical analysis was done on the scores because the visual presentation was found sufficient for the sake of the present analysis. Also, only group scores are presented because the distribution of the scores between subjects followed the same pattern as their distribution in the period analysis.

RC group scores were greater than SC group scores, at all moments (2-sec. intervals) of the pre-CS and CS periods; during the post-CS period, scores were quite similar in both groups, except during omission sessions. During the pre-CS period, there was no detectable increase in scores in any of the two groups, but there was a regular increase of the RC group scores among blocks of training sessions, at each of the ten two-sec. blocks. During the CS period, a goal-gradient pattern of responses appeared in both groups and persisted through the end of the experiment. During the post-CS period, RC group scores increased rapidly to a maximum and then decreased regularly throughout the rest of the post-CS period. However, the decrease of the scores tended to be more and more rapid over sessions. SC group scores followed the same pattern except that the scores were already at their maximum at the beginning of the post-CS period. In both groups, at the end of the post-CS period, the scores were at the same level as at the beginning of the pre-CS period.

The omission procedure affected RC group post-CS scores more than SC group scores. It must be noted, however, that responding during the post-CS period occurred only on trials when IS was presented. Thus, high rates of response during the CS period in RC group prevented IS to appear, a low rate of responding during the CS period in SC group allowed more presentations of IS (see Figure 2, e). It is then to be expected that the post-CS scores would be more affected in RC group than in SC group. When looking at RC group scores from the rear (Figure 9), the effect of the introduction of the omission procedure is seen clearly. All scores, from the beginning of the pre-CS period to the end of the CS period, decreased considerably within the first four sessions of omission procedure (Block 10 of sessions). Most of that decrease occurred immediatly, on the very first session of omission training, as has been already shown (see Figure 2). However, after that immediate decrease, the scores decreased very little during the following sessions.

Discussion

The results of the SC group demonstrated that auto-shaping (stable operant responding with response-independent CS-contingent reinforcement) can be achieved in the rat if the CS and the manipulandum are the same stimulus object. The CS:IS contingency thus appears to have been sufficient to instigate what appears in all respects to be an instrumental approach-contact response.

Even if there existed a de facto instrumental (R:IS) contingency after responding had begun, the CS:IS contingency must still be considered sufficient for instigating the initial responses made before the R:IS contingency could have acquired any great strength.

A comparison of the RC group with the SC group during the 36 acquisition training sessions indicates that the superimposition of the explicit R:IS contingency on the CS:IS contingency produced a substantially higher rate of response in the RC group. However, the two groups did not differ significantly in the probability of making at least one response during the CS period. This suggests that probability of making an approach-contact response in relation to the CS-manipulandum is determined primarily by the CS:IS contingency; what the R:IS contingency adds is an increase in the rate of rsponding. This suggestion is supported by the results of the omission-training sessions.

The omission procedure (CS:$\bar{R}$:IS) reduced the rate of responding, especially in the RC group, but failed to produce total extinction of the response as might be expected to occur in the absence of the S:IS contingency .

The effect of omission training on number-of-trial scores is more surprising. Even if the introduction of the omission procedure produced a greater alteration in contingencies in RC group (from CS:R:IS to CS:$\bar{R}$:IS) compared to the SC group (from CS:IS to CS:$\bar{R}$:IS), the performance in RC group seems to be less affected than performance in SC group, as revealed by the absence of any significant decrease in number-of-trial scores during omission training while performance in SC group was significantly lower at the end of omission training than at the end of acquisition training. In other words, resistance to omission training is greater in BC group than in SC group as judged by trial scores while it is lower as judged by rate scores. It would appear that there were two components to the observed response rates, one determined by the CS:IS contingency that was common to the two groups, and the other determined by the R:IS contingency which was stronger in the BC group than in SC group; the disappearence of R:IS contingency during omission training immediately reduced responses rates. But higher resistance to omission in probability of responding (trial scores) reveals the CS:IS contingency had a stronger influence in the BC group than in SC group.

The post-IS burst of responses, found in rats 104 and 105, at a moment when the interval to the next IS presentation is the longest, and at a moment when the panel is not illuminated, surely cannot be interpreted as an anticipatory responding. Also, the similarity of the post-IS responding pattern in these two rats shows that it is not an outcome of any difference between the two training procedures. Post-IS responding occurred only on "reinforced" trials. Thus such responding could represent a continuation of the unconditioned response (licking) after the removal of IS. Such a continuation of UR has been reported by Shapiro (1960) in the salivary response of dogs, accompanying a lever-pressing response under a FI:2 min.; the rate of salivary responding was at its highest immediately after the presentation of IS (a food pellet), then declined, and this period of low responding was followed by a gradual increase as the next reinforcement approached. But even if there is a parallel between the post-IS salivary response reported by Shapiro, and the panel approach-contact responses of the present experiment, it would not explain why the animals in our experiment responded on the panel. It is more likely that the post-CS responding in our experiment is related to such phenomena as adjunctive behavior (Falk, 1971), or emotional induction (Segal, 1972), or interim activities (Staddon and Simmelhag, 1971), that generally appear after removal of IS.

Turn now to the fundamental question: What is it about the instrumental procedure that produces the higher rate of response (CS:R:IS) than the classical (CS:IS) procedure. The CS:IS procedure and the CS:R:IS procedure used in this experiment were quite similar: in both procedures IS was contingent upon CS. Also, in both procedures, the absence of IS was contingent upon the absence of illumination of the panel. It has already been found that, to be effective, the CS:IS (light:food) occasions (experience) must be contrasted with either a "no-light no-food" occasions (Gamzu & Williams, 1971) or a "no-light less-food" occasions (Gamzu & Schwartz, 1973); if the probability of getting food is the same when the light is OFF as when the light is ON, the CS-response will not develop, or, if already developed, will extinguish. The main difference between the two procedures would appear to be in the requirement of a contact response during the CS period: IS was always presented in the classical procedure (SC group), but was presented in the instrumental procedure only if a response occurred during the CS period. In other words, $CS{:}\bar{R}{:}\overline{T}S$ occasions were experienced only in the instrumental procedure. Thus the $CS{:}\bar{R}{:}\overline{T}S$ occasions appear to be critical in determining the higher rates of response met in the RC group, even if they are not essential in the acquisition and maintenance of the response. But by what exact process might these $CS{:}\bar{R}{:}\overline{T}S$ occasions have their effect is not clear from the results of this experiment.

EXPERIMENT 2

Experiment 1 showed that basis of the greater responding in RC group than in SC group is probably unrelated to the temporal distribution of responses in a trial. Where then should one look for the basis of the difference between the two conditions. One possibility is that the two conditions produced responses of different degrees of precision. It may be, for example, that rats in SC group responded, in some sense, as much as those in RC group but that their responses were not accurately directed toward the CS panel, so that their responses were not spatially accurately enough directed at the panel to be counted as responses. The suggestion that the R:IS contingency may result in more "discriminated" responses was implied in Bindra (1972) and was suggested by Lolordo, McMillan and Riley (1974).. This idea was examined in the second experiment.

In this experiment a new manipulandum was used to measure the spatial distribution of responses. It consisted of a larger drawer with three panels on its front side. These panels could be used as CS (one at a time) and could also register separately the contact responses. Such a moveable CS could make it possible to determine whether the illumination of one of the panels constituted only a signal for initiating responses that would then be as much directed on the other panels as on the CS itself or whether the illumination of one of the panels actually attracted responses that would then be more directed on the CS panel than on the other panels. It was hypothesized that the CS would exercise more control on RC group than on SC group; this control would be manifested in RC group by higher means and lower variance in proportion of responses on the CS panel.

Two new control procedures were also introduced. The first one consisted in the addition of a random control group in order to assess the effect of the presentation of the illuminated panel itself and the effect of independent occurrences of CS and IS on acquisition of responses. The second control procedure consisted in the introduction of pre-acquisition baseline sessions that were identical to the training sessions except that no panel was ever illuminated. IS was presented without response specification and without being signaled. The goal of this control procedure was to make sure that the operation of the drawer or its mere presence in the vicinity of IS did not constitute another CS powerful enough to permit acquisition of responses. In order to control for the effects of the pre-acquisition baseline sessions on subsequent acquisition of response during training sessions, another squad of animals was trained, in a second phase of the experiment, without the pre-acquisition baseline sessions.

Method

Subjects

The subjects were 20 naive male hooded rats weighing 245-255 g. at the time of purchase. They were individually housed and were maintained at approximately 80 percent of their *ad lib.* weight. Ten of these animals comprised Squad 1 and were used in Phase 1 of the experiment (with baseline sessions); the remaining animals comprised Squad 2 and were used in Phase 2 of the experiment (without baseline sessions).

Apparatus

The experiment was conducted in a different test chamber than the one used for the first experiment. The test chamber (Lafayette, No. 85000) was 30.5 cm long, 20.3 cm wide, and 19.7 cm high. The north and south walls, made of Plexiglas, were painted black, the west wall was covered on the inside by a sheet of clear Plexiglas and on the outer surface by a one-way window, and the east wall was made of stainless steel. The floor, the ceiling and the houselight were the same as in the first experiment. The test chamber was itself placed in a sound-protected enclosure. A Plexiglas window on the wall of the enclosure permitted the observation of the animal through the translucent wall of the test chamber. A ventilating fan assured proper air circulation and created a quasi-white noise of 76 dB (measured inside the test chamber) which masked the equipment sounds. Automatic scheduling and recording were controlled by a set of logic modules (BRS-Foringer, series 100).

The reinforcement drawer, still located on the middle of the north wall (with its center 38 mm from the floor), was different than the one used in the first experiment. Now, the front panel of the drawer consisted of three rectangular (14 mm long by 25 mm high) copper wire-grids placed on a white Plexiglas support and bounded by a black frame. Each grid panel could be independently illuminated by two lamps (28 VDC) located inside the drawer; the luminance of each panel was 430 cd/m², measured at a distance of 5 cm from the front of the grid. The water delivery mechanism was the same as in the first experiment.

Three drinkometer circuits (Grason Stadler E4690A-1) were connected independently on the three panels and were used to measure the contact responses on each panel. A fourth drinkometer circuit in the water receptacle was used, as in the first experiment, to record consummatory responses and to control the delivery of water for the next trial.

Procedure

On each of the first two days of the experiment, the animals were individually handled and allowed to explore the apparatus for 10 minutes. On the two subsequent days, the animals were trained to drink water from the extended drawer. This was done in the following way: when the animal was put in the box, the drawer was already open and its hole full of water. After the animal discovered and drank the water, the drawer was retracted quietly so as not scare the animal. Duration of water presentations was progressively decreased to 4 sec., and remained at that value throughout the experiment. A maximum of six presentations of drawer (in two days) was sufficient to train all animals to drink all the available water within 4 seconds.

The following procedure was followed for animals in Phase 1 (Squad 1). During eight successive daily sessions, they were exposed to the complete experimental procedure except for the presentation of the CS- (pre-acquisition baseline sessions). This means that they received during each session 48 presentations of water on a VT (variable-time) schedule regardless of their behavior. During the baseline sessions, the responses were recorded at the time when the CS would have been presented, that is, during the eight seconds preceding water presentation.

