An Experimental Demonstration of the Transitive Conditioned Establishing Operation with Pigeons

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AN EXPERIMENTAL DEMONSTRATION OF THE TRANSITIVE CONDITIONED ESTABLISHING OPERATION WITH PIGEONS

by

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Rachel Nunes Da Cunha, Ph.D.

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Skinner (1938) dealt with motivation in terms of the operations of deprivation/satiation and aversive stimulation. Later, Keller and Schoenfeld (1950) introduced the term *establishing operation* to refer to such motivative variables, and Michael (1982, and in press) expanded the Keller and Schoenfeld (1950) concept to include a type of learned motivative variable not explicitly identified in the earlier treatments. The purpose of the present research is the laboratory demonstration of this form of motivation, that Michael referred to as a transitive conditioned establishing operation (CEO).

The present experiment used a treadle-key procedure similar to that of Alling (1990), but with a small variable ratio of responses required to produce the conditioned reinforcer rather a single response as in the Alling procedure. The behavior of four experimentally naive pigeons was studied in standard operant chambers, with the experimental contingencies arranged by a computer. After preliminary training, three phases were introduced. In Phase 1, the CEO condition, a buzzer came on and off on a variable-time basis with an average time of one minute. For two subjects when the buzzer was on, responding on a variable ratio 6 on the treadle changed the treadle light from white to red for 5 s, and a key peck within 5 s resulted in food reinforcement. When the buzzer was off, responding on the treadle changed the treadle light from white to red, but a key peck did not produce reinforcement, and after 5 s the treadle

light changed back to white. For the other two subjects the relation between food reinforcement and the presence/absence of the buzzer was reversed. In Phase 2 the procedure was exactly the same except that the completion of the required response ratio on the treadle set up the food reinforcement for a key peck, but did not produce the light change. Phase 3 was a return to the conditions of Phase 1.

The major dependent variable was the treadle-pressing response rate, and all birds showed much higher rates of treadle pressing in the CEO than in the nonCEO condition. In Phase 2, when the conditioned reinforcer was no longer produced by the treadle pressing, it was expected that the treadle performance would deteriorate, but this was seen clearly in only one of the birds. The other three subjects had probably developed a pattern of pressing the treadle several times, then pecking the key, and if reinforcement were not delivered, returning to the treadle for more presses, etc. When the treadle light change was omitted, this pattern would have been successful in producing food reinforcement. Once again, an effort to show that a stimulus was functioning as CEO had failed to unambiguously eliminate the possibility that the stimulus was simply a discriminative stimulus for a complex pattern or chain of behavior, because that pattern was differentially related to food reinforcement.

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Rachel Nunes da Cunha

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CHAPTER I

INTRODUCTION

The Transitive Conditioned Establishing Operation

Motivation has long been considered an important determiner of human action, but in traditional treatments of the topic (e.g. Mook, 1987) it has usually been assigned status as an internal process or condition. In behavior analysis the role of such inferred internal processes is minimized in favor of environmental causes of behavior. Skinner (1938) deals with motivation in terms of the operations of deprivation/satiation and aversive stimulation, both constituting environmental determiners of behavior. In an approach derived primarily from that of Skinner (1938) and from Keller and Schoenfeld (1950), Michael (1982, and in press) has further developed the concept of the establishing operation (EO) to include a type of learned motivative variable not explicitly identified in the earlier treatments.

Keller and Schoenfeld (1950) were the first to use the term "establishing operation." Their use was related to the drive concept, but the term did not refer to an inner event, but was only a convenient term for "the fact that operations can be performed on an organism (for example depriving it of food) that have an effect upon behavior which is different from that of other operations" (p. 265). Likewise, Millenson (1967, p. 366) identified the drive concept as a way of emphasizing "...the ability of certain operations to establish reinforcers." Millenson classified two kinds of "drive" operations: one that had the function of reducing or eliminating reinforcing value (satiation), and the other that works to increase the value of the reinforcers (deprivation). In this sense, Millenson defined motivation as Skinner(1953) had (i.e., in terms of deprivation/satiation), although Skinner did not specifically use the term "establishing operation."

Much later Michael (in press) offered a more explicit definition as follows: "An establishing operation (EO) is an environmental variable that (1) momentarily alters the reinforcing effectiveness of some other object, event or stimulus; and (2) momentarily alters the frequency of the type of behavior that has been reinforced by that object, event or stimulus." The former is called a reinforcer-establishing, and the latter an evocative effect. He further classifies EOs into two categories: unconditioned establishing operations (UEOs), of philogenic provenance, varying from species to species; and conditioned establishing operations (CEOs), of ontogenic provenance related to each organism's own history. The distinction between the two is made on the basis of whether the reinforcer-establishing effect is innate or learned. (The evocative effect is generally learned for both UEO and CEO.) Food deprivation is an example of a UEO: Food becomes more effective as reinforcement for many mammals as a result of food deprivation, without any learning history; but the repertoire that acquires food has to be learned for most such organisms.

The previously unrecognized form of learned motivative variable that is the focus of the present study, which Michael calls a transitive[1] CEO (in press), is closely related to the concept of conditional conditioned reinforcement. The effectiveness of many forms of conditioned reinforcement would be expected to be at least somewhat dependent upon the stimulus conditions in which they were developed as conditioned reinforcers. Michael (in press) illustrates this concept as follows:

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[1]Transitive is meant in the grammatical sense, as with a transitive verb which takes a direct object.

> Imagine a food-deprived animal in an environment where it can always produce a 10-second buzzer sound by pressing a lever. Distinctive visual stimuli are related to the relation of this auditory stimulus to food. In the presence of a red overhead light, the 10-second buzzer sound ends with the delivery of food. In the absence of the red light, the buzzer sound lasts for 10 seconds and then ends without any food delivery. This is a situation where the auditory stimulus functions as conditioned reinforcement, but conditional upon the color of the overhead light. Thus the buzzer onset is not effective as reinforcement until the red overhead light comes on. When it does, with a well-trained animal, the lever press will be evoked. What is the reinforcement for the lever press? Obviously the buzzer onset. How does the red overhead light evoke the lever press?

Michael argues that it may be more effective terminology to consider the red light to be a motivative rather than a discriminative variable, even though it would currently be considered an S^D for the lever press. The argument hinges on the definition of the discriminative relation in terms of a correlation with reinforcer availability, as follows: "An S^D is a stimulus condition that has been correlated with the availability of a type of consequence given a type of behavior. A correlation with availability has two components: An effective consequence (one whose EO was in effect) must have followed the response in the presence of the stimulus; and the response must have occurred without the consequence (which would have been effective as reinforcement if it had been obtained) in the absence of the stimulus (Michael, in press). In the example above the red light is not correlated with availability of the buzzer, which is just as available in the absence of the red light as in its presence. The red light is a stimulus change that alters the reinforcing effectiveness—the value of the buzzer sound—and as with other types of motivative variables, evokes the behavior that produces it.

Laboratory Demonstration of the Transitive CEO

Michael's treatment of motivation was a conceptual analysis, the purpose of which was to suggest a reconsideration of familiar facts. He presented no new empirical information. However, there has been some published (Lubeck, 1987; Lubeck and McPherson, 1986; McPherson and Osborne, 1986; 1988) and some unpublished research (McPherson, Trapp, and Osborne, 1984; 1986; Alling, 1990) which attempted to demonstrate a transitive CEO with pigeons. These studies have been successful in demonstrating the type of control they were trying to develop, but in all cases other interpretations of the control were available. In particular, it has been difficult to exclude the possibility that the supposed CEO is actually functioning as an S^D for a two-response chain. The present research is aimed at further refining the methodology related to the transitive CEO, and reducing the plausibility of the alternative interpretations. What follows is a description of the various experimental approaches to this problem, and the related alternative interpretations.

The Three-key Procedure in CEO Studies

McPherson and Osborne (1986, 1988) used pigeons as subjects in a three-key discrete-trial procedure. During the intertrial interval all keys were dark. A trial began with illumination of the right key. The first peck on that key caused illumination of the center key, after which pecks on the right key had no effect. Illumination of the left key was controlled according to either a variable-time (VT) or random-time (RT) schedule. When the left key was lit, a peck on the center key was followed by food, the only situation in which center-key pecking had any effect. Each trial was finished after access to food, and trials were separated by an intertrial interval (ITI). According to Michael (in press) the reinforcement for pecking the right key is the lighting of the center key, because food can only be obtained by pecking that key when it is lit. However, the lighting of the center key is only effective as a form of conditioned reinforcement when the left key is lit. When the left key is not lit the lighting of the center key is of no value. The lighting of the left key, then, is functioning as a transitive CEO, establishing the lighting of the center key as an effective form of conditioned reinforcement, and evoking the behavior (a peck on the right key) that produces this stimulus condition. The lighting of the center key is a conditional conditioned reinforcer, whose reinforcing effectiveness is conditional on the illumination of the left key. A good performance, one which would constitute evidence for the CEO interpretation, would consist in waiting until the left key was lit, then pecking the right key, which would light the center key, then pecking the center key, which would result in food reinforcement.

In terms of data collection, they plotted the number of trials (out of the 50 trials per session) on which the first response on the right key occurred only after the left key was lit. In the first study (McPherson and Osborne, 1986) the subjects waited appropriately for the lighting of the left key before pecking the right key on the majority of the trials. The control was far from complete, however, and fair control (40 out of the 50 trials) was achieved only after 60 or so sessions. Also, one of the four birds showed good control for a while then lost it for a number of sessions. The second study was actually aimed at investigating the relation between performance in the three-key situation and the reinforcing strength of the conditioned reinforcer, the lighting of the center key. This was manipulated by altering the time between onset of the center key and onset of the left key. When the left key was lit an average of 12 s after lighting of the center key, the control by the CEO (the lighting of the left key) over responding on the right key was generally very weak—the birds generally lit the center key before the left key was lit. When the time between lighting of the center key and lighting of the left key had an average duration of 72 s, control by the CEO was better. The control was not as good as in the first study, but good control was not the purpose of this later study.

