JOURNAL OF THE EXPERIMENTAL ANALYSIS OF BEHAVIOR 1969, 12, 539-550 NUMBER 4 (JULY)

SELECTIVE ATTENTION: THE EFFECTS OF COMBINING STIMULI WHICH CONTROL INCOMPATIBLE BEHAVIOR[1]

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Four rhesus monkeys learned both a color and tilt discrimination. The stimuli were combined to produce incompatible behavior. The behavior controlled by one set of stimuli was reinforced until "errors" virtually disappeared. The stimuli were tested separately again. Sixteen replications of the entire procedure indicated that the stimuli producing "errors" were ignored.

Skinner has defined attention as "a controlling relation—the relation between a response and a discriminative stimulus" (Skinner, 1953, p. 123). This definition, once accepted, leads to an approach to the study of selective attention that departs from traditional concepts (*cf.* Mackintosh, 1965*a*). The approach to selective attention described in the present study is derived directly from Skinner's definition, but it also involves some subsidiary definitions of the author's.

Primarily, attention is viewed as a positive instance of control between a stimulus and a response. Attention is synonomous with stimulus control and selective attention is used when it is demonstrated that a response is controlled by one stimulus and not controlled by another. Terrace has expressed a different, but similar, point of view: "The concept of attention has entered the description of those situations in which a certain element of a stimulus that is correlated with reinforcement does not reliably control the response in question" (Terrace, 1966, p. 289). For the purposes of the present paper, the term attention always refers to a positive instance of stimulus control, and selective attention refers to a positive and negative instance of stimulus control for the same response. According to this definition, selective attention may describe behavior to test stimuli that do not covary and are not associated with the same contingencies of reinforcement, although these situations are not of much experimental interest.

Another point of view peculiar to the present study is the notion of a controlling stimulus-response relation as a behavioral unit with, at least, some of the properties of an operant response (Skinner, 1938). In Skinner's original formulation of the operant, he recognized the existence of a stimulus antecedent to each response, but deliberately rejected any attempt to identify each antecedent stimulus on the grounds that it would be irrelevant to the functional analysis of responses and their consequences. For those concerned with the study of attention, it is necessary to resurrect that antecedent stimulus as part of the controlling stimulus-response relation which may be influenced by its consequences. It is not enough, for this purpose, just to determine the presence of an antecedent stimulus before a response. To identify a controlling stimulus-response relation it is necessary to distinguish between: (a) a response that is controlled by a stimulus, and (b) a response that simply occurs in the presence of a stimulus.

A controlling relation between a stimulus and a response, it is generally agreed (Terrace, 1966, p. 271; and Honig, 1969, p. 1), is measured by independent stimulus variation. If stimulus variation fails to affect response probability, no controlling relation exists between the varied stimulus property and the response. If stimulus variation produces systematic changes in response probability, a controlling relation has been identified. The study of attention poses the problem of refining existing

[1]This research was supported by USPHS Research Grant MH-05408. Reprints may be obtained from the author, Neurology Research, Massachusetts General Hospital, Boston, Massachusetts 02114.

[2]The author is indebted to Deborah Skinner whose understanding of the concepts described in this paper and exceptional skill in running the experimental procedures made this study possible.

measures of stimulus control, for example the S^D/S^Δ ratio and the generalization gradient, with the goal of bringing measurement closer to the ideal of detecting stimulus control for each response so that reinforcement may be delivered contingently (Ray and Sidman, in press).

To the extent that a controlling relation can be identified, the analysis of selective attention is the study of the interplay between several controlling relations. Galloway and Petre (1968) showed that the probability of concurrent controlling relations can be manipulated by their concurrent schedules of reinforcement. Migler (1964) and Cumming and Eckerman (1965) showed that an organism taught to respond to two values along the same stimulus continuum with responses that represent two values along a response continuum, behaves as though the stimulus-response relations thus created do not belong to a functional class, but occur with independent probabilities. Both studies support the notion of a controlling stimulus-response relation as a behavioral unit with a probability of occurrence influenced by its consequences.

The present study was concerned with whether a controlling stimulus-response relation may occur more or less frequently without disturbing the relation between stimulus and response. By analogy with the operant response, the question is similar to asking whether a response may change in probability of occurrence without any accompanying change in topography. When an organism learns to respond to a new stimulus, it seems that this falls in the category of creating a new stimulus-response relation, a new stimulus control topography. The only purpose in suggesting this analogy between a controlling stimulus-response relation and an operant response is to encourage the testing of known behavioral principles that may readily apply to the phenomena of selective attention.

Several studies (Johnson and Cumming, 1968; Kamin, 1968; Miles and Jenkins, 1965) have shown that training an animal to discriminate one set of stimuli may prevent or postpone its learning to discriminate stimuli that are subsequently added to the original set. This effect might be summarized as follows: discrimination training raises the probability of certain stimulus-response relations. These same stimulus-response relations continue at high probability when additional, and redundant, stimuli are added to the situation. This finding follows logically if controlling relations are considered as operants, since the opportunity to establish redundant controlling relations does not change the consequences of ongoing behavior. Johnson and Cumming (1968, Exp. II) showed that stimulus selection is affected by single stimulus training before or after compound stimulus training. This finding suggests that selective attention phenomena may be replicated many times in the same organism.

