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The Effects of a Conditioned Establishing Operation on Performance of a Two-Component Chain

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THE EFFECTS OF A CONDITIONED ESTABLISHING OPERATION ON PERFORMANCE OF A TWO-COMPONENT CHAIN

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Subjects were exposed to a discrete-trial procedure in which reinforcement following the completion of a two-component response chain was dependent upon the presence or absence of the houselight. The procedure used closely resembles the hypothetical procedure suggested by Michael (1982) for developing control by a conditioned establishing operation. All subjects came to respond differentially in the presence and absence of the houselight. However, removal of the supposed conditioned reinforcer following completion of the first component of the response chain had little effect on control by the houselight, casting some doubt on Michael's (1982) theoretical analysis.

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CHAPTER I

INTRODUCTION

Michael (1982) suggested the possibility of behavioral control by an establishing stimulus. He referred to an establishing stimulus as any change in the environment which alters the effectiveness of some object or event as a conditioned reinforcer and simultaneously alters the momentary frequency of behavior that has been followed by that conditioned reinforcer. An establishing stimulus differs from an establishing operation in that an establishing operation alters the reinforcing effectiveness of an unconditioned reinforcer and evokes responses which have in the past been followed by that unconditioned reinforcer.

More recently Michael (1988) has suggested that the term *unconditioned establishing operation* (*UEO*) replace *establishing operation*, and that the term *conditioned establishing operation* (*CEO*) replace *establishing stimulus*. This allows *establishing operation* (*EO*) to be used as a general term referring to both conditioned and unconditioned variables. Michael's more recent terms will be used throughout the remainder of this paper.

Michael (1982) differentiated between control by a CEO and control by a discriminative stimulus. A discriminative stimulus is a stimulus which increases the momentary frequency of a particular response because the response has been followed by reinforcement with greater frequency in its presence than in its absence. A CEO is a stimulus which increases the frequency of a response because the conditioned reinforcer which follows that response is a more effective conditioned reinforcer in its presence than in its absence.

Michael (1982) gave the following example of a procedure which might allow for control by a CEO:

> Consider a food-deprived monkey in a chamber with a chain hanging from the ceiling and a retractable lever. Pulling the chain moves the lever into the chamber. Pressing the lever has no effect unless a light on the wall is on, in which case a lever press dispenses a food pellet. To prevent the chain pull from functioning as a standard preparatory component of the behavioral sequence, we could require that the chain be held in a pulled condition, or we could arrange that each chain pull makes the lever available for only a limited period, say five seconds (p. 153).

Michael (1982) suggested that with training the monkey would come to respond in the following manner: While the wall light is off, the monkey does not pull the chain, even though a chain pull would produce the lever. When the light comes on, the monkey pulls the chain, then presses the lever, and finally eats the food pellet that is delivered. Responding in this manner would be indicative of control by a CEO (i.e., the wall light functions as a CEO which evokes the chain pull response).

McPherson and Osborne (1986, 1988) used a three-key discrete trial procedure in an attempt to experimentally verify the existence of control by a CEO. Under this procedure each trial began with the right key illuminated green. The first peck on the right key resulted in the illumination of the center key (white). Additional pecks on the right key had no effect. The left key was illuminated (red) according to either a variable-time (VT) or random-time (RT) schedule. Following illumination of the left key (red), the first peck to the white key resulted in access to grain. Pecks on the white key prior to the onset of the red keylight had no effect. Access to grain marked the end of a trial, and trials were separated by an intertrial interval (ITI), which varied in length across conditions.

In this procedure, the onset of the white key (center) was presumed to function as conditioned reinforcement for the response on the green key (right). Further, the red keylight was considered a CEO which altered the effectiveness of white key

(center) onset as a conditioned reinforcer. Pecks on the green key only after onset of the red keylight were taken to indicate control by the CEO.