For the purpose of demonstrating a CEO effect, the above three-key procedures have two possible weaknesses. The contingencies on the three keys facilitate an autoshaping interpretation of some aspects of the performance. In addition, the fact that when the right key response produces the conditioned reinforcer—lighting of the center key—that stimulus condition remains until food is obtained, reduces the contact per trial with the uselessness of the center key light when the left key light is not lit. This feature of the procedure also results in the supposed CEO functioning simply as an S^D for a center key peck when the center key light has been lit before the CEO condition is present. Improving on these features was the purpose of the next two studies.

The Treadle-and-Key Procedure

Alling (1990) ruled out the interpretation of the CEO control as having something to do with elicited or autoshaped pecking by requiring a response with a very different topography to produce the conditioned reinforcer. The pigeon had to press a treadle located near the floor to change a light behind the treadle from white to red. This stimulus change was the conditioned reinforcer, the value of which would depend on the condition of the house light. In addition, in his procedure the conditioned reinforcer—the treadle light being red—only lasted for 5 s. This meant that it could be produced many times during the nonCEO condition, and in the CEO condition, its production—rather than just its presence—would always be close in time to the food reinforcement that made it a conditioned reinforcer.

The general procedure (shown in state notation in Figure 1 on the next page) consisted of a two-response chain in which a treadle press changed the color of the light above the treadle from white to red for 5 s. A single key peck (only one key was active) during the red treadle light would produce food reinforcement, depending on the condition of houselight. For two pigeons, the key peck when the treadle light was red

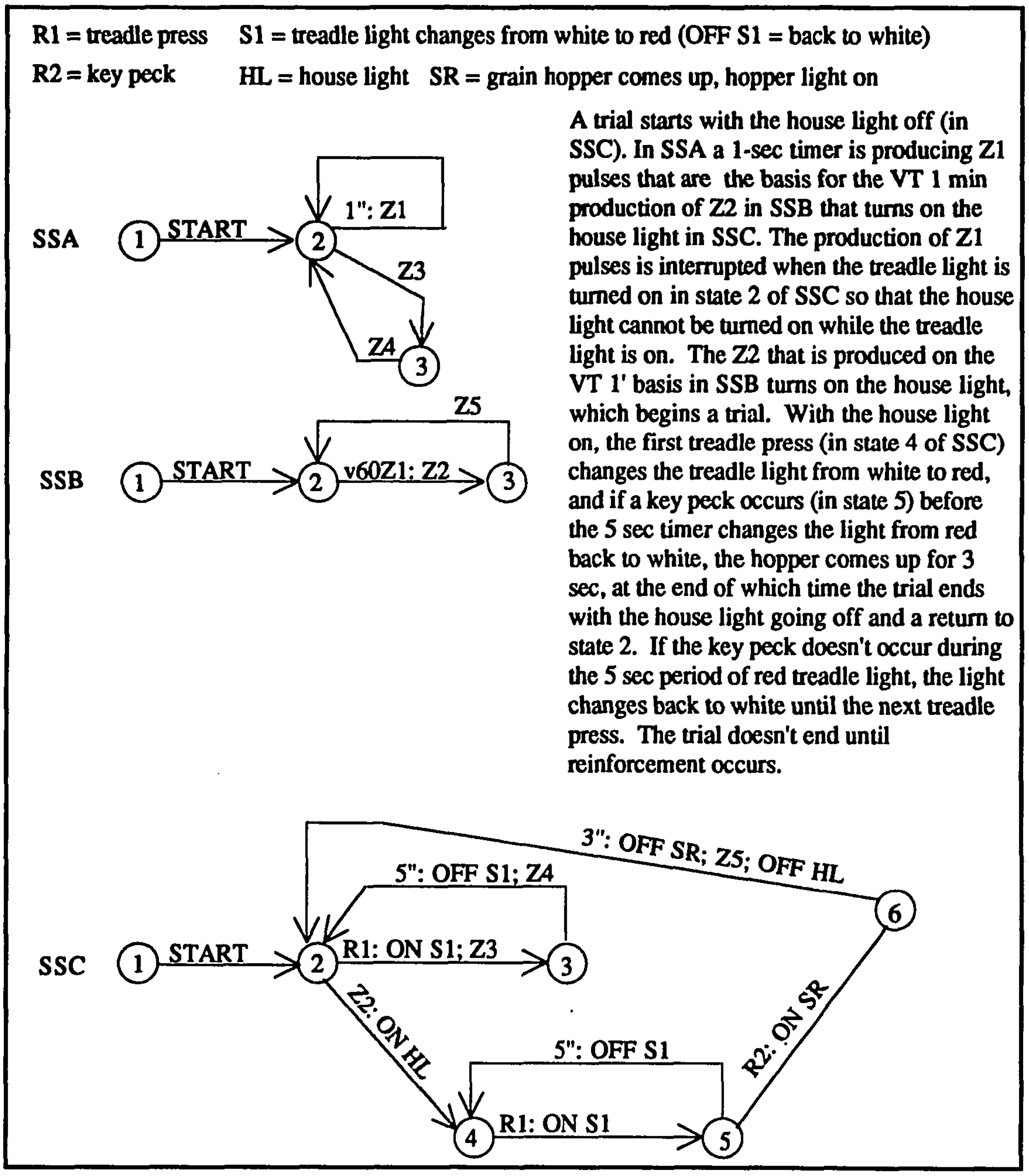


Figure 1. Phase 1 of the Alling Procedure.

was followed by a 3-s presentation of the grain hopper when the houselight was on. For one pigeon, the key peck when the treadle light was red was followed by a 3-s presentation of the grain hopper when the houselight was off. A trial began in the nonCEO condition, and the CEO was produced on a VT-60 sec basis. When the CEO condition began, it remained in effect until food reinforcement was obtained.

A good performance consisted in not pressing the treadle until the CEO-condition came on, then pressing the treadle and pecking the key before the 5-s duration of the treadle-light change was up. All three birds developed good performances (90% or more of the trials in a session with no treadle press until the CEO-condition was present), two of them in less than 25 sessions, and one after about 50 sessions. This phase of the experiment was continued for more than 90 sessions to be sure that there was no deterioration in the performances, as had occurred in the earlier McPherson and Osborne (1986) study. The treadle-and-key procedure was quite effective in developing effective CEO control, and in relatively few sessions of training. According to the Michael interpretation, the treadle-light change was functioning as a conditioned reinforcer for the treadle press, but its reinforcing effectiveness depended upon the house light condition, and therefore the treadle-press response was under the control of the house light, not as an S^D, but as a CEO. To confirm this interpretation, the treadle-light change was eliminated in a second phase of the experiment, but with all other aspects of the procedure remaining the same. In other words, treadle responses did not cause a treadle light change in either the nonCEO condition or the CEO condition. In the latter, however, a treadle response started the 5-sec timer, and a key peck occurring before the 5 sec elapsed was reinforced with food. It was expected that this change, since it eliminated the ostensive reinforcement for the treadle response, would lead to considerable disruption in the performance.

Surprisingly, there was almost no disruption. The birds simply waited until the CEO-condition, then pressed the treadle and pecked the key, as they had been doing before, and received reinforcement. The treadle press had possibly become simply the first component of a two-component response chain, which was controlled by the house-light change functioning as an S^D for the two-response chain. The treadle light change was no longer relevant. Alling suggested (1990) that its function might have been assumed by the relevant response-produced kinesthetic, tactile, etc. stimulus changes. However, it is possible that there never was any CEO control, and the treadle-key procedure was simply a slow way to develop a two-response chain, the faster way being backward shaping.

Phase 2 lasted 55 sessions for all three birds, and two of the birds continued to wait for the house light change before pressing the treadle on almost 100% of the trials per session. One bird's performance did become somewhat less effective in that by the end of the 55 sessions he was waiting for the house light change on only about 75% of the trials per session. This was not the kind of disruption that was expected, however, since it consisted in more treadle responding in the absence of the CEO rather than a disrupted performance in the presence of the CEO. Phase 3 consisted of a return to the Phase 1 condition for a minimum of 25 sessions. The purpose was just to see if there would be any further changes in performance, and to see if the bird whose performance had become somewhat less accurate would improve when the treadle-light change was restored. Interestingly, its performance showed only partial recovery, increasing to about 85% correct trials by the end of the 25 sessions, but since the increased treadle responding in the nonCEO condition was not easily understood in terms of the Phase 2 change, the meaning of this failure to recover completely is unclear.

Purpose of the Present Study

The present research uses a treadle-key procedure similar to that of Alling (1990), but with two differences. In the Alling procedure the change in houselight condition was meant to be the CEO, in both the presence and absence of which the treadle-light change could be produced. A possible problem with using the house light in this manner is that the treadle-light change might appear somewhat different when the house light is on than when it is off. If the bird became sensitive to this difference, then the supposed CEO would simply be an ordinary S^D. The stimulus change that is to function as conditioned reinforcement in the presence of the CEO but not in its absence must be exactly the same stimulus change in both conditions. For this reason, in the present study an auditory stimulus, a buzzer, was used as the CEO or as the non-CEO condition. In addition, instead of a single treadle press, a small variable ratio (VR 6) was necessary on the treadle to cause the treadle-light change. The purpose of this latter contigency was to reduce the possibility that a two-response chain would develop as a response unit, and hence render the conditioned reinforcer for the first component unnecessary. With this contingency there should be more obvious disruption when the treadle response no longer produces the treadle-light change.