Another group of studies (Lawrence, 1950; Goodwin and Lawrence, 1955; Mackintosh, 1963) attempted to establish the conditions under which selective control by an element of a compound stimulus will survive a discrimination reversal for the controlling element. The results of these studies were not always consistent. For example, when control by one set of stimuli has been established, and the reinforcement contingencies are reversed for this original set at the same time that new stimuli are added, the subjects may: (a) reverse the original discrimination without shifting to the other cues made available (Mackintosh, 1965*b*), or (b) the subjects may learn to discriminate only the added stimuli (Sutherland and Mackintosh, 1966). The source of these contradictory results most probably lies in the control exerted by the added stimuli when they are first introduced. There is no reason to assume that they exert "zero" control because they have not previously been used in the experiment. An attempt to measure the baseline of control by all elements of a compound discrimination problem may clear up some of the apparent contradictions in the literature on selective attention.

The present study attempted to trace the control exerted by two sets of discriminative stimuli as they were repeatedly combined and then separated. The control exerted by the combined stimuli is interpreted in terms of the control which each stimulus element is known to exert alone. The study asks: (a) if two separately established controlling relations will both continue when they are allowed to occur concurrently by combining their discriminative stimuli; (b) if the probability of the concurrent controlling relations is a direct function of the concurrent reinforcement contingencies (*cf.* Galloway and Petre, 1968); and

(c) if reversing the reinforcement contingencies for one of the concurrent controlling relations will decrease its frequency of occurrence without changing the relation between stimulus and response, or will modify the controlling relation itself, creating a new stimulus control topography.

METHOD

Subjects

Four rhesus monkeys, adolescent to young adult, were maintained at 80% of their free-feeding weight. Two monkeys, R8 and R9, had an extensive experimental history of tilt discrimination procedures. The other two were experimentally naive at the start of this study.

Apparatus

The stimulus projection apparatus and animal cubicle were both contained in a larger, sound-attenuating box. The animal was contained in an area 2 by 2 by 2 ft. A system of blowers served both to mask outside noises emanating from the scheduling equipment and to exhaust the hot air produced by a Kodak Carousel slide projector. The slides in the projector provided the stimuli for all discrimination procedures and were punched to project a spot of light onto an array of photocells that decoded the correct response for each trial. At no time were these spots of light visible to the animal. In the animal cubicle, one wall contained two stimulus-response keys and a dimly illuminated cup to receive 1-g Ciba banana pellets. The circular response keys were 2 in. in diameter and 5.5 in. apart, center to center. The food cup was located below and to the left of the response keys. This apparatus is described in considerably more detail in Ray (1967).

A 20-pen Esterline Angus operations recorder provided a running account of responses during and between trials. The scheduling of trials and reinforcements and the recording of responses were controlled by solid-state equipment.

Procedure

To start, all four monkeys were taught both a color and a tilt discrimination. To be sure of the control exerted by each of the stimuli, the animals were taught a specific response to each stimulus value. Only four stimulus values were used: red and green for the color discrimination, and vertical and horizontal for the tilt discrimination. It was necessary to have at least two values from each dimension to demonstrate that color and tilt were the effective stimulus dimensions.

All the monkeys were taught to discriminate the colors red and green via a program of graduated stimulus changes (*cf.* Ray, 1967) currently being developed. The experiment was designed to define stimulus control only in terms of discrimination performance, so the lengthy details of the initial training program are omitted. All four monkeys reached a criterion, based on a 60-trial session, of 95% correct or better on the following discrimination problem: when both keys are red, press only the left key; when both keys are green, press only the right key (see Fig. 1). This particular set of response contingencies was termed "original color" to distinguish it from subsequent color discriminations in which the response contingencies were reversed.

When a monkey met criterion on the color discrimination, it was taught to discriminate, via a program being developed (*cf.* Ray, 1967), black vertical and horizontal lines on a white background. The lines, when projected onto the keys, were 1.5 in. long and 0.1 in. wide. All monkeys reached the 60-trial criterion of 95% correct or better on the following discrimination problem: if both keys contain vertical lines, press only the left key; if both keys contain horizontal lines, press only the right key (see Fig. 1). This particular set of contingencies was called "original tilt" to distinguish it from subsequent tilt discriminations in which the response contingencies were reversed.

Once criterion was met on the color and tilt discrimination separately, the usual 60-trial session was divided into 30 consecutive trials of each discrimination problem. The discrimination tested first, either color or tilt, was varied in subsequent replications of the experiment. The session was called the "immediate history check" and was run to ensure that both discriminations were performed at 95% correct or better immediately before the stimuli were combined. If a monkey failed to perform at 95% accuracy or better on either discrimination, the immediate history check was repeated to criterion.