Responding by subjects in this experiment came under control of the purported CEO; however, for all subjects control was incomplete. It is possible that the three-key procedure used by McPherson and Osborne (1986, 1988) resulted in some elicited pecks which confounded control by the CEO. Further, the procedure used by McPherson and Osborne allows for preparatory responses, which Michael (1982) warned against. That is, once the conditioned reinforcer (the white key) was produced (by a response on the right key) it remained until the end of the trial, regardless of whether it was produced in the presence or absence of the purported CEO. This is a problem because if a peck to the right key occurred prior to onset of the left side key (i.e., onset of the purported CEO) a response on the right key would not be required after onset of the left key. Therefore, on trials where a peck on the right key occurred prior to onset of the left key, illumination of the left key (red) would function as an S^D for pecking the center key rather than a CEO for pecking the right key. Consequently, the procedure used by McPherson and Osborne was truly not a CEO procedure.

In the present experiment preparatory responses could not occur. Further, a treadle-press response, rather than a keypeck, was required to complete the first component of the chain, in an effort to decrease the likelihood of elicited responding (i.e., control for autoshaping). The initial procedure involved a two-response chain in which a treadle press resulted in a light above the treadle (i.e., treadle light) changing from white to red for 5 sec. The occurrence of a key peck while the treadle light was red resulted in a 3 sec presentation of the grain hopper, dependent on the condition of the house light. For two subjects (#7172 and #6840) a key peck while the treadle light was red resulted in hopper presentation only in the presence of the

houselight. For the other subject (#1403) a key peck while the treadle light was red resulted in the hopper presentation only in the absence of the houselight.

This procedure provided clear and consistent results. The purported CEO came to control responding on at least 95% of the trials for all three subjects. Therefore, it appeared that the houselight was altering the conditioned reinforcing effectiveness of the treadle light and evoking a treadle press (i.e., the houselight was functioning like a CEO). However, it might be argued that the subjects were emitting a chain of responses which was maintained solely by the unconditioned reinforcer at the completion of the chain, and that the houselight was functioning as a discriminative stimulus (S^D) for the entire two-response chain. Said another way, the control by the houselight may not have been due to its altering the reinforcing effectiveness of the treadle light changing from white to red, but due to its functioning as an S^D for performing a two-response chain.

Phase II of this study was performed in an attempt to determine if the red light was important in maintaining the treadle press or if the 3-sec hopper presentation was maintaining the entire chain. In Phase II the procedure used was the same as in Phase I except that a treadle press no longer produce a stimulus change.

In Phase III the conditions present in Phase I were reinstated (i.e., a treadle press once again resulted in the treadle light changing from white to red) in order to see if there was any lingering performance deterioration as a result of removing the conditioned reinforcer from the chain in Phase II.

CHAPTER II

THE EXPERIMENT

The main purpose of the present study was to demonstrate greater control by a CEO than was shown in the McPherson and Osborne (1986, 1988) studies by eliminating both the effects of autoshaping and the possibility of preparatory responses. In a subsequent investigation, the conditioned reinforcer was removed in an attempt to analyze further its function in the CEO procedure.

Method

Subjects

Three experimentally naive White Carneau pigeons served as subjects in this experiment. They were maintained at 80% of their free-feeding weights, and were individually housed with unlimited access to water and grit. Subjects were run, on average, six days a week at the same time each day.

Apparatus

Experimental sessions were conducted in operant chambers measuring 40 cm high, 40 cm wide, and 40 cm long. A 5 x 6 cm aperture centered on the front wall 7 cm from the floor permitted access to a food hopper. When raised, the hopper was illuminated with a 7.5-W light bulb. Two response keys were centered 9 cm above this aperture 7.5 cm apart. The left key was illuminated red during experimental sessions and could be operated by a force of 0.2 N or greater. The right key was not

used and remained dark throughout this experiment. An aluminum foot treadle approximately 8 cm long and 2 cm wide was mounted on the response panel 6 cm from the right side wall. The treadle was sloped 30 degrees from the vertical with the front edge of the treadle 2 cm above the chamber floor. When a force of 1 N or greater with an excursion of 2 mm was applied to the treadle, a microswitch was operated. A 1.5 x 1.5 cm plexiglas window was located above the treadle, 15 cm from the chamber floor and 4 cm from the right side wall. Red and white light bulbs (7.5-W) mounted behind the window served as stimulus lights. General illumination of the chambers was supplied by a 7.5-W houselight centrally located on the ceiling of each chamber. Masking noise was provided by a white noise generator (Grason-Stadler, Inc.). Ventilation was provided by exhaust fans mounted on each experimental chamber. All stimulus conditions and data collection were arranged by a PDP8-E minicomputer (Digital Equipment Corporation, Maynard, MA) equipped with SuperSKED© software (State Systems, Inc., Kalamazoo, MI) and electromechanical interfacing.