CHAPTER II

METHOD

Subjects

Four experimentally naive adult White Carneaux pigeons served as the subjects. They were obtained from the Palmeto Pigeon Plant. Throughout the experiment, all subjects were maintained at 80% of their free-feeding weights. The birds were housed individually in a room with a 12-hour light/dark cycle and they had free access to water and grit. The daily sessions were run seven days per week at approximately the same time each day.

Apparatus

Two standard operant pigeon chambers measuring 40 cm by 40 cm were used. The two subjects of the same group were run at the same time in different chambers. On the ceiling of each chamber was a houselight which was off during the entire experiment. The right wall of the chamber contained two translucent disks (keys) the right one of which was illuminated with red light (7.5-W light bulb). A peck on the disk needed a minimum force of .2 N to operate the microswitch that registered the response. The left key was unilluminated during the entire experiment.

When the food magazine was raised it could be accessed by the bird through an aperture of 5 cm by 6 cm centered on the wall 7 cm above the chamber floor. The magazine operation made grain available for 3-s intervals and at the same time, all the lights in the chamber (left treadle light and right key light) were turned off and the hopper light (7.5-W light bulb) was illuminated. With an inclination of 30 degrees an aluminum foot treadle (8 cm long and 2 cm wide) was located on left side of the right wall. The front edge of the treadle was 2 cm above the floor. A treadle light with white and red bulbs of 7.5-W was located above the foot treadle. On the right side of the right wall was a similar aluminum foot treadle and treadle light., but no contingencies were programmed on that treadle, even though responses were registered, and the lights above it were off during the entire experiment. A force of .2 N was necessary to operate the treadle. A buzzer was produced by a Grason-Stadler White Noise Generator through a speaker mounted on the left wall in the chamber. An exhaust fan for ventilating the chamber was on during all phases of the experiment. A PDP-8 minicomputer (Digital Equipment Corporation) with SUPERSKED@ software (State Systems) and with electromechanical interfacing controlled the data collection and experimental events.

Procedure

Training Phase

Initially, subjects were exposed to hopper training, after which the key peck was shaped. During key-peck training, the treadle light and the left key were illuminated red except during the reinforcement presentation (3-s exposure to grain), when only the hopper light was on.

The next step was treadle-press training. Initially, the treadle response was shaped using food reinforcement (3-s grain exposure). Once the treadle press was acquired, a fixed-ratio schedule of reinforcement was introduced and progressively increased until stable behavior was obtained under FR 11. This aspect of the training took approximately 5 to 9 sessions. Next, with the treadle light white and the key light red, the birds were trained to complete a chain consisting of a variable number of treadle presses (VR 6) which changed the treadle light from white to red, followed by a single key peck which resulted in food reinforcement. During the reinforcement period, only the hopper light was on. After the reinforcement period, the treadle light changed back to white and the birds could complete another ratio of responses on the treadle and change the treadle light to red, peck the key and receive food reinforcement, etc. When the treadle light was white, key pecking had no effect.

When the birds had reliably exhibited this two-component chain for several sessions, the duration of the red treadle light condition was limited to 5 s, and if the key peck did not occur during this 5-s period the treadle light changed back to white. To receive food reinforcement the bird would then have to complete another ratio of responses on the treadle to change the treadle light to red, peck the key, and so on. When the subjects had exhibited a stable performance on the two-component chain with the red treadle light being limited to 5 s duration, Phase 1 began. In all, the training up to the beginning of Phase 1 took over 50 sessions, with approximately 40 reinforcements per session.

Phase 1: The CEO Condition

The purpose of this phase was to develop control of treadle pressing by the CEO condition, ostensibly showing that the treadle light change functioned as conditioned reinforcement for treadle pressing in the presence of the CEO, but not in its absence. During this phase, the buzzer came on and off based on a variable-time schedule (VT-1 min) and the final component of the chain was not always followed by grain. For two subjects (subjects 1 and 2—Group 1), when the buzzer was on, responding under VR 6 on the treadle changed the treadle light from white to red for 5-s; and a key peck within 5-s resulted in 3-s access to grain while the treadle light was red. However, when the buzzer was off, responding on the treadle changed the treadle light from white to red for 5-s; but a key peck did not result in 3-s access to grain, and after the 5-s period the treadle light changed back to white. Further treadle-pressing could make the treadle light red again for 5 s, and so on until the VT timer timed out. As before, key pecks while the treadle light was white had no effect. For these two subjects (#1 and #2), onset of the buzzer was supposed to be the conditioned establishing operation (CEO).

A state diagram of state set C of the procedure is shown in Figure 2 below, with the changes from the Alling procedure indicated in boldface type. State sets A and B were identical to those in the Alling procedure.

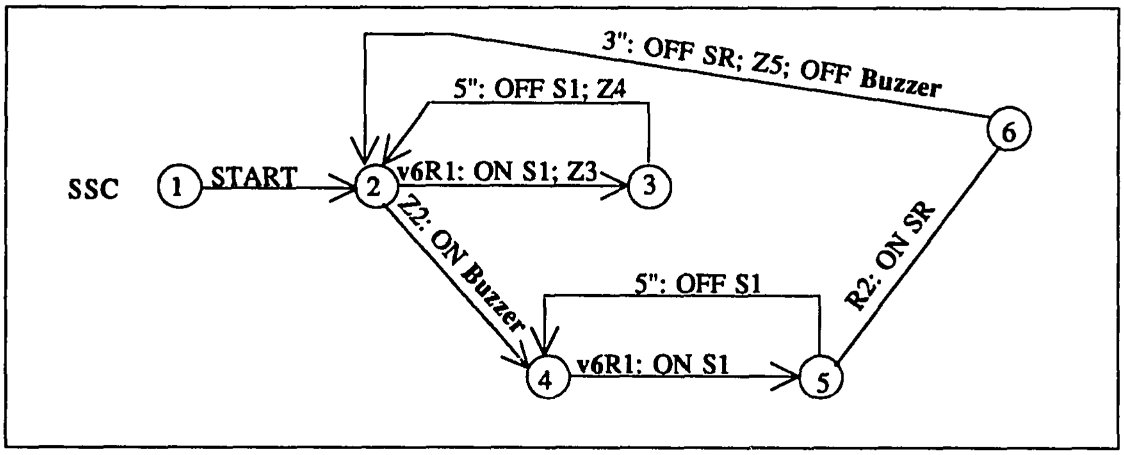


Figure 2. State Set C of the Present Procedure.

The two other subjects (subjects 3 and 4—Group 2) were exposed to the reverse of the conditions described above. When the buzzer was off, a treadle press on the VR 6 schedule changed the treadle light from white to red for 5-s, and a response on the key while the treadle light was red resulted in 3-s access to grain. However, when the buzzer was on, a treadle press under VR 6 changed the treadle light from white to red for 5-s, but a key response while the treadle light was red did not result in 3-s access to grain, and after 5-s the treadle light changed back to white. Further treadle-pressing could make the treadle light red again, and so on, until the VT timer timed out. Again, the key pecks while the treadle light was white had no effect. For these two subjects (#3 and #4), offset of the buzzer was the supposed conditioned establishing operation (CEO).

Phase 2: Omitting the Conditioned Reinforcer

The purpose of this phase was to see the extent to which eliminating the treadle light change from the chain would disrupt the performance. During this condition, response on the treadle under the VR 6 schedule did not produce a change in the treadle light from white to red, but otherwise, the same contingencies were in place. A key peck within 5-s after the treadle press ratio had been completed in the presence of CEO stimulus resulted in 3-s access to grain. For all subjects, this process was in place until the subjects exhibited a stable performance.

Phase 3: Return to the CEO Condition

This phase consisted of a return to the Phase 1, in order to see if there would be any further changes in performance, and to see if any of the birds whose performance had deteriorated during Phase 2 would recover when the Phase 1 contingencies were reintroduced.

CHAPTER III

RESULTS

A good performance during Phase 1 would consist of rapid responding on the treadle as soon as the CEO condition occurred, but little or no responding on the treadle in the nonCEO condition. The variable ratio contingency on the treadle made it possible to use response rate in the CEO and in the nonCEO as a dependent variable, although percent of trials with the first treadle response in the CEO condition was also available for comparison with the other studies. The experiment had the same three phases as the Alling (1990) study, a CEO phase, elimination of the treadle light change, and return to the CEO condition. There were four birds in the study. Figure 3 shows response rate data and 4 shows percent trials with no error, along with number of reinforcements per session, for Bird 1. Figures 5 and 6 show the same data for Bird 2, and so on. These eight figures, Figures 3–10, are shown on the next pages.