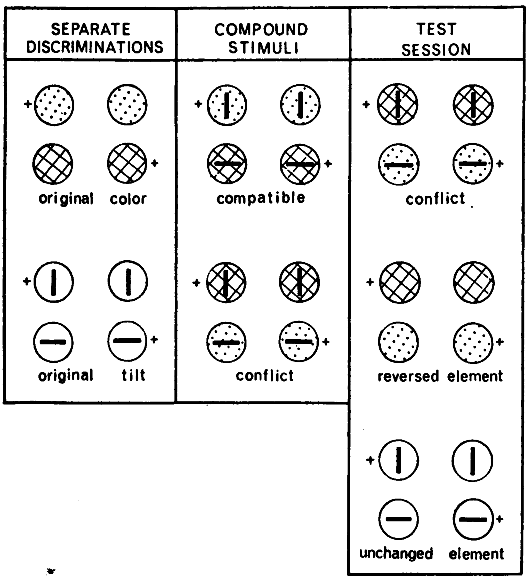

Fig. 1. An outline of the procedures necessary for each test. In this example, control initially established by color is not reinforced (+) in the conflict compound. The test is run after "errors" disappear to the conflict compound. The test session is comprised of: 20 trials of the conflict compound, 20 trials of color alone, and 20 trials of tilt alone.

After the immediate history check, the monkeys were confronted with stimuli that combined values of color and tilt, *i.e*, a black line on a colored background. Sometimes the values were combined to produce compatible behavior, that is, each stimulus value controlled a response to the same key position, as in combining "original color" and "original tilt" ("compatible" compound in Fig. 1). This was done to control for the possibility that merely combining the separate stimuli might disrupt behavior. These "compatible" compounds always produced criterion accuracy immediately, so it was never necessary to run more than one session. After either the immediate history check or the compatible compound, when the latter was used, the animal was confronted with a "conflict" compound of the stimuli of the original discriminations. The conflict compound contained values of color and tilt that controlled different position responses, and the responses controlled by only one of the dimensions continued to be reinforced. In the example given in Fig. 1, the conflict compound contingencies were such that the previously learned tilt discrimination continued to be reinforced, but the previously learned color discrimination did not. The response contingencies for the color stimuli have been reversed. This particular situation may be summarized as follows: the monkey's history of separate color and tilt discriminations is "original color" and "original tilt"; the subsequent conflict combines "reversed color" with "original tilt". As a direct result of the animal's immediate history, any responses based on the reversed element will, at first, not be reinforced. Therefore, responses based on the reversed element were initially identifiable as "errors" to the conflict compound.

Each monkey continued to respond to the conflict compound for 60 trials each day until 95% or more of its responses were again reinforced. This criterion session defined the point in reacquisition that was of major experimental interest: what, if any, control was now exerted by the element that had been reversed?

To answer this question, a test was administered to each monkey in the session that immediately followed criterion accuracy to the conflict compound. In the test, the color and tilt stimuli were presented alone and in combination. The response-reinforcement contingencies were the same whether a stimulus appeared alone or in the combination (see Fig. 1). Each test lasted for 60 trials composed of: 10 consecutive trials of the conflict compound to detect possible changes in the criterion accuracy of the previous session; 10 consecutive trials of the reversed element to see if it accounted for the control exerted by the conflict compound; 10 consecutive trials of the unchanged element to see of it accounted for the control exerted by the conflict compound; 10 more trials of the reversed element to check for possible changes since previous testing; 10 more trials of the unchanged element to check for possible changes since previous testing; and, finally, 10 more trials of the conflict compound to be sure that accurate performance had not been disrupted by testing the elements separately. All in all, there were 20 trials of the conflict compound, 20 trials of the reversed element, and 20 trials of the unchanged element in a test session.

The preceding describes the details of the procedures necessary to obtain a single test result. The entire procedure was recycled after a monkey completed a given test, and the monkey learned new original color and tilt discriminations. Care was taken to reverse oc-

Table 1

The specific color and tilt discriminations that each monkey learned in the successive replications (cycles) of the experimental procedure. The column "L" indicates that a response to the left key was reinforced for the designated stimuli (R = red; G = green; V = vertical; H = horizontal). The column headed "R" indicates that a response to the right key was reinforced for the designated stimuli.