These 10 animals were then randomly distributed into three groups, a designated stimulus-contingent group (SC1 group, n=4), a designated response-contingent group (RC1 group, n=4), and a random control group (RAND1 group, n=2).

Three training procedures were used with the three corresponding groups. The two first groups were as in the experiment 1: (1) stimulus-contingent (CS:IS) training procedure (SC1 group); (2) response-contingent (CS:R:IS) training procedure (RC1 group); (3) random control procedure (RAND1 group). Each animal in the RAND1 group received 48 presentations of CS at the same exact moments throughout each session as in the two experimental groups but IS were presented on a different (random) schedule. All three groups were trained with their respective procedure during 16 sessions.

Each daily session lasted 48 min. and consisted of 48 trials, 16 with each of the left, center, and the right panel illuminated for eight seconds. In each trial, one of the three panels was illuminated for eight seconds. Each panel was illuminated 16 times during a session. The order of presentation was randomized before each session but all animals in each session received the same order of presentation. IS presentations (water deliveries) were identical to those in Experiment 1. The length of the ITI was variable, the average being 44 sec., the shortest 28 sec., and the longest 72 sec. After each session, the animal was returned to its cage and, about one hour after, was given an amount of water needed to maintain the weight at 80 percent of its *ad lib*. weight.

The procedure for the animals in the second phase of the experiment (Phase 2) was as follows. They were treated in the same way as the animals in Phase 1, with the exception that they were not given the eight pre-acquisition baseline sessions. That is, immediatly after the habituation period and drawer training procedures, these rats were randomly distributed into training groups (SC2, RC2, and RAND2) and training was carried in for 16 sessions. The animals in Phase 2 were given the same order of presentation at each corresponding session as in the animals of the first phase of training.

Results

Figure 10 shows the mean number of responses on the CS panel in units of two-seconds (rate scores), and the number of trials on which there was at least one response on the CS panel (trial scores) for the baseline and training sessions of SC1, RC1 and RAND1 groups (Phase 1) and for the training sesssions of SC2, RC2, and RAND2 groups (Phase 2).

Analyses of variance were carried out on rate scores and on trial scores. The results of these analyses are presented in Tables 16 to 25. The RAND1 and RAND2 groups were not included in the analyses, as they contained only two subjects; references to RAND groups will be based on individual results.

Baseline sessions were not effective in producing approach and contact with panels; the response rates of all three groups stayed nearly equal at a rather low level. Individual results (Figure 11) show that one animal in SC1 group and one animal in RC1 group acquired rapidly a higher rate of response, but all the others stayed at nearly zero level. Analysis of variance done on baseline sessions (Sessions x Groups) revealed no differences between groups or between sessions for either rate or trial scores (Tables 16 and 17). Analyses of variance were also performed on baseline and training sessions of Phase 1 (Blocks x Sessions x Groups, with repeated measures on the first two factors) (Tables 18 and 19). The 24 sessions of Phase 1 were grouped in three blocks of eight sessions (Block 1:

baseline sessions; Block 2 and Block 3: training sessions). In each analysis, a significant difference was found between blocks (rate scores: p < .01; trial scores: p < .001). The introduction of the illuminated panel in Phase 1 sessions was reflected in all three groups. The two animals in RAND1 group showed their highest rate and trial scores at the very first session of training and then decreased gradually during the remaining 15 sessions. In the two other groups, performance (rate and trial scores) at the first training session were nearly the same and well over performance of RAND1 group.

Figure 10 shows that CS rates stayed at about the same level throughout the training sessions for SC1 and RC1 groups. Animals in the second phase of training sessions produced results similar to those in the first phase except for SC2 group. RAND2 group remained at a near-zero level but without the initial higher rates of RAND1 group; animals in RC2 group increased their performance in a similar way to those in RC1 group. SC2 group behaved in a different way: starting at a near-zero level, both rate and trial scores increased regularly up to the last sessions. This trend is particularly evident in the trial scores of SC2 group which attained the same asymptotic level as trial scores of RC2 group.

In order to compare the results between the training sessions of the first phase of the experiment (SC1 and RC1 groups) with the training sessions of the second phase (RC2 and SC2 groups), a three-way analysis of variance (Sessions

FIGURE 10. Rate and trial scores for the baseline and training sessioons of SC1, RC1, and RAND1 groups (Phase 1) and for the training sessions of SC2; RC2, and RAND2 groups (Phase 2).

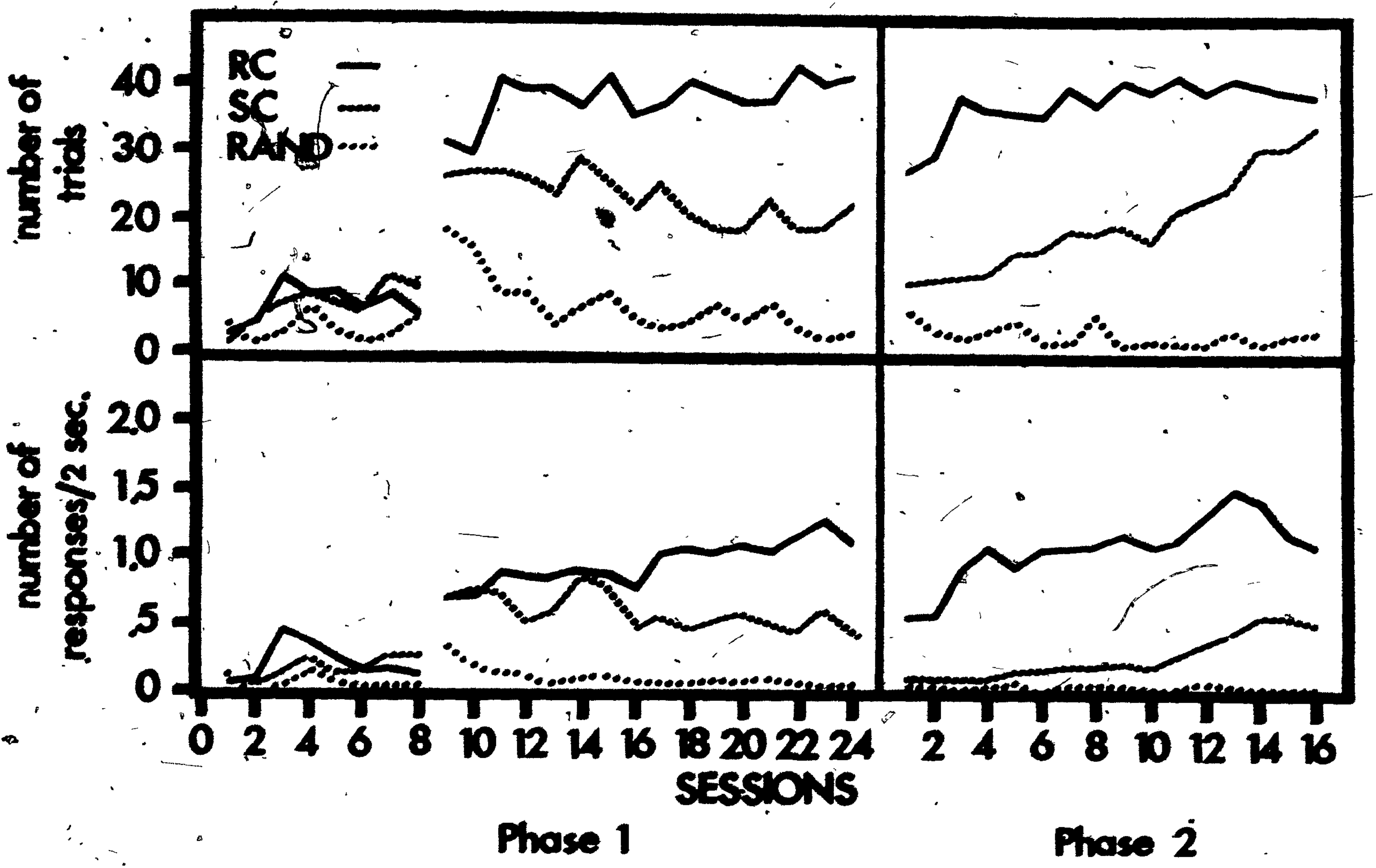
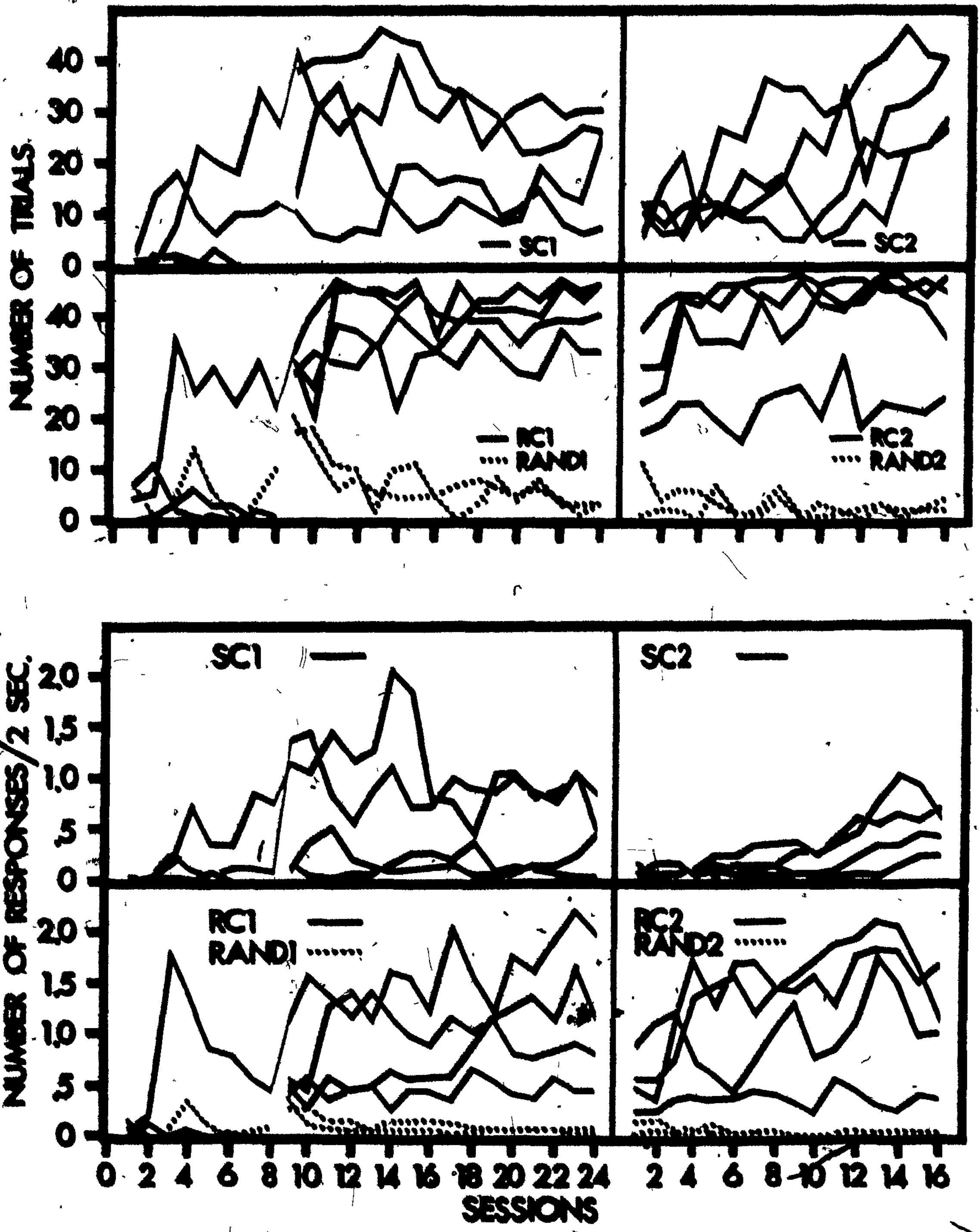

RC
SC
RAND
number of trials
40
30
20
10
0
number of responses/2 sec.
2,0
1,5
1,0
,5
0
0
2
4
6
8
10
12
14
16
18
20
22
24
2
4
6
8
10
12
14
16
SESSIONS
Phase 1
Phase 2

FIGURE 11. Individual results in rate and trial scores for the baseline and training sessions of SC1, RC1, and RAND1 groups (Phase 1) and for the training sessions of SC2, RC2, and RAND2 groups (Phase 2).