Looking at response rate in the two conditions, two of the four birds (1 and 3) had performances that were somewhat as expected (see Figure 3 and 7). They developed clearly different response rates in the two conditions (CEO and nonCEO) with 24 or more responses per minute in the CEO, but only around four responses per minute in the nonCEO condition, and they reached this level of differential responding in less than 20 sessions. The rate in the nonCEO condition was clearly below that in the CEO condition by as early as the 8th session. In Phase 2, performance in the CEO condition clearly deteriorated. The rate for Bird 1 dropped to about half of what it had been in Phase 1, and for Bird 3 it dropped to the low level of responding that had

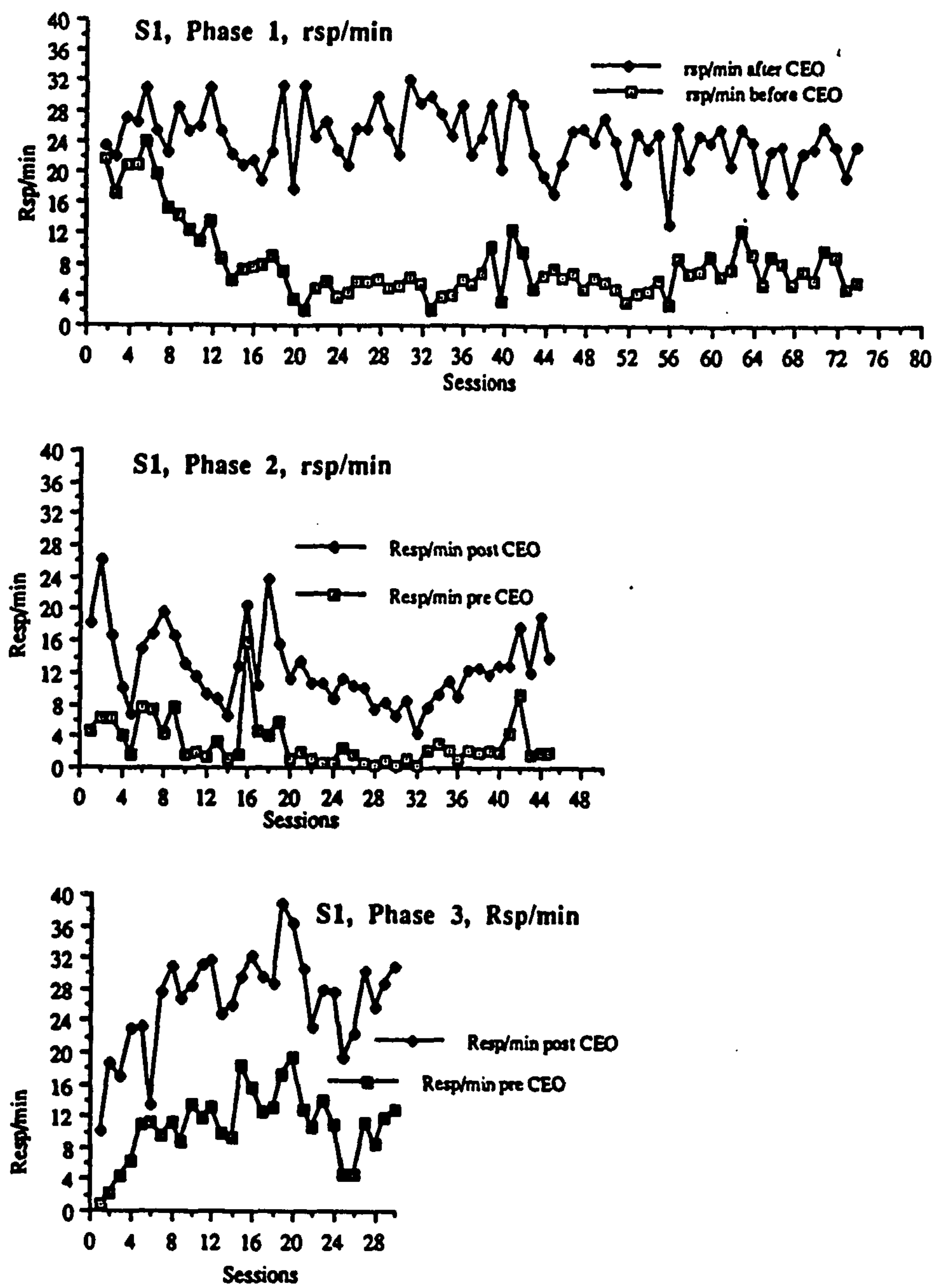


Figure 3. Treadle Pressing Rate During Phases 1, 2, and 3 for Subject 1.

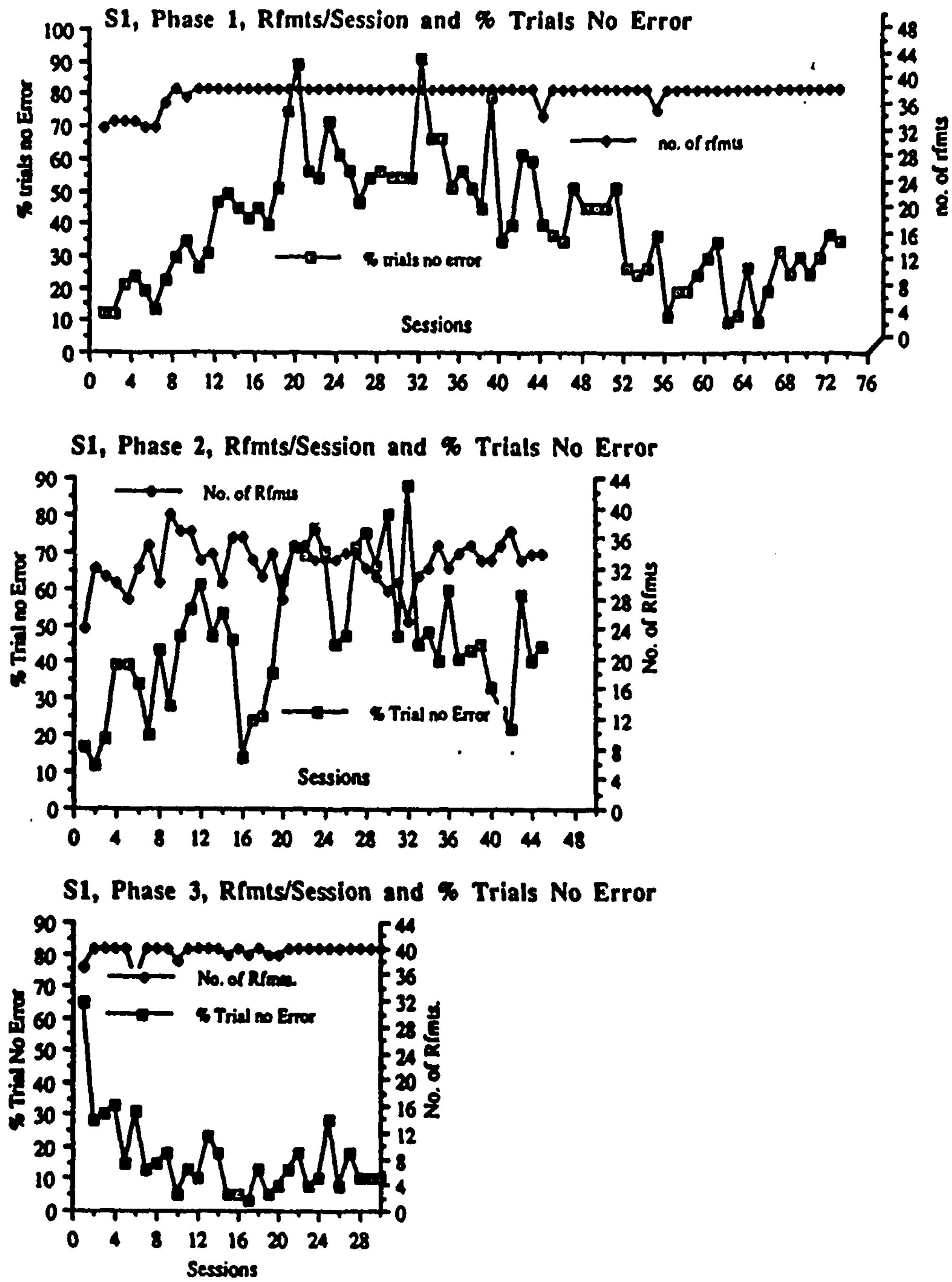


Figure 4. Percent Trials With No Error and Number of Reinforcements During Phases 1, 2, and 3 for Subject 1.