Monkey R8												
Cycle	*1*		*2*		*3*		*4*		*5*		*6*	
Reinforced Response	*L*	*R*	*L*	*R*	*L*	*R*	*L*	*R*	*L*	*R*	*L*	*R*
Original Discriminations	R	G	R	G	R	G	R	G	R	G	R	G
	V	H	V	H	H	V	H	V	H	V	H	V
Compatible Compound	–	–	–	–	R+H	G+V	R+H	G+V	R+H	G+V	–	–
Conflict Compound	G+V	R+H	R+H	G+V	G+H	R+V	R+V	G+H	G+H	R+V	R+V	G+H
TEST:												
Conflict Compound	G+V	R+H	R+H	G+V	G+H	R+V	R+V	G+H	G+H	R+V	R+V	G+H
Reversed Element	G	R	H	V	G	R	V	H	G	R	V	H
Unchanged Element	V	H	R	G	H	V	R	G	H	V	R	G

Monkey R9												
Cycle	*1*		*2*		*3*		*4*		*5*		*6*	
Reinforced Response	*L*	*R*	*L*	*R*	*L*	*R*	*L*	*R*	*L*	*R*	*L*	*R*
Original Discriminations	R	G	R	G	R	G	G	R	G	R	R	G
	V	H	V	H	H	V	H	V	V	H	H	V
Compatible Compound	R+V	G+H	–	–	R+H	G+V	–	–	–	–	R+H	G+V
Conflict Compound	G+V	R+H	R+H	G+V	G+H	R+V	G+V	R+H	R+V	G+H	R+V	G+H
TEST:												
Conflict Compound	G+V	R+H	R+H	G+V	G+H	R+V	G+V	R+H	R+V	G+H	R+V	G+H
Reversed Element	G	R	H	V	G	R	V	H	R	G	V	H
Unchanged Element	V	H	R	G	H	V	G	R	V	H	R	G

	Monkey R21				*Monkey R32*			
Cycle	*1*		*2*		*1*		*2*	
Reinforced Response	*L*	*R*	*L*	*R*	*L*	*R*	*L*	*R*
Original Discriminations	R	G	G	R	R	G	G	R
	V	H	H	V	V	H	H	V
Compatible Compound	R+V	G+H	G+H	R+V	R+V	G+H	G+H	R+V
Conflict Compound	R+H	G+V	R+H	G+V	G+V	R+H	G+V	R+H
TEST:								
Conflict Compound	R+H	G+V	R+H	G+V	G+V	R+H	G+V	R+H
Reversed Element	H	V	R	G	G	R	V	H
Unchanged Element	R	G	H	V	V	H	G	R

casionally the particular color and tilt discriminations that were established as "original" in any given cycle of the procedure. Only the discrimination criterion of 95% accuracy defined the controlling relations existing at the moment of stimulus combination. The sequence of color and tilt discriminations taught to each monkey is listed in Table 1. Monkeys R8 and R9 were tested after each of six complete cycles of the procedure. Monkeys R21 and R32 were tested after only two cycles.

RESULTS

There are two major findings of the study. First, each test revealed that it was the unchanged element that supported criterion accuracy in the conflict compound when criterion accuracy was finally achieved. This was indicated by the accurate performance when the unchanged element was presented alone and the inaccurate performance when the reversed element was presented alone. Second, the reversed element either still controlled the original discrimination of the immediate history check, or the reversed element no longer exerted any clear control over responding. There was no evidence that the reversed element controlled any behavior in line with the recently reversed contingencies of reinforcement. The results of the test sessions are summarized in Fig. 2.

The conflict compound (left bars in Fig. 2) continued to support criterion accuracy from the criterion session into the test, except in Tests 3, 4, and 6 for Monkey R9. In Tests 3 and 6, the fact that the unchanged element supported almost perfect accuracy, but "er-