NUMBER OF TRIALS
0
10
20
30
40
SC1
SC2
RC1
RAND1
RC2
RAND2
NUMBER OF RESPONSES/2 SEC.
0
.5
1.0
1.5
2.0
SC1
SC2
RC1
RAND1
RC2
RAND2
0
2
4
6
8
10
12
14
16
18
20
22
24
2
4
6
8
10
12
14
16
SESSIONS

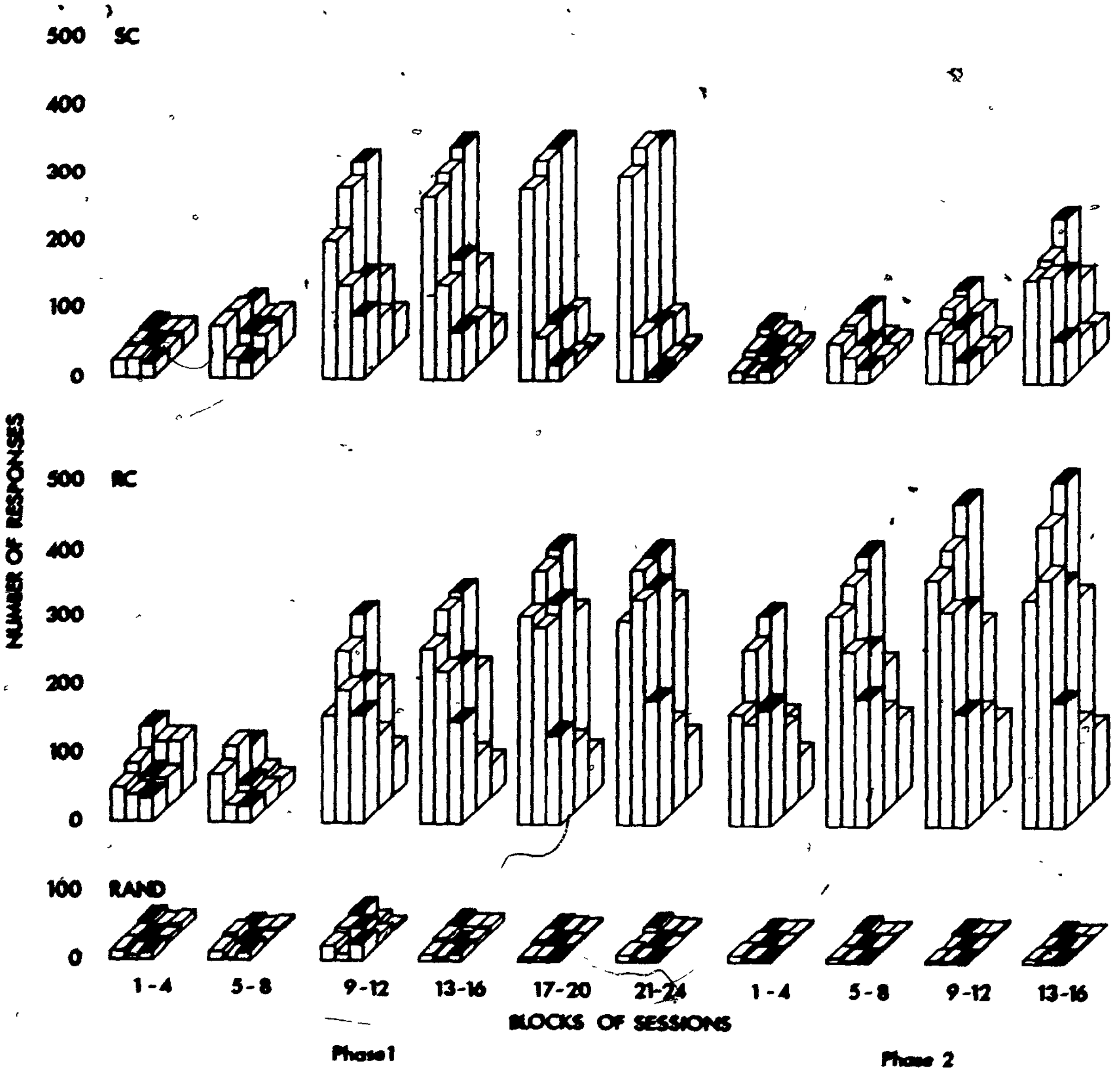
x Phases x Groups) with repeated measures on the first factor was used. There were 16 sessions and four groups nested in two phases of training (Phase 1: SC1 and RC1 groups; Phase 2: SC2 and RC2 groups). No significant difference was found between the two phases of training sessions in rate and trial scores (Tables 20 and 21). Significant differences between sessions were found for each of the two analyses ($p < .001$) but an interaction between Sessions and Phases (rate scores: $p < .05$; trial scores: $p < .001$) indicates that these differences between sessions could have been present only in one of the two phases. Significant differences between groups were found in each analysis (rate scores: $p < .05$; trial scores: $p < .01$). Separate analyses of variance done on each phase (Sessions x Groups) revealed significant differences between sessions during Phase 2 for rate and trial scores ($p < .001$) but not in Phase 1 (Tables 22 to 25).

My initial intention was to calculate the proportion of responses on the CS panel without regard to the location of the CS -- the particular panel illuminated. However, while inspecting the data, it soon became evident that there were strong patterns of preferences, for one of the two side panels. It was then decided to make a distinction, in the analysis of the spatial distribution of response, between the trials with the CS on the left panel, the trials with the CS on the center panel, and the trials with the CS on the right panel. However, it was then revealed that these preferences could shift from subject to subject and from session to session (see Table 26 for the distribution of side preferences for each animal and for each session). When calculating group means, these preferences canceled each other and at the same time obscured the effects of the preferences for the illuminated panel. To remedy this, it was decided to prepare a table in which the preferred panel, left or right, was put in the same column of the table. For example, when in a given session, the preference was already on the left side, nothing was changed; but when the preference was on the right side, the three totals for the left side and the three totals for the right side were interchanged. The total number of responses for each of the three panels at each of the three types of trials (corresponding to whether the illuminated panel was left, center, or right) were then grouped in blocks of four sessions. This method made it possible to isolate the effect of side preference on the distribution of responding, and to reveal any other effect that might have been hidden by the effect of side preference.

Figure 12 presents three-dimensional histograms showing the total number of responses, averaged over sessions, on each of the three panels for each of the three types of trials. Each histogram contains nine blocks: z scale represents, from floor to ceiling, scores; x scale represents, from left to right, the left, the center and the right panels; and y scale represents, from front to rear, trials with the CS on the right panel, trials with the CS on the center panel, and trials with the CS on the left panel. All group scores are presented in blocks of four sessions (on the x scale).

When performance is seen in the form of these histograms, remarkable differences are revealed between the response scores obtained from the present spatial distribution analysis and the rate scores and the trial previously obtained. In the first phase (SC1, RC1, RAND1 groups) of the experiment, while the CS scores showed a gradual differentiation of SC1 and RC1 groups, this differentiation was to be found in histogram scores only on the center and right (non-preferred) panels. Scores on the left (preferred) panel were the same in both groups. Also, the rate scores and the trial scores showed that, over sessions, responding increased in RC1 group but decreased in SC1 group. Histogram scores still showed increased responding over sessions in RC1 group, but only on the left and center panel; scores on the right panel remained at the same level. In SC1 group, decreased responding (over sessions) was to be found only on the center and right panels; performance on the left panel remained constant over the four blocks of sessions. Phase 2 groups (SC2, RC2, and RAND2) that were given no baseline sessions showed more regular acquisition of responses, particularly in SC2 group, where performance started from near-zero level. Thus the differences that were found in rate scores and trial scores between SC2 and RC2 group in

FIGURE 12. Three-dimensional histograms of scores on each of the three panels for each of the three types of trials, for the baseline and training blocks of sessions of SC1, RC1, and RAND1 groups (Phase 1) and for the training blocks of sessions of SC2, RC2, and RAND2 groups (Phase 2). Each histogram contains nine blocks representing scores (z scale). From left to right (x scale) are presented in order the left, the center and the right panels, and from front to rear (y scale) are presented in order trials with the CS on the right panel, trials with the CS on the center panel, and trials with the CS on the left panel. The blocks with the black top represent an illuminated panel.


NUMBER OF RESPONSES
SC
500
400
300
200
100
0
RC
500
400
300
200
100
0
RAND
100
0
1-4
5-8
9-12
13-16
17-20
21-24
1-4
5-8
9-12
13-16
BLOCKS OF SESSIONS
Phase 1
Phase 2

the second phase of the experiment were found again, and this time, on each of the three panels.

Baseline sessions (of Phase 1 of the experiment) did not show any systematic pattern of response distribution in any of the three groups. An analysis of variance was performed on baseline sessions (Table 27). The design of this analysis was a four-way analysis of variance (Blocks x Trials x Panels x Groups) with repeated measures on the first three factors. There were two blocks of four sessions, three trials, three panels and two groups (SC1 and RC1 groups). None of the factors was found significant. Performance of RAND1 groups stayed at a near-zero level at all blocks of sessions, except at the first block of training sessions of Phase 1, when scores on all three CS panels were higher. These results are consistent with rate and trial scores, which were at their highest at the first session of Phase 1.

An analysis of variance was performed on training sessions for SC1, RC1, SC2, and RC2 groups (Table 28). The design of this analysis was a five-way analysis of variance (Blocks x Trials x Panels x Phases x Groups) with repeated measures on the first three factors. There were four blocks of four sessions, three trials, three panels, and four groups nested in two phases of training (Phase 1: SC1 and RC1 groups; Phase 2: SC2 and RC2 groups). As in the preceding analysis, RAND groups of the two phases of the experiment were not included in the analysis. Significant differences were found between Blocks of sessions ($p < .001$), Trials ($p < .05$), Panels ($p < .001$), and Groups ($p < .05$) but not between Phases. Significant interactions were also found between Trials and Panels ($p < .01$) and between Blocks and Panels ($p < .05$). These results confirm the existence of a strong interaction between Trials and Panels, pointing to the existence of two different factors that could have controlled the response.