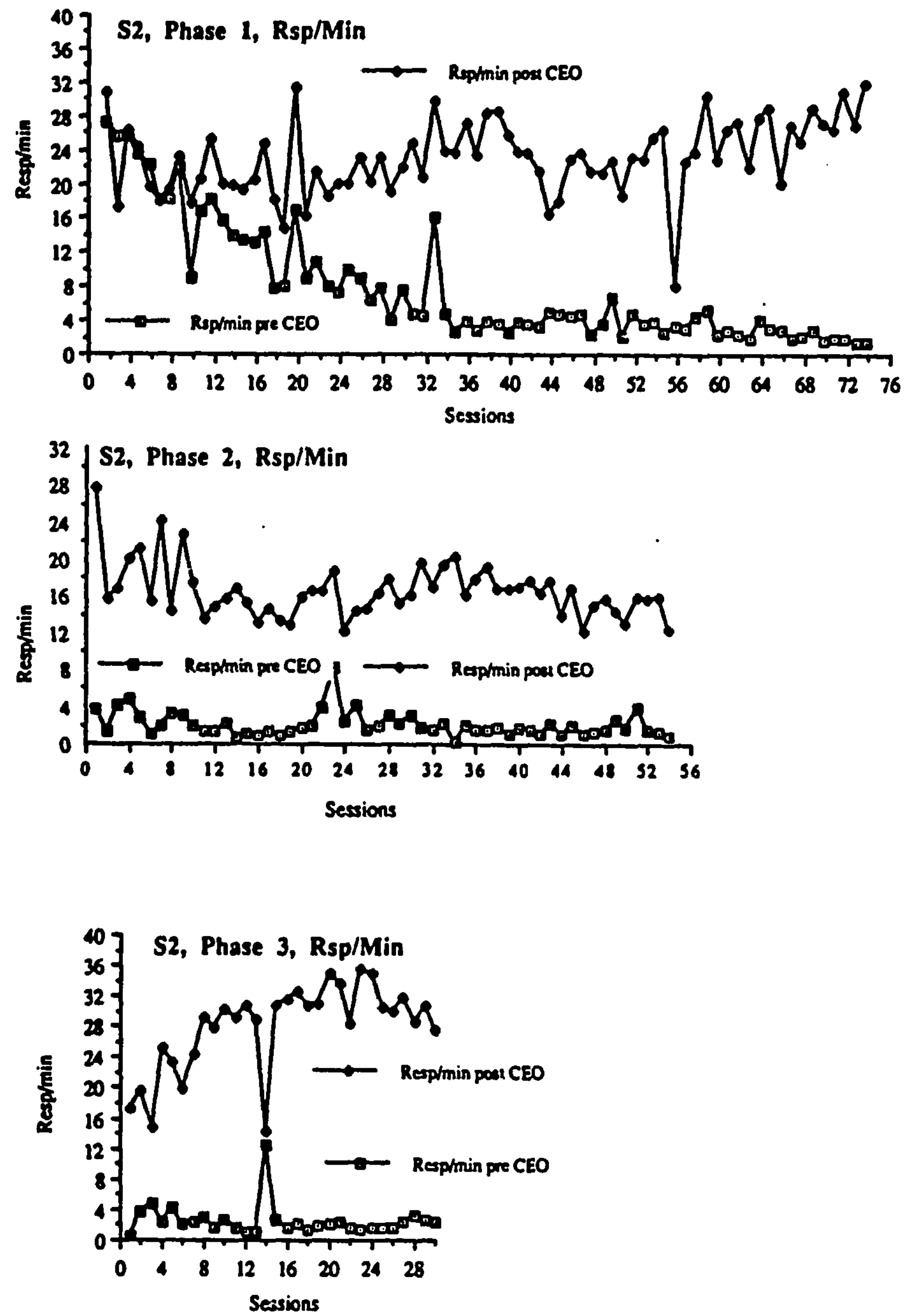


Figure 5. Treadle Pressing Rate During Phases 1, 2, and 3 for Subject 2.

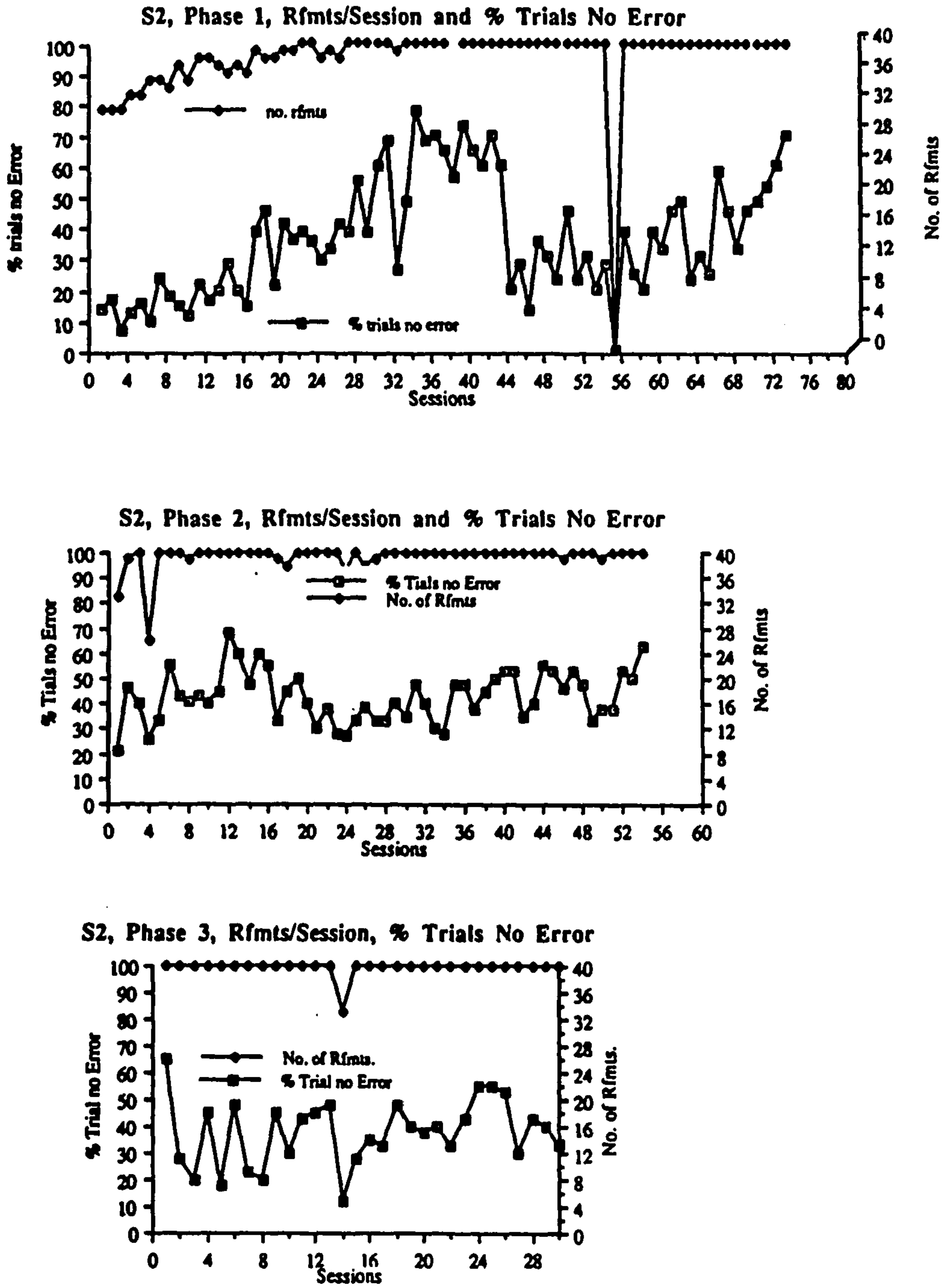


Figure 6. Percent Trials With No Error and Number of Reinforcements During Phases 1, 2, and 3 for Subject 2.

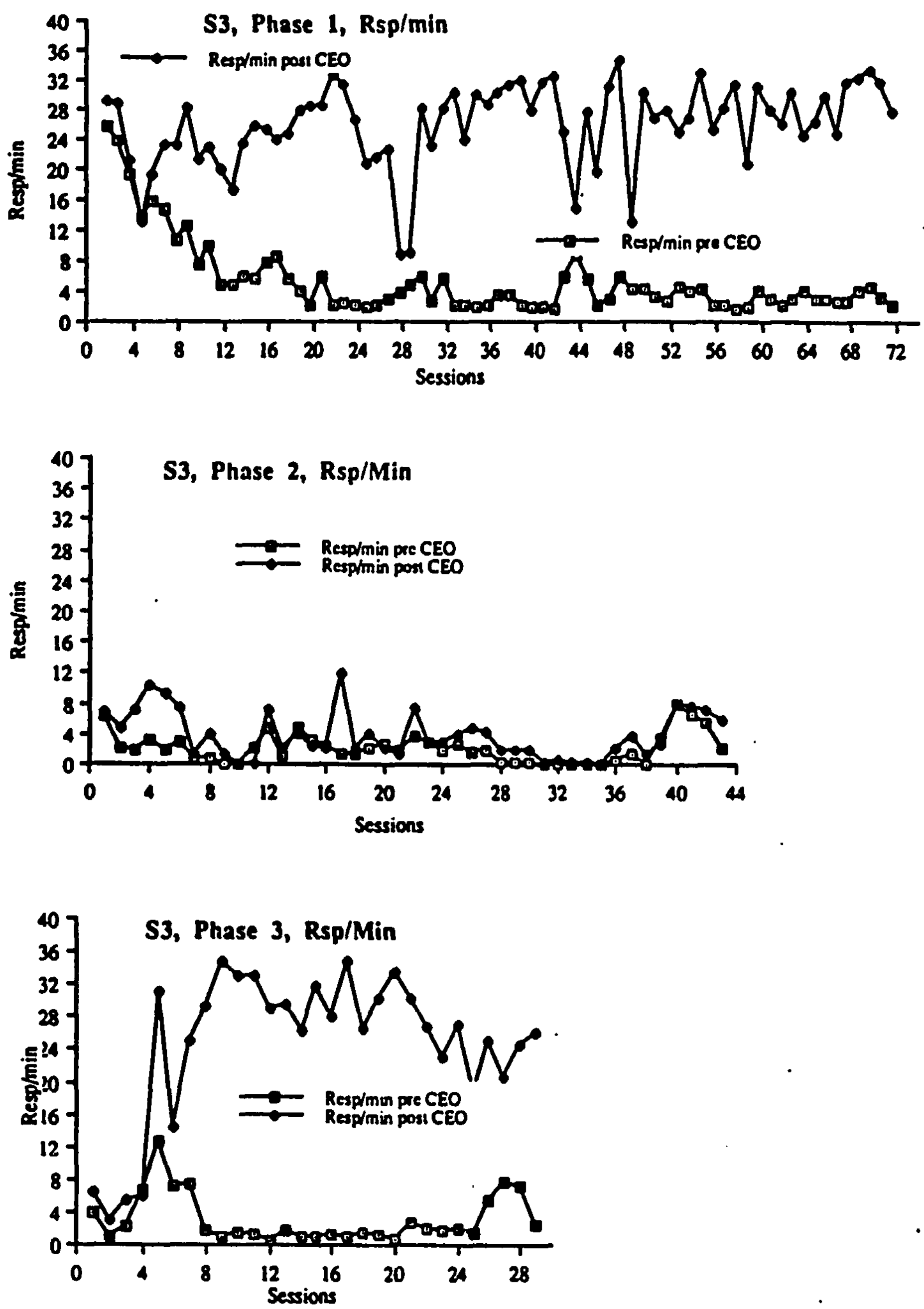


Figure 7. Treadle Pressing Rate During Phases 1, 2, and 3 for Subject 3.