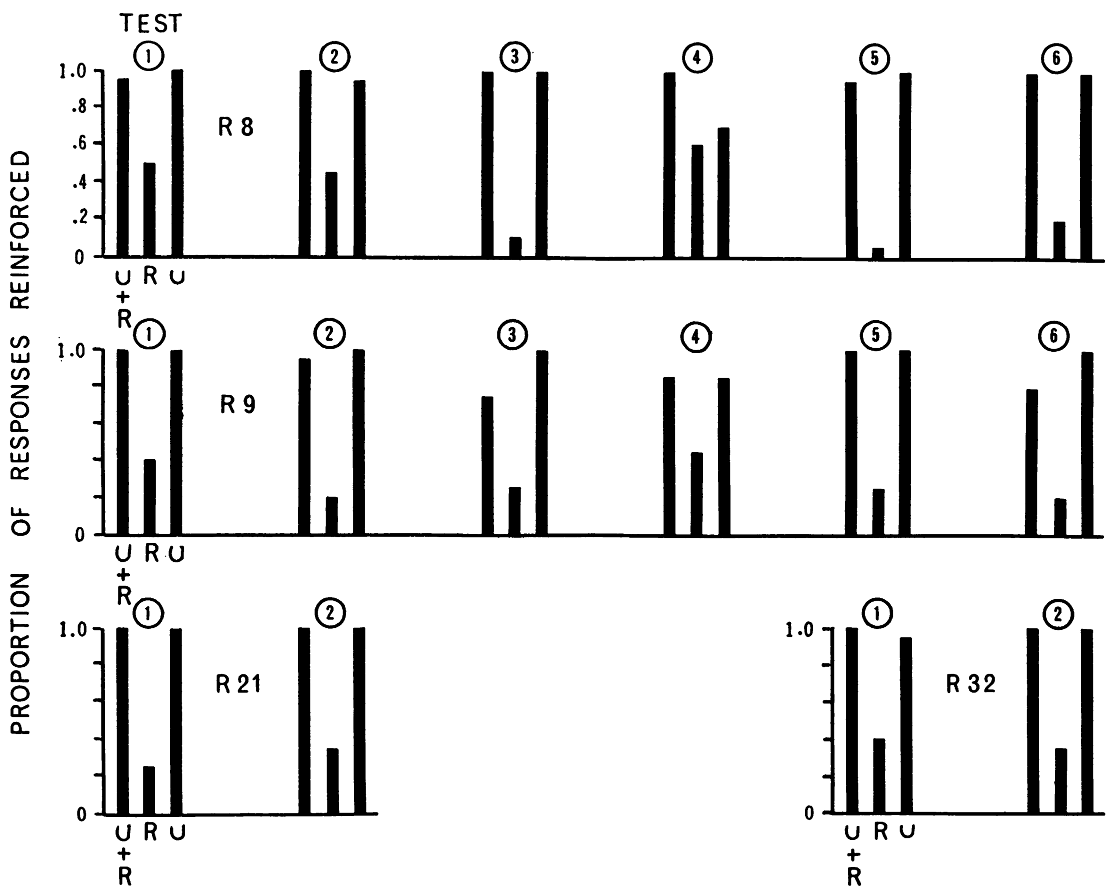

Fig. 2. The results of each test session expressed as the proportion of responses reinforced. U+R: the data from the 20 trials of the conflict compound. R: the data from the 20 trials of the reversed element. In order to be reinforced, a response must conform to the recently reversed reinforcement contingencies for this element. U: data from the 20 trials of the unchanged element. In order to be reinforced, a response must conform to the unchanged reinforcement contingencies for this element.

rors" were made to the conflict compound, suggests that the reversed element was responsible for these conflict compound errors. In Test 4, however, the unchanged element does not support criterion accuracy and it is not possible to explain the errors to the conflict compound as occasional control by the reversed element. The basis for the errors to both the conflict compound and the unchanged element was not explained by inspection of the individual trials of Test 4 for Monkey R9.

The unchanged element (right bars in Fig. 2) supported criterion accuracy in all but two of the tests (Monkey R9, Test 4; Monkey R8, Test 4). Apparently, the errors the monkeys made while learning the conflict compound discrimination did not disrupt control by the unchanged element. The relatively poor accuracy shown by Monkey R9 to the unchanged element in Test 4, 0.85, could not be explained and is apparently reflected in the equally poor performance in the conflict compound trials. Whatever reduced accuracy to the unchanged element presumably also disrupted accuracy when the element was part of the conflict compound. The even lower accuracy shown by Monkey R8 to the unchanged element in Test 4, however, is not reflected in the performance in the conflict compound. Is is difficult to explain a perfect conflict compound performance when the unchanged element performance is not also perfect, in view of the otherwise consistent finding that the unchanged element is responsible for reinforced responding to the conflict compound. For this reason, it was suspected that Monkey R8's errors to the unchanged element were the temporary effect of the reversed-element test trials which always preceded each block of unchanged-element test trials. Inspection of the individual test trials showed that Monkey R8 made errors early in each block of unchanged element trials, *i.e.*, immediately after reversed-element trials.

Monkey R8's exact pattern of responding in Test 4 was as follows: the monkey responded correctly for the first 10 trials, which presented the conflict compound. Ten trials of the reversed element were presented next and the monkey responded once to the right key, once to the left key, six times to the right key, and then six times to the left key, at which point four trials of the unchanged element had already been presented. The monkey responded correctly to the remaining six trials of the unchanged element. Again, 10 trials of the reversed element were presented and the monkey responded to the right key for nine consecutive trials and the left key for five consecutive trials, at which point four trials of the unchanged element had already been presented. The monkey responded correctly to the remaining six trials of the unchanged element. In the last 10 trials, which presented the conflict compound once again, the monkey responded correctly. The fact that errors occurred only at the beginning of each block of unchanged-element trials suggests that these errors perseverated from the preceding reversed element trials. Furthermore, the pattern of responding during the reversed-element trials is a familiar one that has tentatively been interpreted as unstable position-based responding. Although the evidence is not conclusive, the poor accuracy of Monkey R8's responding to the unchanged element in Test 4 seems to derive from the preceding reversed-element trials which produced position-based responding and temporary inattention to what was appearing on the keys.

Finally, in all but one test, the reversed element (middle bars in Fig. 2) supported accuracy at or below 0.50. The exception was a score of 0.60 in Test 4 for Monkey R8. This is the same test just discussed, in which the reversed element presumably generated position-based responding. If the notion is accepted that Monkey R8 responded to the reversed element with an unstable position habit in this test, it would easily explain the inflated accuracy score of 0.60, since any tendency to shift position might adventitiously increase or decrease reinforcement frequency. But the evidence for this interpretation is inconclusive.