Further analysis of the Trials x Panels interaction was done using the Newman-Keuls procedure. The pertinent comparisons were (1) between the three panels at each trial, (2) between the three trials for each panel and (3) between the three illuminated panels (Table 31). At each trial, significant pairwise comparisons between each pair of the three panels were found. Significant pairwise comparisons were also found for each panel between the three trials, except for the left panel between Trial 1 and Trial 2 and for the center panel between Trial 2 and Trial 3. The pairwise comparisons between pairs of the three illuminated panels were all significant. Thus, the pattern of responses was influenced not only by the location of the panels but also by the location of the CS panel. That is, subjects responded on the preferred side more when that same side was illuminated than when the non-preferred side was illuminated. Subjects also responded on the non-preferred side more when that same side was illuminated than when the preferred side was illuminated. Analyses of variance performed during each of the two phases (Blocks of sessions x Trials x Panels x Groups, with repeated measures on the first three factors) revealed on the location of the different significant factors (Tables 29 and 30). The interaction between Trials and Panels was found significant only during Phase 1 ($p < .05$), while the significant differences found between Groups and between Blocks of sessions was found only during Phase 2 ($p < .05$). Observation of Figure 12 reveals that during Phase 1, the average rate of response was about the same in SC1 group and in RC1 group at each of the four blocks of sessions; on the contrary, during Phase 2, there was considerable difference in speed of acquisition between the two groups; in RC2 group, performance was asymptotic already at the second block of sessions while in SC2 group, performance started from a near-zero level and increased gradually during the four blocks of sessions.

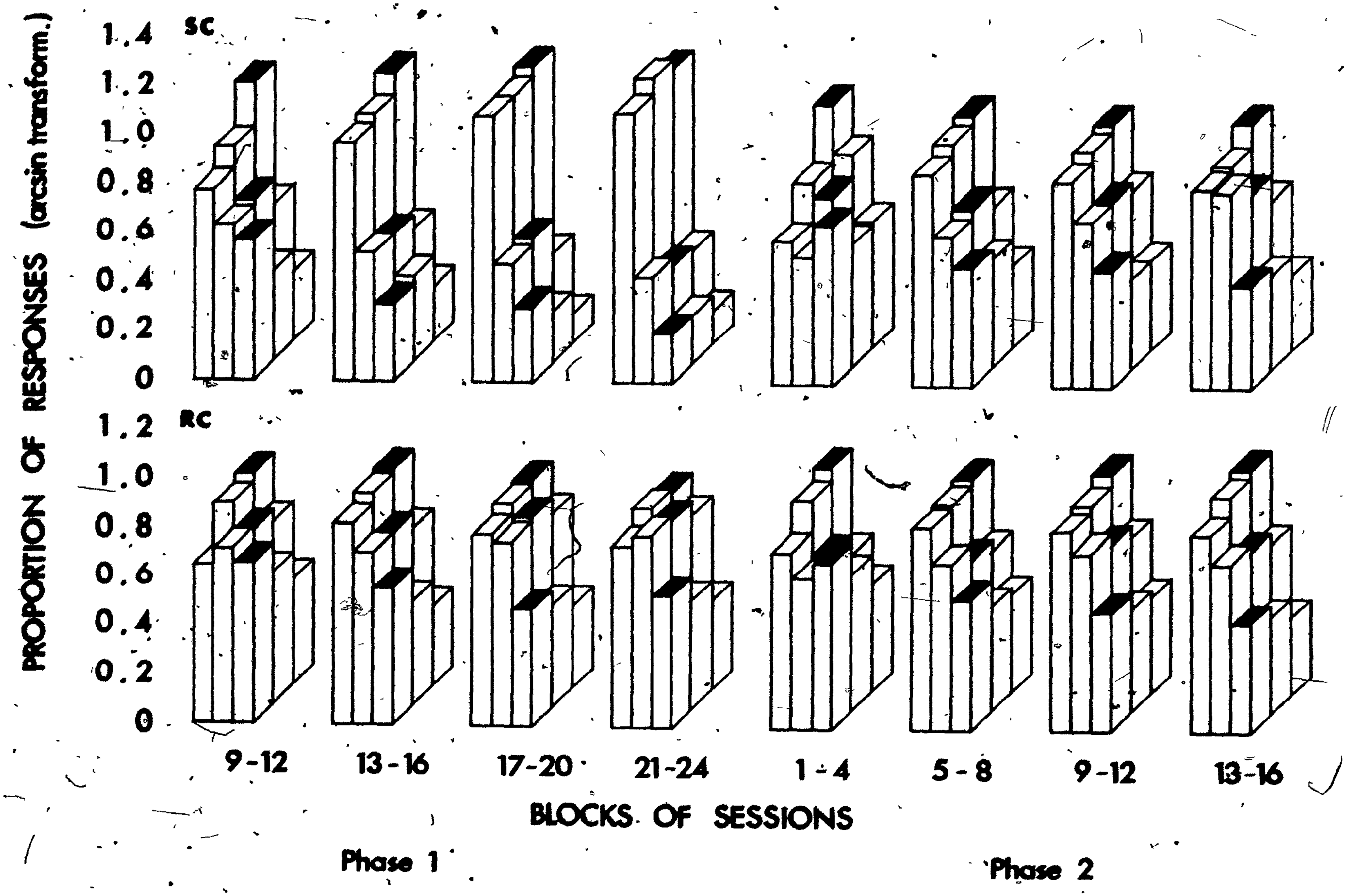
The absence of significant difference between the SC1 and RC1 groups means that the average number of response on all panels at all trials is about the same in the two groups. However, the spatial distribution of these responses, as revealed in Figure 12, is different.

To be able to compare the two groups in the relative differences in responding on each panel for each of the three types of trials, proportion scores were calculated for each group at each block of sessions at each of the two phases. A proportion score was derived from the number of responses on a given panel at a given type of trials divided by the total number of responses on the three panels for the three types of trials. In order to stabilize the variance of the proportion scores, an arcsin transformation was used, as suggested by Winer (1971, p. 400). Because the arc proportion scores were calculated for each Block of sessions, then any differences between Blocks of sessions did not mean differences in response rates but rather a change in the spatial distribution of responses over sessions.

The arc proportion scores are presented in Figure 13. In Phase 2 of the experiment, the proportion scores were roughly the same in the two groups. During the training sessions of Phase 1, however, the arc proportion scores on the left panel were greater in SC1 group than in RC1 group while the arc proportion scores on the center panel and on the right panel were greater in RC1 group than in SC1 group.

Analyses of variance were performed on arc proportion training scores. The designs of these analyses were identical to the corresponding designs used with the histogram scores. The analysis of variance performed on training sessions for SC1, RC1, SC2, and RC2 groups (Table 32) confirmed the significant differences found in histogram scores between Blocks of sessions ($p < .05$), Trials ($p < .05$), Panels ($p < .001$), Groups ($p < .05$), and the significant interaction between Trials and Panels ($p < .001$). Two other significant interactions were revealed: they were Panels x Groups ($p < .05$) and Trials, Panels and Blocks of sessions ($p < .05$). The Newman-Keuls procedure

FIGURE 13. Three-dimensional histograms of proportion scores (arcsin transformation) on each of the three panels for each of the three types of trials, for the training blocks of sessions of SC1 and RC1 groups (Phase 1) and for the training blocks of sessions of SC2 and RC2 groups (Phase 2). See Figure 12 for more explanation.


PROPORTION OF RESPONSES (arcsin transform.)
SC
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
RC
1.2
1.0
0.8
0.6
0.4
0.2
0
9-12
13-16
17-20
21-24
1-4
5-8
9-12
13-16
BLOCKS OF SESSIONS
Phase 1
Phase 2

was again used to analyse the Trials x Panels interaction (Table 33). All pairwise comparisons were found significant except for the center panel between Trial 2 and Trial 3. More revealing were the results of analyses of variance performed separately on each of the two phases. Contrary to what was found with histogram scores, no significant differences were revealed in arc proportion scores during Phase 2 between SC2 and RC2 groups and between Blocks of sessions (Table 35). This means that the spatial distribution of responses was the same in the two groups during acquisition of response, even if there were large differences in response rates between the two groups. However, during Phase 1, while there were no difference in histogram scores between SC1 and RC1 group and between Blocks of sessions, a significant difference was found in arc proportion scores between SC1 and RC1 groups ($p < .001$) and between Blocks of sessions ($p < .05$) (Table 34). This means that there was a significant difference in the spatial distribution of responses between the two groups, even if there was no significant differences in response rates between the two groups, and that there was a significant evolution of the spatial distribution of responses in SC1 and RC1 groups, even in the absence of any significant change over Blocks of sessions in response rates.

In order to establish the nature of the significant difference between the two groups of each of the two phases, tests of simple effects were performed between the two groups for each trial on each panel at each block of sessions (Table 36). These tests of simple effects revealed that, during Phase 1, arc proportion scores on the left panel, for the three types of trials, were significantly higher in SC1 group than in RC1 group while the proportion of responses on the center and on the right panels, again for the three types of trials, was significantly higher in RC1 group than in SC1 group. That is, SC1 group proportionally responded more on the preferred side than RC1 group while RC1 group proportionally responded more on the non-preferred side than SC group. During Phase 2, most of the differences were not significant.

Observation of Figure 13 reveals that the evolution over blocks of sessions of the spatial distribution of responses was not similar in SC1 group and in RC1 group. For example, in SC1 group, arc proportion scores from the left panel stayed at the same level or increased over sessions while scores from the center and the right panel decreased; that is, the difference between the scores on the left panels and the scores on the two other panels increased over sessions. Concomitant to this increase, there was a decrease over sessions in the differences (1) between the score on the left panel at the trial with the CS on the left panel and the score on the left panel at the trial with the CS on the right panel and (2) between the score on the right panel for the trial with the CS on the right panel and the score on the right panel for the trial with the CS on the left panel. Thus there was in SC1 group an increase in difference over sessions between scores on left and right panels concomitant to a decrease in difference over sessions between scores at each type of trials. In RC1 group, there was no such pattern of evolution. On the contrary, the arc proportion scores were about the same at each block of sessions for each panel at each trial. During Phase 2, evolution over sessions in the distribution of responses was about the same in SC2 and RC2 groups. In each group, there was no change over sessions in left and center panel arc proportion scores while there was a decrease in right panel arc proportion scores.

In order to assess the significance of the differences between Blocks of sessions, pairwise comparisons were made between blocks of sessions, for each trial and each panel among SC1 and RC1 groups (Phase 1) and among SC2 and RC2 groups (Phase 2) using the Newman-Keuls procedure (Table 37). In SC1 group, there was no significant difference between blocks of sessions in the left panel, when it was illuminated, but a significant increase was found at the two other trials. All other arc proportion scores decreased significantly over sessions. In RC1 group, no differences between blocks of sessions were found except for a slight but significant decrease in the right illuminated panel. During Phase 2, the evolution of the arc proportion scores over blocks of sessions was about the same in SC2 and RC2 groups. It must be remembered, however, that there were significant differences in histogram scores between these two groups.