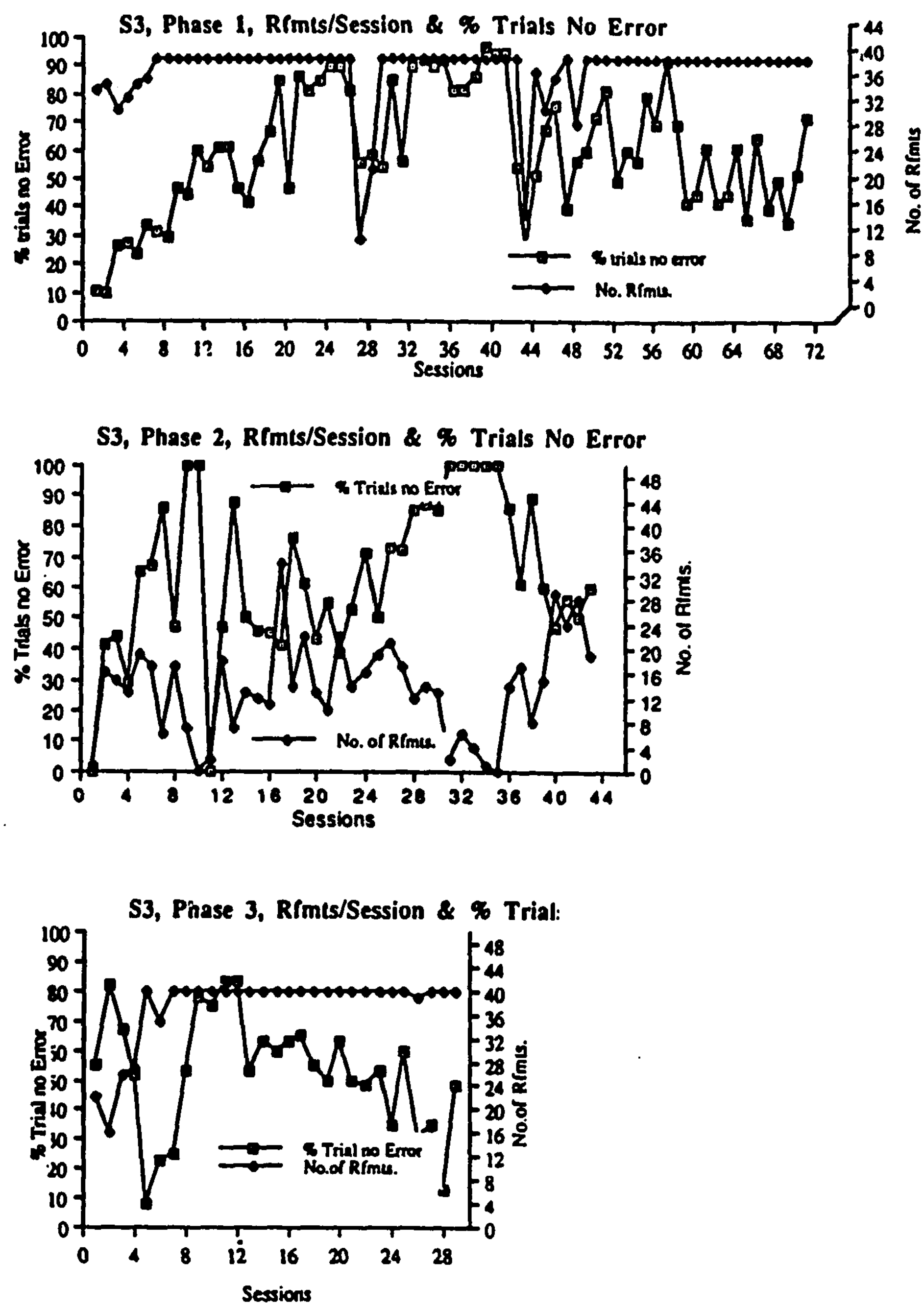
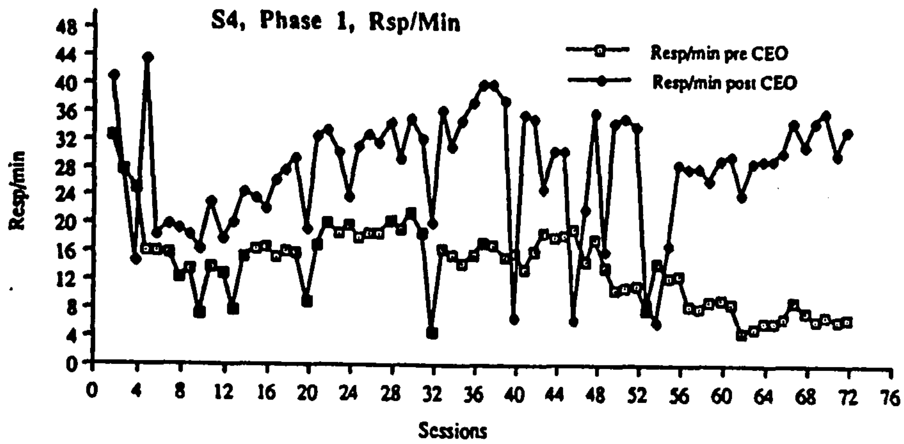
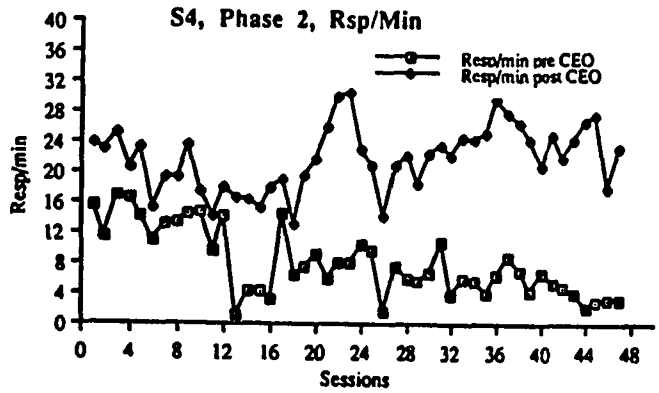


Figure 8. Percent Trials With No Error and Number of Reinforcements During Phases 1, 2, and 3 for Subject 3.





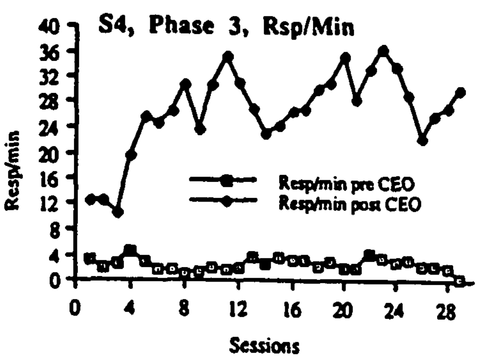


Figure 9. Treadle Pressing Rate During Phases 1, 2, and 3 for Subject 4.