Procedure

Subjects were initially trained to eat from the food hopper. Following hopper training, they were shaped to peck the left key. During key peck training the houselight was on, the treadle light was illuminated red, and the left key was illuminated red. When a key peck occurred on the left key the hopper was raised for 3 sec. Once the subjects were reliably responding on the left key under a continuous reinforcement schedule the subjects were shaped to press the treadle. During treadle-press training, the house light was illuminated, the left key remained illuminated red, and the treadle light was illuminated white. When a treadle press occurred, the treadle light changed from white to red and the hopper was raised for 3 seconds. The treadle

light returned to white following the 3 sec access to grain. Key pecks had no effect during treadle-press training.

Once the subjects reliably responded on the treadle, they were trained to complete a two-component response chain involving a treadle press as the first component and a peck on the left key as the second (and final) component. Under these conditions, the house light was illuminated, the left key was illuminated red, and the treadle light was illuminated white. A treadle press resulted in the treadle light changing from white to red, and then a peck on the left key resulted in the hopper coming up for 3 sec. While the hopper was up, all stimulus lights were extinguished except the hopper light. Immediately following 3 sec access to grain, the treadle light was illuminated white once again. A key peck when the treadle light was white had no effect. Responding on the treadle when the treadle light was red also had no effect.

When subjects reliably performed this two-component chain, the duration of the treadle light remaining red following a treadle press was set at 5 sec. Under this condition, a trial began with the house light being turned on, the left key being illuminated red, and the treadle light being illuminated white. A treadle press would result in the treadle light changing from white to red for 5 sec. If a key peck did not occur while the treadle light was red, the treadle light returned to white after the 5 sec elapsed. If, however, a response was made on the left key while the treadle light was red, the hopper was raised for 3 sec access to grain. While the hopper was up all stimulus lights were extinguished except the hopper light. Following the 3 sec access to grain, a new trial began. Key pecks while the treadle light was white had no effect, and responses on the treadle while the treadle light was red had no effect. Sessions lasted 50 min or until the subject earned 40 reinforcers, whichever came first.

Phase I

When the subjects completed 10 sessions performing this response chain, the conditioned establishing operation (CEO) procedure was begun. During the CEO procedure the previous stimulus conditions and response contingencies remained in effect, except that the houselight came on and went off on a variable-time basis with an average interval of 1 min (i.e., under a VT 1 min schedule) and completion of the response chain did not always produce access to grain. For two of the three subjects (#7172 and #6840), when the house light was on, a response on the treadle changed the treadle light from white to red for 5 sec, and a key peck while the treadle light was red resulted in 3 sec access to grain. When the houselight was off, however, a response on the treadle changed the treadle light from white to red for 5 sec, but a key peck while the treadle light was red did not result in access to grain (key pecks while the treadle light was white never had an effect). Onset of the house light was the supposed CEO for these two subjects.

For the other subject (#1403) the situation described above was reversed. When the houselight was off a treadle press functioned to change the treadle light from white to red for 5 sec, and a response on the left key while the treadle light was red resulted in 3-sec access to grain. When the houselight was on, however, a response on the treadle changed the treadle light from white to red for 5 sec, but a key peck while the treadle light was red did not result in access to grain (again, key pecks while the treadle light was white never had an effect). For this subject, offset of the house light was the supposed CEO. In general, control by the CEO is shown by treadle pressing occurring only after presentation of the supposed CEO, even though the treadle press produces the treadle light change in the absence of the CEO.

For all subjects this phase lasted a minimum of 95 sessions, and until data from the last 5 sessions were stable. Throughout the experiment the dependent variable was the percent of trials during a session where a treadle press occurred only after presentation of the supposed CEO. Stability required that there be no more than 10% variability in this datum over 5 successive sessions.

Phase II

In Phase II, the procedure described for Phase I was used with one modification. Responses on the treadle no longer changed the treadle light from white to red. The same contingencies were in place otherwise. A key peck within 5 sec after a treadle press in the presence of the CEO resulted in 3-sec access to grain. For all subjects, this phase lasted a minimum of 55 sessions with data from the last 5 sessions being stable. Of interest was whether the subjects would respond on the treadle prior to or after CEO onset.