7 In summary, there is strong evidence that SC1 and RC1 groups were different in the spatial distribution of their responses. In both groups, the preference for a certain side was stronger than the preference for CS, but the magnitude of the preference for a side was greater in SC1 group than in RC1 group, while the magnitude of the preference for CS was greater in RC1 group than in SC1 group. Further, in SC1 group the preference for a side became stronger over sessions, while in RC1 group the preference for a side remained the same. Finally, the preference for the CS, on both preferred and non-preferred sides (Left and Right panels) decreased over sessions in SC1 group while it remained the same in RC1 group.

Discussion

Baseline sessions. The introduction of pre-acquisition baseline sessions for the animals in Phase 1 of the experiment permitted isolation of the effects of the presentation of unsignalled IS. It was feared that the movement of the drawer, although preceding the presence of IS by only a fraction of a second, would constitute a CS powerfull enough to permit acquisition of responses of approaching and contacting the front part of the drawer, where the three panels were situated. Only one animal in SC1 group acquired such a response tendency. One animal in RC1 group did show high rates of responses during the first sessions but these rates were greatly reduced on the last sessions of baseline. Thus, it can be safely concluded that the operation of the drawer did not materially interfere with the presentation of the illuminated panel on the front wall of the drawer. It seems that it takes a more prominent (more precisely defined in space and time) CS like the illumination of the panel to allow acquisition of responses centered on the CS.

Though responding did not develop during baseline sessions, some latent learning did take place, as became evident when groups of animals in Phase 1 were compared with those in Phase 2 in respect to performance in the training sessions. The data of Phase 1 revealed very little increase in responding over the training sessions in RC1 group and not at all in SC1 group. On the contrary, in Phase 2, data revealed that remarkable increases in level of responding occurred in both groups. In other words, the animals in Phase 1 showed close to asymptotic as soon as the training trials were begun, while the performance of animals in Phase 2 improved gradually; even RAND1 group, during the initial training sessions, had a higher performance than RAND2 group. Thus, during baseline sessions, the presentation of IS, or the combination of the movement of the drawer and the presentation of IS, in the absence of CS, permitted a more rapid acquisition of responses during training sessions, when the presentation of IS was preceded by the illumination of one of the panels. Presumably, the animals in Phase 1 had already learned the contingency between the opening of the drawer and water, so that, during training, they had only to learn the CS:IS contingency.

Random control group. No stable level of responding developed in the random control groups, indicating that the independent presentation of CS (the illuminated panel) and IS were not sufficient for response acquisition. The performance of the RAND1 and RAND2 subjects showed that the use of a random contingency between CS (illuminated panel) and IS might initially result in some responses directed at the CS, but that these responses disappeared after a few sessions. Higher rates during the initial training sessions in Phase 1, as compared to those in Phase 2, may have been caused, not only by the novelty of the CS, but also by its placement in a location (the drawer) that probably already had acquired some incentive value because of its spatial proximity with IS.

SC and RC groups. The main finding of this experiment is that the difference in the level of performance between SC group and RC group is not in response strength but in the spatial distribution of responses.

This conclusion is derived from the spatial distribution analysis of the results of Phase 1, and to some extent of Phase 2, of the experiment. Both SC1 and

RC1 groups were, at the beginning of training, near their asymptotic level of performance. There was no difference between the two groups in the number of responses given on the preferred side; only on the non-preferred side did RC1 group show higher performance.

The results of Phase 2 of the experiment were somewhat different. RC2 group did not attain asymptotic level as rapidly as RC1 group but both groups were nearly identical toward the end of the training sessions. However, SC2 group was very different than SC1 group; the rate of acquisition of SC2 group was much slower. Thus, SC2 and RC2 groups were more difficult to compare in respect to the spatial distribution of their response, since they were at different levels of learning. It is probable that, with more training sessions, SC2 group would have reached an asymptote similar to that of SC1 group.

The spatial distribution of the responses seems to be under the control of two separate interacting factors. The first factor can be called a preference for one of the two side panels (side preference) and the second factor a preference for the CS panel (CS preference). Possibly, these two factors could be indices of two separate but interacting processes.

The side preference may be controlled solely by the spatial layout of IS in relation to the drawer. As it is more difficult for the rat to climb over the drawer to drink the water, it would prefer approaching the water receptacle from one of the two sides of the drawer. It may therefore be expected that, with training, the responses during CS presentation would become increasingly more directed toward one of the two sides of the drawer; this is what was found.

The CS preference may be controlled by the incentive value of the CS. The incentive value of the CS would in turn be controlled by the nature of the contingency between CS and IS; the stronger the contingency between CS and IS, the stronger would be the incentive value of the CS. As noted before, the nature of the CS:R:IS contingency in RC group would have the consequence of increasing the incentive value of the CS because the response-requirement makes the observation of the CS:IS contingency much more likely, for the animal must perform the response in relation to the CS. As the CS:IS contingency would be stronger in the RC group than in the SC group, the stronger incentive value of CS would counterbalance the influence of the side preference more in RC group than in SC group. Thus differences between the SC and RC groups may be plausibly attributed to differences in the relative strengths of the incentive values of panels (or sides) and the incentive value of the CS; the incentive value of CS is greater as a consequence of response-contingent training than as a consequence of stimulus-contingent training.

GENERAL DISCUSSION

This discussion examines the main findings of the two experiments in relation to the response-reinforcement and incentive motivation principles of learning outlined in the introduction.

Experiment 1 showed that the CS:IS contingency (SC group) was sufficient for acquisition of responses centered on the CS panel. What the R:IS contingency (RC group) added to the CS:IS contingency was an increase in the frequency of the response. Frequency of response in RC group was greater than in SC group during training; the effect of the omission procedure was to reduce the frequency of response in both groups, but the reduction was greater with RC group. In order to reveal the basis of the greater response frequency in the RC group, a temporal distribution analysis was undertaken. However, no difference between SC and RC groups was found in the temporal distribution of responses. During training, the frequency of response was greater in the RC group at all moments of a trial preceding the IS presentation. During the omission procedure, the reduction in response frequency occured at all moments preceding and following IS presentation. These results suggest that the temporal distribution of responses was not influenced, differentially by the CS:IS and R:IS contingencies. Thus no clue to the basis of the greater response frequency generated by the

R:IS contingency could be found in the temporal distribution analysis.

Experiment 2 explored further the difference in frequency of response between SC and RC group and produced some strong evidence that it could be the manifestation of a different spatial partition of responses. Two factors were found to control the spatial distribution of response in the experimental environment that was used: the first, and stronger one, was called side preference; it had the effect of directing the approach response toward one of the two corners of the front part of the drawer. It appeared that the side preference was determined by the closeness of the corners of the drawer to the water delivery hole. The second factor was called CS preference; it had the effect of directing the responses toward the panel that was illuminated -- that served as CS in a given trial. It was evident that the CS preference was determined by the contingency between the illumination of the panels and IS (CS:IS). At the asymptote level of performance, the side preference was found stronger in SC group than in RC group, and the CS preference was stronger in RC group than in SC group. The fact that the CS preference was stronger in RC group was interpreted as the manifestation of the greater strength of CS:IS contingency. The basis of the greater strength of CS:IS contingency in RC group presumably lies in the requirement of a drawer-centered response (R:IS contingency), which must have increased the probability that the animal would have observed the CS whenever IS was presented. It was also found that the CS preference decreased over training sessions in both SC and RC groups, while the side preference was maintained or increased.

Response-reinforcement principle

The results of the present study do not support the response-reinforcement principle. In experiment 1, one of the main difficulties was the discrepancy between the concept of an instrumental response as an efficient action to produce a certain outcome, and the behavior observed under the instrumental procedure (R:IS) in this experiment. The rate of response in RC group was well over the one response (during the 8-sec. CS period) that was required for reinforcement. Moreover, the RC Group made many more responses before the illumination of the grid panel, that is, during the 20-sec. pre-CS period. Further, and this is more important, this "goal-gradient" pattern of responding (see Figure 2) increased slowly over sessions; in other words, "instrumental responding" became more indiscriminate as training progressed. Finally, while the asymptote of the probability of occurrence of a response during CS was attained around the 16th session, the rate of response continued to increase even without a concomitant increase in reinforcement probability. Williams (1966) has reported that rats would continue to increase their speed of wheel-running even when more rapid running did not produce more reinforcement. In experiment 2, one of the main difficulties concerns the interpretation of the acquisition of side preference. Indeed, there was an increase in side preference through training sessions. So, it can be said that the responses that were given on one of the two side panels were reinforced, so that their probability of occurrence increased with training. But then, following the response-reinforcement principle, side preference should have been stronger, in RC group, in which the R:IS contingency was the strongest. But side preference was found to be clearly stronger in SC group, in terms of the amount of difference between the preferred side and the non-preferred side, as well as in terms of the rate of development of the preference.

Further, CS preference, indicated by approach and contact with the illuminated panel, is also difficult to explain in terms of the response-reinforcement principle. The first responses on the illuminated panel may well be explained in terms of accidental contacts with CS while the rat approached the water receptacle. Since the CS preference was stronger in RC group than in SC group, it would appear plausible to argue that the R:IS contingency may have played an important role in the development of CS preference. But then, following the response-reinforcement principle, if the responses on the CS panel were reinforced, there should have been an increase of the CS preference over sessions. However, in fact, the CS preference was at maximum during the first sessions, and there was a regular and slow decrease of the CS preference over training sessions in both groups!

Finally, if the response-reinforcement principle cannot explain separately the side preference or the CS preference, surely it cannot explain both of them at the same time. How can it be possible that the same reinforcer (water presentation) would increase the probability of occurrence of the side preference and at the same time decrease the probability of occurrence of the CS preference. Perhaps an explanation in terms of two different factors may account for the results; the R:IS contingency could be responsible for the side preference and the CS:IS contingency could be responsible for the CS preference. However, it has already been shown that the R:IS contingency could not explain adequately either the side preference or the CS preference. There is no way then to use a two-factor explanation, involving the R:IS contingency as one of the two factors.

Even if the response-reinforcer principle does not account for some of the present results, the R:IS contingency can still be considered as a possible component of any total explanation of the results. It is obvious that the differences in performance between the two groups have to be explained in terms of the only difference in procedure between the SC group and the BC group, that is, by the difference in response requirement. This difference in response requirement between the two groups could not have been a factor on trials on which the animal responded because in both groups responses were followed by water presentation. Only when the animal did not respond during CS presentation was there a difference in the operative contingencies between the two groups: in SC group, water was presented ($CS:\bar{R}:IS$) while in RC group water was not presented ($CS:\bar{R}:\overline{IS}$). Thus, performance was stronger in RC group than in SC group because of the presence of the $CS:\bar{R}:\overline{IS}$ contingency.