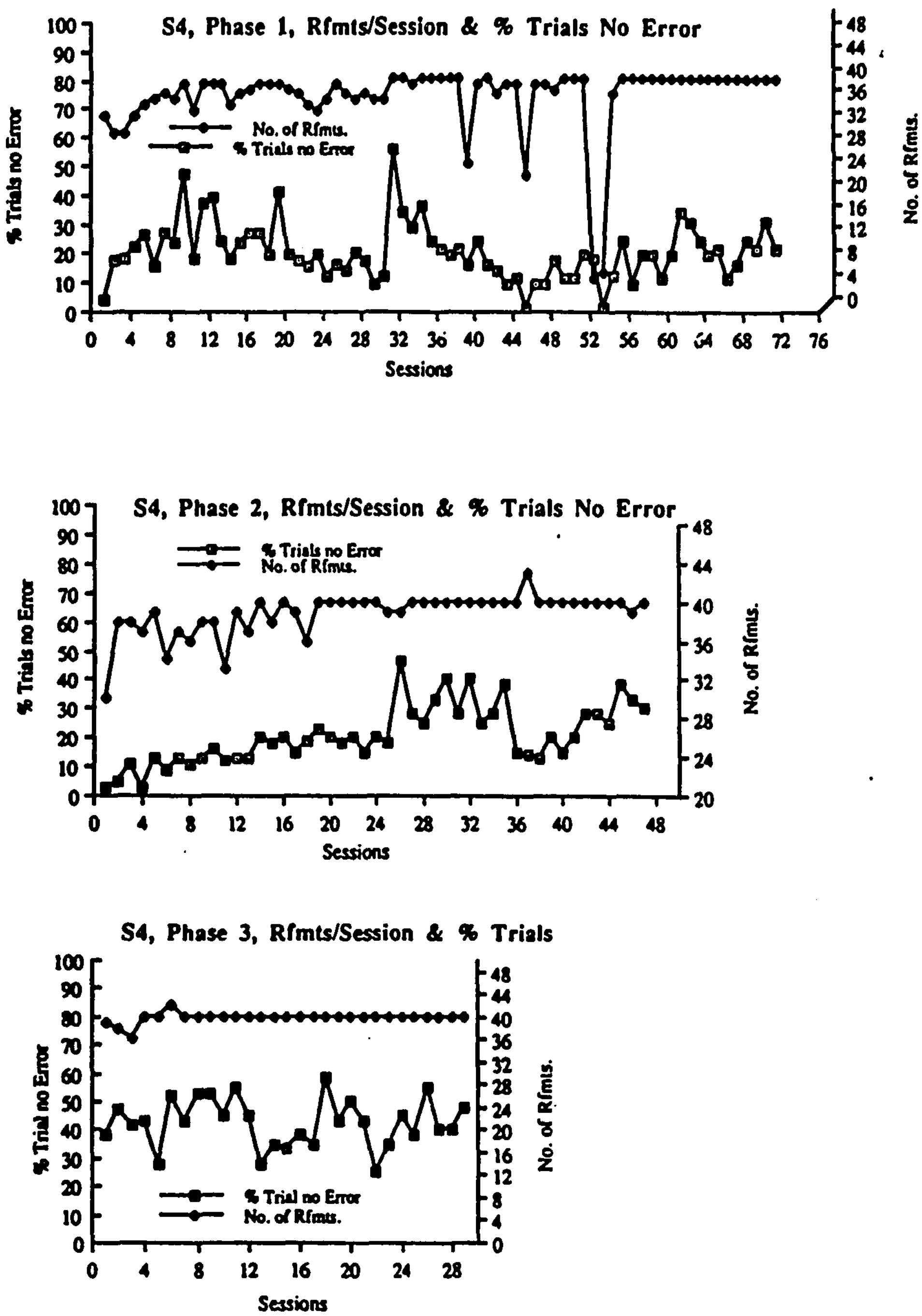


Figure 10. Percent Trials With No Error and Number of Reinforcements During Phases 1, 2, and 3 for Subject 4.

prevailed in the nonCEO condition. Both birds showed clear recovery of their CEO performances by the 8th session in Phase 3 when the conditions of Phase 1 were restored.

Control by the CEO was not nearly as clear when percent trials with no error is used as the dependent variable (see Figures 4 and 8). Bird 1 never showed much better than 50% trials with no error, and in Phase 3 this value dropped to below 20%, even though the response rate data showed clearly different performances in the two conditions. Bird 3 had a better performance in Phase 1 (but not as good as the birds in the Alling 1990 study), it dropped appropriately in Phase 2, and recovered somewhat in Phase 3, but dropped below 30% near the end of this phase.

Response-per-minute data for Bird 2 (see Figure 5), aside from a much slower development of a good separation between CEO and nonCEO rates in Phase 1, was as expected, with some deterioration in Phase 2, and good recovery in Phase 3. Percent trials with no error (see Figure 6) was never much above 40, and didn't change much over the three phases. Rate differences in the CEO and nonCEO conditions for Bird 4 (see Figure 9) were not as good as with the other three birds in Phase 1, largely because rates in the nonCEO condition remained around 18 until around the 60th session when they dropped to around 6. Percent trials with no error only rarely exceeded 20 in Phase 1 and in Phase 2, but stabilized around 40 in Phase 3.

CHAPTER IV

DISCUSSION

Response Rate Data

The clear separation in rate between what were referred to as the CEO and the nonCEO conditions certainly implies control by the relevent stimulus (buzzer), but that this was CEO control is not clear. Bird 3 showed the kind of disruption, a drastic reduction in responding in the CEO condition, that would be expected if the treadle-light change was in fact the main reinforcement for the treadle responding. Bird 1 showed some disruption, Bird 2 showed hardly any, and Bird 4 showed only a temporary disruption and it consisted of an increase in nonCEO rate as well as a decrease in CEO rate.

A problem with the procedure that was only appreciated after most of the data had been collected may have been responsible for the unexpected results of the Phase 2 manipulation. I noticed during Phase 1 that all of the birds had some tendency to switch to the key before completing the VR 6 ratio on the treadle, and then return to the treadle when the key response was not reinforced. It is my recollection that some birds did this more than others, but I did not realize its significance, and collected no systematic data on this pattern of responding. If such a pattern of responding were quite strong, it could have interfered with control by the treadle-light change, and when the treadle-light change was no longer provided in Phase 2 such a pattern of switching from treadle to key and back would result in a moderate to high rate of continued food reinforcement. There is some reason to believe that is exactly what was happening for

Birds 2 and 4, since they continued to received all available food reinforcements during Phase 2 of the experiment (see Figures 6 and 10). From Figure 4 it appears that Bird 1 also had such a pattern, since it only lost a few reinforcers per session in Phase 2.

Another problem with the procedure, again only realized when the research was completed, concerned a possible confound of the food reinforcement stimuli with the stimulus control supposedly due to the CEO stimulus. Rate of responding in the nonCEO condition was, I now believe, erroneously taken during the entire period in this condition. However, only the responding prior to the first unreinforced key peck can be attributed solely to the nonCEO stimulus. Once a treadle light change had been followed by a nonreinforced key peck, no further food reinforcement was ever received until the CEO stimulus occurred. It is thus possible that the birds' lower rates in the nonCEO condition were not as much due to control by the buzzer (or absence of the buzzer) as by the production of a treadle light change followed by an unreinforced key peck.

Percent Trials With no Errors

As compared with the data obtained by Alling (1990), this dependent variable was not very sensitive to the Phase 1 training conditions of the present experiment. It is possible (as mentioned earlier) that in the Alling (1990) experiment, the house light's causing the treadle-light change to look different in the CEO and nonCEO condition contributed to the high percent-trials-with-no-error data that he obtained. It is also possible that these relatively poor percent-trials-with-no-error data are at least in part due to the use of the auditory CEO, because as a sense mode it may not be as effective with pigeons as the visual sense mode. It is also possible that the variable ratio on the treadle resulted in an increased general tendency to press the treadle, which was manifested in the nonCEO condition as well as in the CEO condition.

Although useful for comparison with earlier studies, percent trials with no errors would not seem to be a very sensitive dependent variable. A single treadle response in the nonCEO condition constitutes an error, but such a response could occur even when the overall tendency to behave in the two conditions was drastically different. In ordinary S^D–S^Δ training a good discrimination is often considered demonstrated when the S^Δ rate is 10% of the S^D rate, which clearly does not imply zero S^Δ responding. It would be especially likely for an occasional treadle press to occur during the longer intervals of the VT schedule for the change from the nonCEO to the CEO condition.

In summary, the experiment does not supply an unambiguous demonstration of Michael's transitive CEO in the pigeon subjects.

Recommendations for Future Research

Although there must be many other ways of studying the transitive CEO, it is possible on the basis of the present study to suggest four simple changes that will correct what seemed to be its main problems.

1. The choice of the treadle response as the one to be followed by conditioned reinforcement, with the key peck reinforced by food, simply followed the Alling (1990) procedure. It would be more reasonable to reinforce the treadle press with food, since treadle pressing is a more difficult and "unnatural" response for the pigeon. This means that a variable ratio of key responses would produce the stimulus change that functions as conditioned reinforcement in the CEO condition.

2. A steady auditory stimulus (or its absence) would not seem optimally effective as the condition upon which the conditioned reinforcing effectiveness of another stimulus depends because of the tendency to "stop noticing" such a stimulus after it has been on for a while. Key color is, in a sense, being repeatedly contacted in

the process of pecking the key, and may be more difficult to ignore. The onset of an auditory stimulus, on the other hand, is often appropriate for some particular behavior at the moment of the onset. It would thus be an improvement to reverse the role of the visual and the auditory stimuli, as follows: A variable ratio of key responses will produce the onset of the buzzer, which will last for 5 s, and the CEO condition will be correlated with the color or some other visual characteristic of the key.

3. Treadle responses occurring prior to the completion of the key ratio requirement must be monitored, and such responses must reset that ratio requirement. This should decrease any tendency to switch to the treadle, the food reinforced operandum, prior to completing the ratio and turning on the buzzer. If such responding continues in spite of the reset contingency, then some other means of eliminating such responses, such as a brief time out, should be instituted before proceeding to Phase 2.

4. The response rate on the key during the nonCEO condition must be collected in such a way that rate can be separately determined before and after the first production of the conditioned reinforcer. This would make it possible to measure response rate in the relevant key color without the possible confound with an unreinforced treadle press as a stimulus condition correlated with no further reinforcement. (A state diagram of the improved procedure is shown as Appendix B.)

The changes suggested above should make it possible to demonstrate the transitive CEO, or to determine whether or not such stimulus control is possible in the pigeon. If the demonstration is successful, this design could then be used to investigate various temporal parameters affecting this type of control, the role of CEO and of conditioned reinforcer stimulus modality, intensity, etc., the effect of UEO strength and other variables known to be relevant to other forms of stimulus control.

Appendix A

Research Protocol Approval

Date of Receipt 7/25/91
Date of Approval 8/20/91
Date of Third Year Review 8/94
Approved IACUC Number 91-07-03

WESTERN MICHIGAN UNIVERSITY INSTITUTIONAL ANIMAL CARE AND USE COMMITTEE

Application to Use Vertebrate Animals for Research or Teaching

IACUC Review for (check one):

A. [ ] New sponsored grant/contract proposal
B. [ ] Continuation grant/contract proposal (present IACUC Number ________)
C. [X] Department funded or unfunded research
D. [ ] Teaching or demonstration exercise
E. [ ] Revision of ongoing animal research protocol (present IACUC Number ________)

Title of Project: A Two-component Chain Performance with Variable-Ratio Schedule of Reinforcement for one component under Conditioned Establishing Operation Control.