The results of each reversed-element test in Fig. 2 make it clear that this was not the element responsible for the monkey's criterion accuracy to the conflict compound. In some instances, Monkey R8, Tests 3 and 5, the reversed element yielded almost 100% "errors" while the conflict compound yielded less than 5% "errors". This raises the question of what control, if any, the reversed element had over responding.

The reversed element, in several tests, continued to control the original discrimination of the immediate history check as indicated by close to 100% "errors", or nearly perfect accuracy on the original discrimination. Sometimes the reversed element seemed to exert no control over the animals' responding as indicated by scores close to 0.50 (Monkey R8, Tests 1 and 2; Monkey R9, Test 4). Monkey R8, in Test 1, had a perfect left-key position habit during reversed-element trials. In other instances of chance performance, the sources of stimulus control during reversed-element trials was not identified. In the majority of tests, the monkeys responded to the reversed element with neither a chance performance or with 100% "errors". These intermediate scores probably represent a combination of loss of control by the reversed element and occasional re-emergence of the original discrimination, there being no reason to assume that these possibilities are mutually exclusive.

Whenever a test was completed, new "original" discriminations were established before the next cycle of the entire procedure. Sometimes this meant teaching a monkey the reversed-element discrimination that it had failed to learn while the element was part of the conflict compound. Figure 3 shows the course of acquisition of the reversed discrimination whenever it was established to criterion. The figure also shows (data points in circles) the test performance for every reversed element and every unchanged element. There were two tests in which a monkey did not respond to the unchanged element with criterion accuracy, and these tests were eventually followed by training sessions to restablish criterion. Only one training session was necessary in both instances (Fig. 3). There was no test in which a monkey responded to the reversed element with criterion accuracy. Many training sessions were necessary to establish criterion on the reversed-element discriminations whenever it was attempted. Figure 3 shows that the reversed element does not support an above-chance performance for, at least one, and usually several sessions after the test. This is further evidence that the monkeys learned nothing about the reversed reinforcement contingencies while the reversed element was part of the conflict compound.

Regardless of which discriminations were established for the immediate history check, and regardless of how many times they had been reversed and unreversed in the remote

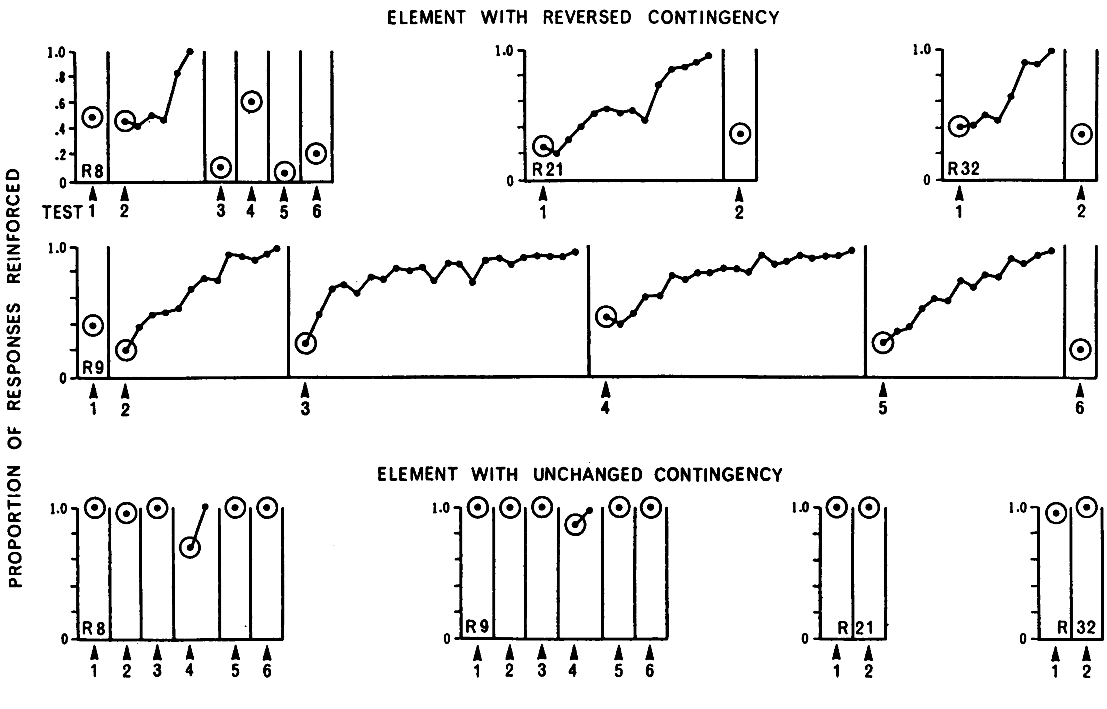

Fig. 3. A comparison of the course of acquisition, whenever attempted, of the reversed-element discrimination and the unchanged-element discrimination. Discrimination training begins in each test session when the elements are presented alone. The test data points are marked by circles.