Incentive-Motivation principle

The incentive-motivation principle may be stated as follows: (1) CS:IS contingencies are sufficient to account for the acquisition of new responses. (2) The animal responds at a given moment in relation to the feature of the environment that has acquired the highest relative incentive value through its contingency with IS, assuming that IS itself is not present. According to this, there were two relevant CS:IS contingencies in the experimental situation of the second experiment: (1) the movement of the drawer that immediatly preceded water presentation (D:IS contingency) and (2) the illumination of the panel that also preceded water presentation (CS:IS contingency).

It is doubtful that acquisition of the side preference is related as such to the D:IS contingency, because, if it were so, side preference would have been acquired immediatly during baseline sessions, when the D:IS contingency was present in the situation, but this did not happen. In fact, the movement of the drawer announced the immediate avaibility of water; this meant that a much more powerful incentive stimulus than the drawer itself was present immediatly after the movement of the drawer. It is probable that the only response produced by the D:IS contingency was the approach toward the water receptacle. Thus both the acquisition of side preference and the acquisition of CS preference were related to the CS:IS contingency rather than to the D:IS contingency.

To be plausible, an explanation in terms of the CS:IS contingency should answer three questions: (1) Why were responses centered on the CS panel and other responses centered on one of the two side panels? (2) Why did CS preference decrease over sessions while side preference increased? (3) Why was CS preference greater in RC group than in SC group, while side preference was greater in SC group than in RC group? Within the general framework of the incentive-motivation principle, these three questions may be answered as follows. The animals first learned the CS:IS contingency, which resulted in responses centered on the CS (the illuminated panel). Then, as the animals took the proper position to reach the water receptacle as soon as the drawer moved, the responses got displaced to the side panels. The R:IS contingency had the effect of increasing the incentive value of the illuminated panel, giving more time allocation to the CS panel and therefore less time allocation to the side panels (when they were not themselves CS). In SC group, where the illuminated panel had a lesser incentive value, because of the absence of the R:IS contingency, there was less time allocation to the CS panel and therefore more time allocation to the side panels.

The hypothesis that led to the second experiment was that the R:IS contingency would lead to greater precision of CS-centered responses by the group where the R:IS contingency was stronger, that is, by RC group. The results of the second experiment confirmed this hypothesis, in the sense that RC group showed greater precision of response in terms of CS preference. The greater precision in side preference found in SC group does not weaken the hypothesis but on the contrary can be explained by using the same hypothesis: the lesser incentive value of the illuminated panel in SC group allowed greater time allocation for the manifestation of the side preference.
It now appears appropriate to elaborate this hypothesis further and to arrange direct tests of its implications.

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Table 2

Three-way Analysis of Variance with Repeated Measures on Mean Rate Scores for Groups SC and RC during the ITI Period

Source	Mean Square	Degrees of Freedom	F
MEAN	1.7401	1	9.1236*
B:Blocks	.0412	4	1.506
G:Groups	.8950	1	4.6926
S(B):Sessions (Blocks)	.0052	55	.9565
s(G):subjects (Groups)	.1907	6	
BG	.0273	4	.7634
SG(B)	.0065	55	1.1786
Bs(G)	.0358	24	
Ss(BG)	.0055	330	

* $p < .05$

Table 3

Three-way Analysis of Variance with Repeated Measures on Mean Rate Scores for Groups SC and RC during the pre-CS Period

Source	Mean Square	Degrees of Freedom	F
MEAN	9.6002	1	10.0110*
B:Blocks	1.0649	4	4.0299*
G:Groups	4.4705	1	4.6617
S(B):Sessions (Blocks)	.0162	55	.07418
s(G):subjects (Groups)	.959	6	
BG	.615	4	2.3273
SG(B)	.0232	55	1.0598
Bs(G)	.2642	24	
Ss(BG)	.0219	330	

* $p < .05$

Table 4

Pairwise Differences between Mean Rate Scores Among Blocks during the pre-CS Period, Tested with the Newman-Keuls Procedure

	B5	B4	B1	B2	B3
B5		.0141	.0522	.1501	.2498
B4			.0381	.136	.2357
B1				.0979	.1976
B2					.0997
B3					

$S_{\bar{B}}$ = .0525	r =	2	3	4	5
$S_{\bar{B}}\ q_{.01}(r,6)$ =		.275	.332	.369	.397
$S_{\bar{B}}\ q_{.05}(r,6)$ =		.182	.228	.257	.278

Table 5

Three-way Analysis of Variance with Repeated Measures on Mean Rate Scores for Groups SC and RC during the CS Period

Source	Mean Square	Degrees of Freedom	F
MEAN	275.0831	1	14.3965**
B:Blocks	21.6486	4	7.7276**
G:Groups	108.0788	1	5.6563
S(B):Sessions (Blocks)	.1684	55	2.3884**
s(G):subjects (Groups)	19.1076	6	
BG	9.4353	4	3.368 *
SG(B)	.1296	55	1.8387**
Bs(G)	2.8015	24	
Ss(BG)	.0705	330	

* $p < .05$, ** $p < .01$

Table 6

Pairwise Differences between Mean Rate Scores Among Blocks during the CS Period, Tested with the Newman-Keuls Procedure

	B5	B1	B4	B2	B3
B5		.0125	.17427	.7911*	1.0228*
B1			.16182	.7787*	1.0104*
B4				.6169*	.8485*
B2					.2317
B3					

$S_{\bar{B}} = .1708$	r =	2	3	4	5
$S_{\bar{B}}\ q_{.01}(r,6)$ =		.895	1.081	1.201	1.291
$S_{\bar{B}}\ q_{.05}(r,6)$ =		.591	.241	.837	.905

* $p < .05$

Table 7

Pairwise Differences between Mean Rate Scores Among Blocks for Group SC during the CS Period, Tested with the Newman-Keuls Procedure

	B5	B4	B1	B3	B2
B5		.0884	.3178	.3557	.4394
B4			.2294	.2673	.351
B1				.0379	.1216
B3					.0837
B2					

$S_{\bar{B}} = .2416$	r =	2	3	4	5
$S_{\bar{B}}\, q_{.01}(r,6)$	=	1.226	1.53	1.7	1.826
$S_{\bar{B}}\, q_{.05}(r,6)$	=	.836	1.049	1.184	1.282

Table 8

Pairwise Differences between Mean Rate Scores Among Blocks
for Group RC during the CS Period,
Tested with the Newman-Keuls Procedure

	B1	B5	B4	B2	B3
B1		.0966	.3614	1.2394*	1.2913*
B5			.2912	1.1428*	1.6947*
B4				.878*	1.4299*
B2					.5519
B3					

$S_{\bar{B}} = .2416$	r = 2	3	4	5
$S_{\bar{B}}\, q_{.01}(r,6)$ =	1.266	1.53	1.7	1.826
$S_{\bar{B}}\, q_{.05}(r,6)$ =	.836	1.049	1.184	1.282

* $p < .05$

Table 9

Test on Mean Rate Scores between Groups among Blocks during the CS Period using Student's Procedure

Block	df	t
1	6	.6533
2	6	2.488 *
3	6	3.762 **
4	6	1.449
5	6	1.0885

SSw = 114.649

SSb = 67.23

* $p < .05$, ** $p < .01$

Table 10

Three-way Analysis of Variance with Repeated Measures on Mean Rate Scores for Groups SC and RC during the post-CS Period

Source	Mean Square	Degrees of Freedom	F
MEAN	55.93	1	3.1046
B:Blocks	3.7817	4	2.0107
G:Groups	.0125	1	.0007
S(B):Sessions (Blocks)	.2003	55	1.6076**
s(G):subjects (Groups)	18.0151	6	
BG	.1533	4	.0815
SG(B)	.0581	55	.4663
Bs(G)	1.8808	24	
Ss(BG)	.1246	330	

** p < .01

Table 11

Three-way Analysis of Variance with Repeated Measures on Mean Scores for Groups SC and RC during the CS Period

Source	Mean Square	Degrees of Freedom	F
MEAN	17302.53	1	29.6165**
B:Blocks	850.0881	4	11.6746**
G:Groups	3657.552	1	2.29
S(B):Sessions (Blocks)	16.6855	55	2.4426**
s(G):subjects (Groups)	1597.168	6	
BG	109.7126	4	1.5067
SG(B)	9.9398	55	1.4551*
Bs(G)	72.815	24	
Ss(BG)	6.8309	330	

* $p < .05$, ** $p < .01$

Table 12

Pairwise Differences between Mean Trial Scores Among Blocks during the CS Period, Tested with the Newman-Keuls Procedure

	B5	B1	B4	B3	B2
B5		1.69	2.65	6.55**	6.64**
B1			.96	4.86*	4.95*
B4				3.9 *	3.99*
B3					.09
B2					

$S_{\bar{B}} = .8709$	$r =$	2	3	4	5
$S_{\bar{B}}\, q_{.01}(r,6) =$		4.564	5.513	6.122	6.584
$S_{\bar{B}}\, q_{.05}(r,6) =$		3.013	3.78	4.267	4.624

* $p < .05$, ** $p < .01$

Table 13

Pairwise Differences between Mean Trial Scores Among Blocks for Group SC during the CS Period, Tested with the Newman-Keuls Procedure

	B5	B4	B1	B3	B2
B5		2.7917	4.375	7.4792*	7.75*
B4			1.5833	4.6875	4.9583
B1				3.1042	3.375
B3					.2708
B2					

$S_{\bar{B}} = 1.2317$ $r =$	2	3	4	5
$S_{\bar{B}}\ q_{.01}(r,6) =$	6.454	7.797	8.659	9.311
$S_{\bar{B}}\ q_{.05}(r,6) =$	4.262	5.346	6.035	6.54

* $p < .05$

Table 14

Pairwise Differences between Mean Trial Scores among Blocks for Group RC during the CS Period, Tested with the Newman-Keuls Procedure

	B1	B5	B4	B2	B3
B1		.9791	3.5	6.5208*	6.6041*
B5			2.5209	5.5417	5.625
B4				3.0208	3.1041
B2					.0833
B3					

$S_{\bar{B}} = 1.2317$	$r =$	2	3	4	5
$S_{\bar{B}}\ q_{.01}(r,6) =$		6.454	7.797	8.659	9.311
$S_{\bar{B}}\ q_{.05}(r,6) =$		4.262	5.346	6.035	6.54

* $p < .05$

Table 15

Test on Mean Trial Scores between Groups among Blocks during the CS Period using Student's Procedure

Block	df	t
1	6	5304
2	6	1.3234
3	6	1.4127
4	6	1.8118
5	6	1.8801

SSw = 9583.008

SSb = 1747.56

Table 16

Two-way Analysis of Variance with Repeated Measures on Rate Scores for SC and RC Groups during Baseline Sessions of Phase 1

Source	Mean Square	Degrees of Freedom	F
MEAN	1.777	1	2.692
SESSIONS	0.070	7	1.173
GROUPS	0.070	1	0.106
subjects (G)	0.660	6	
SG	0.397	7	0.661
Ss(G)	0.601	42	

Table 17

Two-way Analysis of Variance with Repeated Measures on Trial Scores for SC and RC Groups during Baseline Sessions of Phase 1