Principal Investigator: Rachel Nunes da Cunha

Mailing Address: Department of Psychology - Wood Hall - WMU 49008

Phone: Lab.:387-4490 Home:387-4095

Potential grantor/contractor: ________

Please answer the following applicable requests (please type):

1. Animal use information (fill in the appropriate spaces in this table).

Procedure Category*	Species	Age	Number Male	Number Female
A	White Carneaux	1 year		4
B				
C				

*Defined on pages 1 and 2 in *General Information and Instructions.*

2. **Provide an *abstract* or summarize the aims and objectives of this animal research, testing, or instructional project. (Use non-technical language that a layperson can understand.)**

The birds will be an experimental chamber with a treadle to press with their foot and a disk ~~no~~ the wall to peck. A variable number of treadle presses with an average of 6 will cause the light over the treadle to change from white to red. If a buzzer is on, then when the treadle light is red a peck on the disk will cause a food tray to be raised so that the bird can eat for about 3 seconds. If the buzzer is not on, then although the treadle press turns on the red light, pecking the disk does not produce food. Under these conditions the red light should become effective as a form of reinforcement, but only whe: the buzzer is on. Treadle pressing should occur at a high rate in the presence of the buzzer sound, and should become infrequent in the absence of the buzzer sound. After a stable performance of this sort, when the treadle press no longer causes the red light to come on the treadle press-disk peck chain of responses in the presence of the buzzer sound should deteriorate.

3. **Judicious use of animals. (Explain in language that a layperson can understand and cite reference sources.)**

   a) **What are the probable benefits of this work to human or animal health, the advancement of knowledge, or the good of society?**

The buzzer sound in this situation causes the red treadle light to become valuable to the birds, and this sense functions as a motivational var·able. This type c· learned motivation is just beginning to be studied with nor ·ans. This stud· ·l contribute to a body of experimental results related to thi· ·ype of motivati· variable. It is a continuation of the line of investigation exemplified below

Michael, J. (1982). Distinguishing between discriminative and motivational functinons of stimuli. Journal of the Experimental Analysis of Behavior, 37, 149-155.

McPherson,A. & Osborne, J.G. (1986). The Emergence of Establishing Stimulus Control. Psychological Record, 36, 375-386.

McPherson, A. & Osborne, J.G. (1988). Control of Behavior by an Establishing Stimulus. Jpurnal of the Experimental Analysi of Behavior, 37, 149-155

b) **Explain why computer simulation or *in vitro* biological systems or audiovisual demonstration are not acceptable alternatives to the use of animals in this project.**

Computer simulation or "in vitro" biological systems or audiovisual demonstration can not answer this question.

c) **Justify use of the animal species listed in Item #1. Describe the biological characteristics of the animal that are essential to the proposed study. Include evidence of experience with the proposed animal model and manipulation.**

The basic research in the experimental analysis of behavior ~~have~~ has been done with pigeons, so it will possible to compare this data with previous foundings. The key peck and the treadle pressing responses will be measured as a dependent variables. They are sensitive to the contingencies of reinforcement.

d) **Justify use of the *number* of animals listed in Item #1. Specifically address why fewer animals cannot be used?**

From what is known about individual differences between different birds' performanc on this type of task, four subjects is the minimum required for reliable results.

4. **Describe any form of required (a) prolonged animal restraint, (b) painful or aversive stimulation.**

Neither, (a) prolonged animal restraint, nor (b) painful or aversive stimulation will be required in the present investigation.

5. Where applicable to counteract pain, discomfort or distress give name of drugs, approximate dosage and route of administration. (Procedures such as injection, tattooing and blood sampling normally do not require pain relieving drugs.)

In this experiment, it will not used drugs to conteract pain, discomfort or distress.

6. If pain is likely to occur and pain relieving drugs will not be used, give specific details as to why and cite reference sources. (Use continuation sheets if necessary.)

The subjects will be not in pain in this present study.

7. Describe any surgical procedures.

Surgical procedures will not be applied in this study.

8. How will animals be euthanized?

The subjects will be not euthanized. They will be used in the further reseaches.

9. **Describe special handling and care such as diet, litter, lighting or post-operative care that will be required from the animal facility:**

The subjects will be maintained individually housed with unlimited access to fresh wat and health grit, and at 80% of their free-feeding weight. They will be get food daily the experimental sessions and if necessary they will feed after sessions. The pigeon colony is at Wood Hall, room #383.

10. **Identify any biohazardous materials such as radioisotopes, pathogens, toxins and carcinogens. What arrangements have been made to house the animals and to protect personnel?**

Any kind of biohazardous materials will not be required in the present investigation.

11. **If the study involves survival surgery, specify the surgical suite location; what are the post-operative care needs and who will provide the care?**

Survival surgery will not be necessary in the present experiment.

12. **If the studies are performed outside a designated Western Michigan University animal facility, specify building and room number. These locations are subject to IACUC compliance inspections.**

The whole experiment will run at the Laboratory of the Experimental Analysis of Behavic at Wood Hall, room #289. The subjects will be maintained in the pigeon colony at Wood Hall, room #383.

INVESTIGATOR C⁻RTIFICATION

Title of Project: A Two-Cc ponent Chain Performance ith Variable-Rat. Schedule of Reinforceme: for one Component under Conditioned Establishing Operation Control.

If any of the above procedures are changed, I will submit a new protocol.

I understand that any failure to comply with the *Animal Welfare Act*, the provisions of the *DPHS Guide for the Care and Use of Laboratory Animals* and requirements set down by the IACUC may result in the suspension of my animal studies.

Rachelle Cuneo (Jack Michael, Lab Director) | Psychology | 7/18/91

Signature: Principal Investigator | ***Department*** | ***Date***

REVIEW BY THE INSTITUTIONAL ANIMAL CARE AND USE COMMITTEE

____ Disapproved ____ Approved ____ Approved with the provisions listed below

Provisions
or
Explanation: ____________________

Leonard Ginsburg | 8-20-91

IACUC Chairperson | ***Date***

Researcher's Acceptance of Provisions:

____________________ __________

Signature: Principal Investigator ***Date***

____________________ __________

IACUC Chairperson Final Approval ***Date***

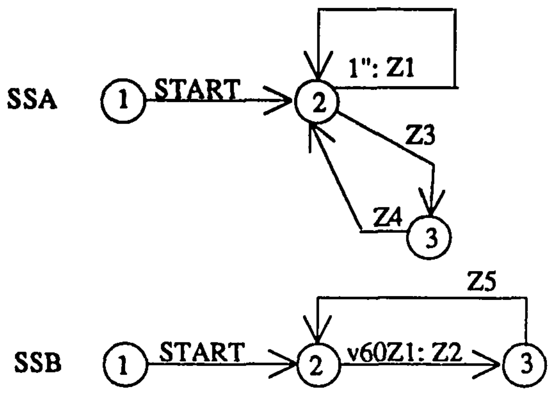
Approved IACUC Number 91-07-03

Revised February 12, 1991

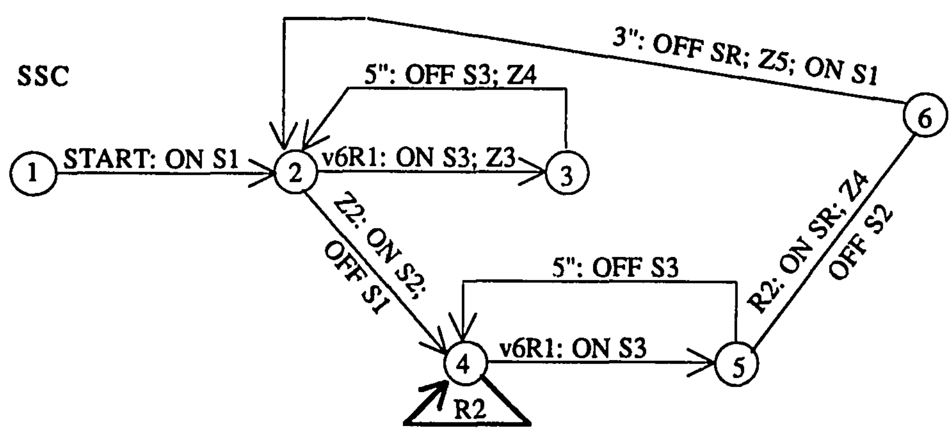
Appendix B

State Diagram of Suggested Experiment

R1 = key peck   S1 = red key light   S2= green key light   S3=buzzer
R2 = treadle press   HL = house light   SR = grain hopper comes up, hopper light on



The procedure starts with the key light red (in SSC). In SSA a 1-sec timer is producing Z1 pulses that are the basis for the VT 1 min production of Z2 in SSB that turns off the red key light and turns on the green key light light in SSC. The production of Z1 pulses is interrupted when the key light changes from red to green in state 2 of SSC so that the key color cannot be changed while it is green until a food reinforced response occurs. The Z2 that is produced on the VT 1' basis in SSB changes the key color from red to green, which begins the CEO condition. With the key light green, on a variable ratio 6 basis, key pecks cause the onset of the buzzer, and if a treadle press occurs (in state 5) before the 5 sec timer turns the buzzer off, the food hopper comes up and the key light goes off. If a treadle press occurs before the v6 ratio is completed the ratio number is reset. The hopper stays up for 3 sec, at the end of which time the red key light comes and the transition to state 2 occurs. If the treadle press doesn't occur during the 5 sec period of buzzer sounding, the buzzer goes off until the next treadle press. The CEO condition doesn't end until reinforcement occurs.



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