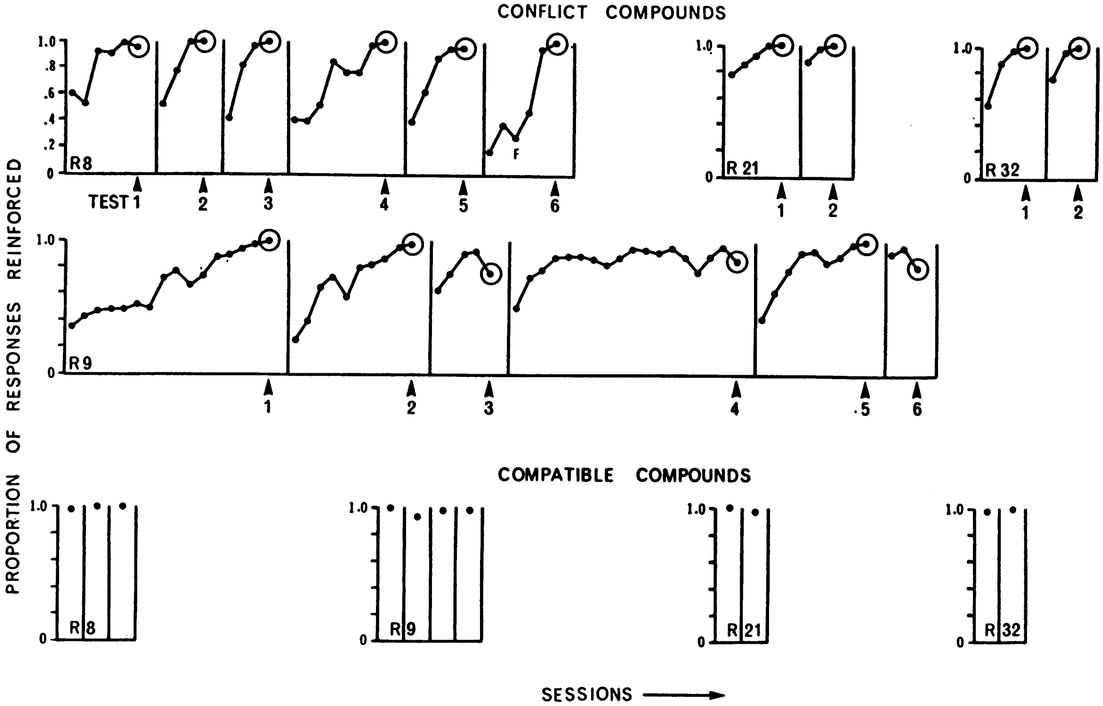

Fig. 4. A comparison of the course of acquisition of the conflict compound discrimination and the compatible compound discrimination. The last training trials, for the conflict discrimination, occur in the test session. These test data points are marked by circles. The data point marked "F" in Test 6 for Monkey R8 is from a session involving occasional feeder malfunction. The problem was corrected before the next session.

past, as long as criterion accuracy was demonstrated in the immediate history check, the stimuli could be combined in compatible compounds without disrupting accuracy (bottom, Fig. 4). Whenever the stimuli of the immediate history check were combined in conflict compounds, accuracy dropped, but the size of the drop varied widely (top, Fig. 4). Since the reversed element is known to control "errors" in, at least the first session of the conflict compound, the number of "errors" indicates the number of times an animal based its responding on the reversed element. "Errors" in subsequent sessions with the conflict compound may also indicate control by the reversed element, but the projection is risky since the animals have encountered extinction of their ongoing behavior and one of the effects of extinction is to increase the variability of behavior (Eckerman and Cumming, 1966).

Using the proportion of "errors" during the first conflict compound session, as a measure of selective attention, there seems to be no evidence in this experiment of a preference for either the color or tilt stimuli. Monkey R8 tended to base about half of its responses on color and half on tilt whenever they were combined. The range of scores during the first sessions of any given conflict compound was 0.40 to 0.52 for Monkey R8. Monkey R9 twice showed a fairly strong preference for one dimension, but in one instance the preference was for tilt (before Test 2) and in the other it was for color (before Test 6). This eliminates the possibility of Monkey R9's having a preference for either dimension *per se*.

Monkey R21 and R32 might be expected to have a preference for color, since these animals did not have the same pre-experimental history of tilt-discrimination training afforded Monkeys R8 and R9. Monkey R21 showed a color preference before Test 1 and then a tilt preference before Test 2. Monkey R32 showed no preference before either Test 1 or Test 2, although this may not seem to agree with Fig. 4, in which scores are based on an entire 60-trial session. Both of the naive monkeys, R21 and R32, reached criterion very quickly in their second conflict compound—so quickly that, in cycle 2, errors had virtually disappeared by the second half of the first conflict compound session. The preference data for these monkeys were, therefore, derived from only the beginning half of the first conflict compound session in cycles 1 and 2. It may be significant that only the monkeys with no pre-experimental history showed faster leaning of the conflict discrimination in cycle 2.