Source	Mean Square	Degrees of Freedom	F
MEAN	3094.141	1	4.749
SESSIONS	54.062	7	1.227
GROUPS	0.391	1	0.0006
subjects (G)	651.599	6	
SG	11.605	7	0.2633
Ss (G)	44.074	42	

Table 18

Three-way Analysis of Variance with Repeated Measures on Rate Scores for SC1 and RC1 Groups during Baseline Sessions and Training Sessions of Phase 1

Source	Mean Square	Degrees of Freedom	F
MEAN	61.706	1	20.730**
BLOCKS	7.738	2	9.295
GROUPS	3.373	1	1.133
SESSIONS (B)	0.051	21	0.835
subjects (G)	2.977	6	
BG	1.189	6	1.428
GS (B)	0.031	21	0.510
Bs (G)	0.832	12	
Ss (BG)	0.062	126	

** $p < .01$

Table 19

Three-way Analysis of Variance with Repeated Measures on Trial Scores for SC1 and RC1 Groups during Baseline Sessions and Training Sessions of Phase 1

Source	Mean Square	Degrees of Freedom	F
MEAN	98237.750	1	87.087***
BLOCKS	11902.720	2	28.833***
GROUPS	4770.047	1	4.229
SESSIONS(B)	34.589	21	1.062
subjects(G)	1128.039	6	
BG	1490.205	6	3.640
GS(B)	25.36	21	0.778
Bs(G)	409.347	12	
Ss(BG)	32.557	126	

*** $p < .001$

Table 20

Three-way Analysis of Variance with Repeated Measures on Rate Scores for SC and RC Groups during Training Sessions of Phase 1 and Training Sessions of Phase 2

Source	Mean Square	Degrees of freedom	F
MEAN	128.520	1	43.667***
SESSIONS	0.224	15	3.370***
PHASES	0.876	1	0.298
GROUPS(P)	12.470	2	4.237
SP	0.124	15	1.873*
subjects(GP)	2.943	12	
SG(P)	0.096	30	1.450
Ss(GP)	0.066	180	

* $p < .05$, *** $p < .001$

Table 21

Three-way Analysis of Variance with Repeated Measures on Trial Scores for SC and RC Groups during Training Sessions of Phase 1 and Training Sessions of Phase 2

Source	Mean Square	Degrees of Freedom	F
MEAN	219082.500	1	184.136***
SESSIONS	118.421	15	3.427***
PHASES	368.160	1	0.309
GROUPS(P)	8629.418	2	7.253**
SP	119.627	15	3.462***
subjects(GP)	1189.786	12	
SG(P)	68.082	30	1.970**
Ss(GP)	34.558	180	

** $p < .01$, *** $p < .001$

Table 22

Two-way Analysis of Variance with Repeated Measures on Rate Scores for SC and RC Groups during Training Sessions of Phase 1

Source	Mean Square	Degrees of Freedom	F
MEAN	75.310	1	21.779**
SESSIONS	0.045	15	0.487
GROUPS	4.253	1	1.230
subjects (G)	3.458	6	
SG	0.121	15	1.296
Ss (G)	0.930	90	

** p < .01

Table 23

Two-way Analysis of Variance with Repeated Measures
on Trial Scores for SC and RC Groups
during Training Sessions of Phase 1

Source	Mean Square	Degrees of Freedom	F
MEAN	5736382.	1	4.759
SESSIONS	43124.68	15	1.684
GROUPS	15237.65	1	0.013
subjects (G)	1205373.	6	
SG	12149.42	15	0.474
Ss(G)	25612.72	90	

Table 24

Two-way Analysis of Variance with Repeated Measures on Rate Scores for SC and RC Groups during Training Sessions of Phase 2

Source	Mean Square	Degrees of Freedom	F
MEAN	54.084	1	22.271**
SESSIONS	0.304	15	7.557***
GROUPS	20.688	1	8.519*
subjects (G)	2.428	6	
SG	.073	15	1.804*
Ss (G)	.040	90	

* $p < .05$, ** $p < .01$, *** $p < .001$

Table 25

Two-way Analysis of Variance with Repeated Measures on Trial Scores for SC and RC Groups during Training Sessions of Phase 2

Source	Mean Square	Degrees of Freedom	F
MEAN	100744.400	1	81.270***
SESSIONS	212.000	15	6.280***
GROUPS	10028.820	1	8.090*
subjects (G)	1239.621	6	
SG	71.436	15	2.116*
Ss(G)	33.758	90	

* $p < .05$, *** $p < .001$

Table 26

Localisation of the preferences (higher number of responses) on left and right panels for each subject of each group at each session of each phases.
L Left panel; R Right panel; - No responses or no preferences.

Phases	Groups	Subjects	Baseline sessions								Training sessions															
			1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	SC1	201	-	L	L	L	L	L	R	R	L	L	R	L	R	R	R	R	R	R	R	R	R	R	R	R
		202	-	-	-	-	-	-	-	-	R	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
		203	-	-	L	-	L	-	-	-	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
		204	R	R	R	R	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
	RC1	205	-	-	L	L	-	-	-	-	R	R	R	R	R	R	R	R	R	L	R	R	L	L	L	R
		206	L	L	R	-	-	-	L	L	R	L	L	L	R	R	R	R	R	R	R	R	R	R	R	R
		207	R	L	R	L	L	L	L	L	L	L	R	R	R	R	R	R	R	R	R	R	R	R	R	R
		208	-	-	-	-	-	-	-	-	L	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
	RAND1	209	-	L	R	-	-	-	-	-	R	R	R	R	L	R	L	R	L	R	L	L	L	L	L	L
		210	R	R	L	R	L	-	L	R	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
2	SC2	211									L	L	L	L	R	R	L	L	R	R	R	R	R	R	R	R
		212									L	R	L	L	L	R	R	R	L	L	L	L	R	L	L	L
		213									L	R	R	L	R	R	R	R	R	R	R	R	R	R	R	R
		214									L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
	RC2	215									R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
		216									R	R	R	L	L	R	L	L	L	L	L	L	L	L	L	L
		217									L	L	R	L	R	L	L	R	L	L	L	R	L	L	L	R
		218									R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
	RAND2	219									R	-	L	L	R	L	L	L	L	L	L	R	R	R	R	R
		220									R	L	L	L	L	R	L	L	L	L	L	L	R	R	L	L

Table 27

Four-way Analysis of Variance with Repeated Measures on Histogram Scores for Sc and RC Groups during Baseline Sessions of Phase 1

Source	Mean Square	Degrees of Freedom	F
MEAN	272310.	1	2.761
S:Blocks of Sessions	961.	1	0.120
T:Trials	2626.	2	2.249
P:Panels	12112.	2	2.541
G:Groups	6778.	1	0.069
s(G)	98615.	6	
ST	1459.	2	0.780
SP	3667.	2	1.720
TP	74.	4	0.691
SG	14360.	1	1.795
TG	556.	2	0.477
PG	843.	2	0.177
Ss(G)	8001.	6	
Ts(G)	1167.	12	
PS(G)	4766.	12	
STP	124.	4	0.986
STG	1989.	2	1.064
SPG	29.	2	0.014
TPG	96.	4	0.894
STs(G)	1870.	12	
SPs(G)	2132.	12	
TPs(G)	107.	24	
STPG	87.	4	0.691
STPs(G)	126.	24	

Table 28

Five-way Analysis of Variance with Repeated Measures on Histogram Scores for SC1 and RC1 Groups during Training Sessions of Phase 1 and for SC2 and RC2 Groups during Training Sessions of Phase 2

Source	Mean Square	Degrees of Freedom	F
MEAN	15208050.	1	46.953***
S:Blocks of Sessions	451654.	3	7.439*
T:Trials	8213.	2	8.099*
P:Panels	2912720.	2	25.470***
C:Phases	104598.	1	0.323
G(C):Groups (Phases)	2869424.	2	4.430*
ST	4556.	6	1.311
SP	247934.	6	6.494*
TP	196940.	4	15.389**
SC	119097.	3	1.961
TC	1959.	2	1.932
PC	199518.	2	1.745
s(CG)	3886718.	12	
SG(C)	236544.	6	1.948
TG(C)	5243.	4	2.585
PG(C)	510506.	4	2.232
STP	10713.	12	2.098
STC	1048.	6	0.302
SPC	24216.	6	0.634
TPC	2294.	4	0.179
Ss(CG)	728606.	36	
Ts(CG)	12169.	24	
Ps(CG)	1372303.	24	
STG(C)	2542.	12	0.366
SPG(C)	89162.	12	1.168
TPG(C)	57115.	8	2.232
STPC	12157.	12	2.380
STs(CG)	41710.	72	
SPs(CG)	458116.	72	
TPs(CG)	153571.	48	
STPG(C)	7959.	24	0.779
STPs(CG)	61294.	144	

* $p < .05$, ** $p < .01$, *** $p < .001$

Table 29

Four-way Analysis of Variance with Repeated Measures on Histogram Scores for SC1 and RC1 Groups during Training Sessions of Phase 1

Source	Mean Square	Degrees of Freedom	F
MEAN	8917568.	1	21.670**
S:Blocks of Sessions	17896.	3	.663
T:Trials	4533.	2	11.318*
P:Panels	1148116.	2	13.652*
G:Groups	434001.	1	1.055
s(G)	411510.	6	
ST	628.	6	1.696
SP	18304.	6	2.557
TP	26670.	4	12.588*
SG	58237.	3	2.157
TG	1301.	2	3.251
PG	130506.	2	1.552
Ss(G)	27002.	18	
Ts(G)	400.	12	
Ps(G)	84100.	12	
STP	870.	12	1.816
STG	161.	6	.435
SPG	10244.	6	1.431
TPG	4926.	4	2.325
STs(G)	370.	36	
SPs(G)	7159.	36	
TPs(G)	2118.	24	
STPG	293.	12	.613
STPs(G)	479.	72	

* $p < .05$, ** .01

Table 30

Four-way Analysis of Variance with Repeated Measures on Histogram Scores for SC2 and RC2 Groups during Training Sessions of Phase 2

Source	Mean Square	Degrees of Freedom	F
MEAN	6395080.	1	27.066**
S:Blocks of Sessions	172354.	3	12.789*
T:Trials	553.	2	.901
P:Panels	408003.	2	13.484*
G:Groups	2435424.	1	10.308*
s (G)	236275.	6	
ST	305.	6	.386
SP	27054.	6	4.856
TP	23138.	4	5.402
SG	20611.	3	1.529
TG	1319.	2	2.147
PG	124748.	2	4.123
Ss (G)	13476.	18	
Ts (G)	614.	12	
Ps (G)	30257.	12	
STP	1306.	12	2.837
STG	263.	6	.333
SPG	4615.	6	.829
TPG	9351.	4	2.183
STs (G)	791.	36	
SPs (G)	5571.	36	
TPs (G)	4283.	24	
STPG	375.	12	1.028
STPs (G)	365.	72	

* $p < .05$, ** $p < .01$

Table 31

Pairwise Differences between Histogram Scores among Trials and Panels Tested with the Newman-Keuls Procedure

	TP13	TP23	TP33	TP12	TP22	TP32	TP31	TP21	TP11
TP13		22.3*	48.4**	92.7**	115. *	120. **	167. **	204. **	222. **
TP23			26.1*	70.3**	92.5**	97.5**	144. **	182. **	200. **
TP33				44.2**	66.4**	71.4**	118. **	156. **	174. **
TP12					22.2*	27.2*	74. **	112. **	130. **
TP22						4.98	51.8**	89.5**	107. **
TP32							46.8**	84.5**	102. **
TP31								37.7**	55.6**
TP21									17.9
TP11									

$s_{\overline{TP}} = 3199.402$	r =	2	3	4	5	6	7	8	9
$s_{\overline{TP}}\, q_{.01}\,(r,12)$	=	9854	12061	13437	14429	15197	15837	16380	16860
$s_{\overline{TP}}\, q_{.05}\,(r,12)$	=	13821	16124	17596	18684	19516	20220	20828	21340

* $p < .05$ ** $p < .01$

Table 32

Five-way Analysis of Variance with Repeated Measures on Arc proportion Scores for SC1 and RC1 Groups during Training Sessions of Phase 1 and for SC2 and RC2 Groups during Training Sessions of Phase 2

Source	Mean Square	Degrees of Freedom	F
MEAN	234.0915	1	11143.000***
S:Blocks of Sessions	.0270	3	7.911*
T:Trials	.0500	2	6.288*
P:Panels	11.0656	2	78.592***
C:Phases	.0468	1	2.222
G(C):Groups (Phases)	.1346	2	6.390*
ST	.1389	6	1.990
SP	.1852	6	7.476*
TP	.1325	4	52.464***
SC	.0051	3	1.484
TC	.0129	2	1.616
PC	.3213	2	2.282
s(CG)	.0211	12	
SG(C)	.0077	6	2.265
TG(C)	.0105	4	1.316
PG(C)	.7580	4	5.384*
STP	.0242	12	5.868*
STC	.0076	6	1.093
SPC	.0220	6	0.888
TPC	.0002	4	0.026
Ss(CG)	.0034	36	
Ts(CG)	.0080	24	
Ps(CG)	.1408	24	
STG(C)	.0145	12	2.071
SPG(C)	.0459	12	1.853
TPG(C)	.0048	8	0.808
STPC	.0045	12	1.085
STs(CG)	.0040	72	
SPs(CG)	.0248	72	
TPs(CG)	.0060	48	
STPG(C)	.0040	24	0.979
STPx(CG)	.0041	144	

* $p < .05$, *** $p < .001$

Table 33

Pairwise Differences between Arcproportion Scores among Trials and Panels Tested with the Newman-Keuls Procedure

	TP13	TP23	TP33	TP12	TP22	TP32	TP31	TP21	TP11
TP13		.074**	.156**	.264**	.316**	.317**	.496**	.560**	.614**
TP23			.083**	.190**	.243**	.244**	.422**	.486**	.540**
TP33				.107**	.160**	.161**	.339**	.403**	.457**
TP12					.053**	.054**	.232**	.296**	.350**
TP22						.001	.179**	.243**	.297**
TP32							.178**	.242**	.296**
TP31								.064**	.118**
TP21									.054**
TP11									

$s_{\overline{TP}}$ = .00596	r =	2	3	4	5	6	7	8	9
$s_{\overline{TP}} \, q_{.01}(r,12)$	=	.018	.022	.025	.027	.028	.030	.031	.031
$s_{\overline{TP}} \, q_{.05}(r,12)$	=	.026	.030	.033	.035	.036	.038	.039	.040

**p < .01

Table 34

Four-way Analysis of Variance with Repeated Measures on Arc proportion Scores for SC1 and RC1 Groups during Training Sessions of Phase 1

Source	Mean Square	Degrees of Freedom	F
MEAN	113.7724	1	29940.000***
S:Blocks of Sessions	.0249	3	8.031*
T:Trials	.0566	2	38.505***
P:Panels	7.5064	2	194.076***
G:Groups	.2691	1	70.988***
s (G)	.0038	6	
ST	.0017	6	.316
SP	.1097	6	4.286
TP	.1578	4	30.248***
SG	.0149	3	4.795
TG	.0016	2	1.067
PG	1.5060	2	38.938***
Ss (G)	.0031	18	
Ts (G)	.0015	12	
Ps (G)	.0387	12	
STP	.0137	12	4.137
STG	.0063	6	1.169
SPG	.0792	6	3.092
TPG	.0050	4	.964
STs (G)	.0053	36	
SPs (G)	.0256	36	
tps (G)	.0052	24	
STPG	.0045	12	1.37
STPs (G)	.0033	72	

* $p < .05$, *** $p < .001$

Table 35

Four-way Analysis of Variance with Repeated Measures on Arc proportion Scores for SC2 and RC2 Groups during Training Sessions of Phase 2

Source	Mean Square	Degrees of Freedom	F
MEAN	120.3922	1	3010.000***
S:Blocks of Sessions	.0071	3	1.920
T:Trials	.0063	2	.438
P:Panels	3.8805	2	15.974***
G:Groups	.0001	1	.002
s(G)	.0383	6	
ST	.0198	6	2.302
SP	.0975	6	4.072
TP	.1549	4	23.156**
SG	.0006	3	.158
TG	.0194	2	1.342
PG	.0010	2	.041
Ss(G)	.0037	18	
Ts(G)	.0144	12	
Ps(G)	.2429	12	
STP	.0149	12	3.014
STG	.0227	6	2.631
SPG	.0127	6	.529
TPG	.0046	4	.688
STs(G)	.0086	36	
SPs(G)	.0239	36	
TPs(G)	.0067	24	
STPG	.0035	12	.711
STPs(G)	.0050	72	

** $p < .01$, *** $p < .001$

Table 36

Test on Arc proportion Scores among Trials, Panels and Blocks of Sessions between SC1 Group and RC1 Group (Phase 1) and between SC2 Group and RC2 Group (Phase 2) using Student's Procedure

PHASE	BLOCK	TRIAL	T		
1	1	1	-3.61***	1.85	2.85**
		2	-0.98	0.61	3.40**
		3	-2.45*	1.65	1.60
	2	1	-4.36***	3.39**	1.70
		2	-2.86**	3.48***	1.31
		3	-2.83**	3.66***	4.89***
	3	1	-5.30***	6.86***	4.27***
		2	-4.68***	5.21***	3.87***
		3	-5.78***	5.28***	3.26***
	4	1	-5.96***	6.34***	4.48***
		2	-6.95***	7.19***	4.51***
		3	-6.75***	6.83***	6.41***
2	1	1	-1.53	-4.26***	-1.45
		2	2.08*	-1.13	1.04
		3	2.70**	2.14*	0.68
	2	1	-1.62	0.24	1.27
		2	-0.99	-0.56	0.27
		3	-0.68	1.43	0.92
	3	1	-0.05	-0.05	0.62
		2	-0.79	-0.15	1.20
		3	-0.41	0.80	0.05
	4	1	-0.19	0.03	-0.01
		2	1.19	-0.88	0.23
		3	-0.19	-2.17*	0.34

df (Satterthwaite approximation) = 91.67

* *p* < .05, ** *p* < .01, *** *p* < .001

Table 37

Pairwise Differences between Arcproportion Scores between Blocks of Sessions among Trials, Panels, and Groups of the two Phases, Tested with the Newman-Keuls Procedure.

Phase	Group	Trial	Panel	Ascending Order of Blocks of Sessions B1	B2	B3	B4	B4-B1	B4-B2	B4-B3	B3-B1	B3-B2	B2-B1	Significant Trends Trial	Panel 1	2	3
1	BC1	1	1	1	2	4	3	.069	.024	.010	.060	.014	.045	1	—	↓	↓
			2	4	3	1	2	.203**	.181**	.099*	.104	.082	.022				
			3	4	3	1	2	.172*	.149*	.048	.124*	.100*	.024				
		2	1	1	2	3	4	.208**	.143*	.083	.205*	.060	.145*	2	↑	↓	↓
			2	4	3	2	1	.265**	.139*	.136	.129*	.023	.106*				
			3	4	3	2	1	.157*	.156*	.013	.144*	.143*	.095				
		3	1	1	2	3	4	.310**	.121	.011	.299**	.110	.189**	3	↑	↓	↓
			2	4	3	2	1	.207*	.158*	.110*	.096	.048	.048				
			3	4	3	2	1	.372*	.277*	.265*	.107	.012	.095				
	EC1	1	1	3	4	2	1	.070	.025	.007	.063	.019	.044	1	—	—	—
			2	2	1	4	3	.077	.059	.006	.072	.053	.019				
			3	4	1	2	3	.108	.098	.064	.044	.035	.010				
		2	1	2	4	3	1	.054	.047	.035	.020	.013	.001	2	—	—	—
			2	1	2	4	3	.081	.067	.003	.078	.064	.014				
			3	4	2	1	3	.131	.121	.100	.032	.023	.010				
		3	1	1	4	3	2	.169*	.083	.044	.126	.040	.086	3	—	—	↓
			2	2	1	3	4	.069	.063	.032	.037	.031	.006				
			3	4	3	1	2	.191**	.122*	.094	.097	.028	.007				
2	BC2	1	1	4	3	1	2	.068	.058	.033	.033	.023	.010	1	—	↓	↓
			2	4	1	3	2	.208**	.174**	.142**	.063	.032	.033				
			3	4	2	3	1	.213**	.181**	.132**	.061	.029	.032				
		2	1	1	4	3	2	.159*	.077	.016	.144*	.061	.083	2	↑	—	↓
			2	3	1	2	4	.061	.025	.022	.039	.002	.037				
			3	4	3	1	2	.143*	.125*	.060	.082	.063	.018				
		3	1	1	4	3	2	.286**	.051	.026	.259*	.025	.234**	3	↑	↑	↓
			2	1	2	3	4	.291**	.195**	.126*	.163**	.069	.096				
			3	4	3	2	1	.223**	.177**	.163**	.061	.014	.047				
	EC2	1	1	3	1	2	4	.052	.026	.012	.060	.014	.026	1	—	—	↓
			2	1	2	4	3	.077	.050	.028	.049	.022	.027				
			3	4	3	2	1	.139*	.045	.040	.100	.005	.094				
		2	1	2	3	1	4	.042	.037	.036	.006	.001	.003	2	—	—	↓
			2	2	1	4	3	.058	.049	.013	.045	.035	.010				
			3	4	3	2	1	.167*	.134*	.128*	.039	.060	.033				
		3	1	1	4	3	2	.110	.026	.012	.098	.014	.084	3	—	—	↓
			2	1	3	2	4	.095	.036	.029	.067	.079	.059				
			3	4	3	2	1	.241**	.210**	.150**	.090	.059	.031				

$s_{\overline{Diff_B(CC)}} = .0042$ r = 1 2 3

$s_{\overline{Diff_B(CC)}}\ q_{.01}(r,12)$ = .013 .016 .017

$s_{\overline{Diff_B(CC)}}\ q_{.05}(r,12)$ = .018 .021 .023

No change

Significant increase

Significant decrease

* $p < .05$ ** $p < .01$