DISCUSSION

The experiment has two major findings. First, monkeys presented with a combination of stimuli controlling incompatible behavior solved the problem by "ignoring" the stimuli which controlled unreinforced behavior or "errors". The term *ignore* is used here to refer to the disappearance of stimulus control previously demonstrated. It is necessary to establish a stimulus control baseline in order to measure the effect. The second major finding is that no monkey gave any evidence of having learned anything about the reversed reinforcement contingencies associated with the stimuli that controlled errors.

Under the present conditions, it seems clear that discontinuing reinforcement of one controlling relation while maintaining reinforcement of another, reduces the probability of the one not reinforced, *i.e.*, reduces errors. What is meant here by a reduced probability of a controlling relation is only that the relation occurs less frequently. The decreased probability does not necessarily imply any change in the type of relation between stimulus and response when it occurs. The distinction between the frequency of a controlling relation and its topography may be analogous to the more traditional, but less rigorous, distinction between a shift in attention and discrimination learning, respectively. This study clearly demonstrated a shift in attention away from the reversed element and toward the unchanged element. It is not clear, however, whether any discrimination learning occurred with respect to the reversed element.

During conflict-compound training, when the frequency of control by the reversed element reached zero, the discrimination index based on errors denoted perfect discrimination of the conflict compound. This is one example of the way in which an error score places an artificial ceiling on measures of stimulus control acquisition. There is no reason to assume that the first criterion session with the conflict compound marks the end of stimulus control acquisition. It was demonstrated that criterion accuracy to the conflict compound was achieved by a shift in attention to the unchanged element. If training had been continued beyond criterion accuracy, *i.e.*, "overtraining", the monkeys may have learned something about the new reinforcement contingencies associated with the reversed element. The learning of the reversed-element discrimination would not necessarily be reflected in the error score, since it has been shown (Schusterman, 1966) that sea lions can learn to reverse a discrimination without errors if control is temporarily shifted to an alternative set of stimuli. The unchanged element in this study provided the alternate set of stimuli.

It is this sort of invisible shift in stimulus control, covered up by an unchanging error score, that is probably responsible for the effects of overtraining on the learning of discrimination reversals (Mackintosh, 1965*c;* Pubols, 1956). Rather than inferring shifting states of attention during overtraining (Mackintosh, 1965*a*), the error score should be abandoned as an appropriate measure of stimulus control in these experiments and replaced by direct measurement of the controlling relations pertinent to the experimental question. Defining overtraining in terms of the number of trials beyond criterion may be a poor substitute for defining the shifts in stimulus control which these extra trials represent.

The question of whether or not discrimination learning occurred to the reversed element during conflict compound training is not directly answered by this study. It was demonstrated that the monkeys had not learned the reversed discrimination, but this does not eliminate the possibility of their having learned something else about the reversed element. Whenever the reversed element proced nearly 100% errors, it seemed fairly clear that the original control by the element had not changed, but simply ceased to occur in the context of the conflict compound. When the reversed element produced nearly 50% errors, it was not clear whether the monkey was continuing to ignore the element when it was presented alone, or whether the relation between the element and responding had itself been changed, a new stimulus control topography. If the monkey continued to ignore the reversed element, responding to another feature of the environment, this would yield an intermediate error score. An example is the left-key position habit of Monkey R8 in Test 1. If a monkey did respond to the reversed element when it was presented alone, but yielded an intermediate error score, it would have to mean that the type of control exerted by the reversed element was not always the same. For example, it is conceivable that the reversed element may have controlled the original discrimination on some trials and the reversed discrimination on others. Supplementary and informal data were collected to help decide between these alternative explanations of what appeared to be random responding to the reversed element.

Responding to the reversed element was examined during the first retraining session involving the reversed stimuli. Retraining always followed a test, except for the last one, in order to prepare new original discriminations for the next cycle. The reinforcement contingencies for the reversed-element stimuli either stayed reversed or were unreversed, since these were the only two possibilities. Comparison of the first retraining sessions for these two conditions showed that it was fairly easy to reestablish the original discrimination, but difficult to establish the reversed discrimination. In the first retraining sessions when the reinforcement contingencies stayed reversed, the accuracy scores were: 0.20, 0.33, 0.40, 0.42, 0.42, 0.47, and 0.48. In no instance did accuracy exceed 0.50, or a chance performance. In the first retraining session, when the reinforcement contingencies were unreversed, the accuracy scores were: 0.52, 0.60, 0.63, 0.82, 0.87, 0.97, 0.98, 1.00. In three of eight instances, the monkeys returned to a criterion performance. The evidence is not conclusive, but it is consistent with the notion that reinstatement of the original reinforcement contingencies reestablished "attention" to, or control by, the reversed element and that attention took the form of the original discrimination. This may mean that the controlling relation between the reversed element and responding had not changed, but rather had ceased to occur even when the reversed element was presented alone.

The evidence strongly indicates that a controlling relation between a stimulus and response is not necessarily modified when it occurs more or less frequently. Thus, any concept which assumes that nonreinforcement somehow weakens the bond between a stimulus and response is clearly not adequate to explain the selective attention phenomena reported here.

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Received 29 July 1968.