Phase III

Phase III consisted of a return to Phase I conditions. One purpose of this phase was to reduce the possibility that any changes in behavior following implementation of Phase II occurred due to a change in some variable not specifically manipulated in this experiment (i.e., confounding variable). A second purpose of this phase was to assess any lingering effects of removing the red treadle light in Phase II. For all subjects, this phase lasted a minimum of 25 sessions with data from the last 5 sessions being stable. Again, of interest was whether the subjects would respond on the treadle prior to or after CEO onset.

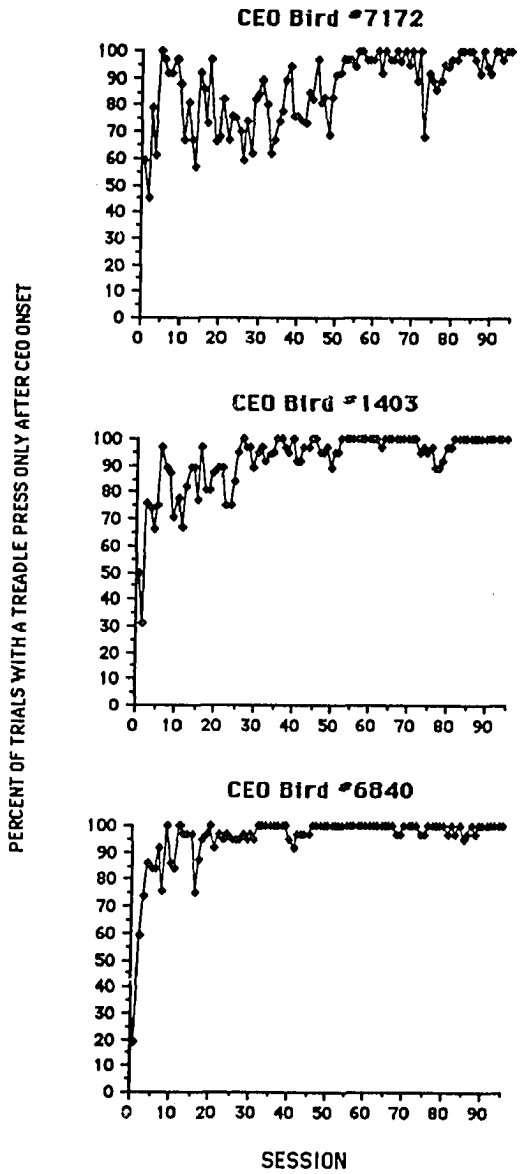

Figure 1. Acquisition of Control by the Purported CEO During Phase I.

Percent of trials per session on which a treadle press occurred only after onset of the supposed CEO are represented. Data from Phase I are depicted for all subjects.

Results

All subjects learned to eat from the hopper, peck the left key, press the treadle, and perform the two-response chain (involving the treadle press and key peck) within two weeks. Figure 1 depicts the acquisition of control by the putative CEO during Phase I for each subject. The percentage of trials per session in which subjects pressed the treadle only after presentation of the CEO are shown. All subjects came to respond on the treadle only after presentation of the CEO on at least 97% of the trials prior to the conclusion of the first phase.

Figure 2 depicts control by the putative CEO during the last five days of each phase of this experiment for each subject. The percentage of trials per session on which subjects pressed the treadle only after presentation of the purported CEO are shown. As can be seen by examining this figure, manipulation of the putative conditioned reinforcer (Phase II) had a little if any effect on the control of responding by the supposed CEO. In fact, removing the conditioned reinforcer from the response chain had a systematic effect on the performance of Subject 1403 only. The reason Subject 1403 differs from the other two subjects in this regard is unclear. However, as noted earlier, Subject 1403 was the only subject for which houselight offset (rather than houselight onset) functioned as the supposed CEO. During Phase I, the mean percent of trials with responses on the treadle only after presentation of the CEO were 99.5%, 100%, and 100% for Subjects 7172, 1403, and 6840 respectively. During Phase II, the mean percent of trials with responses on the treadle only after presentation of the CEO were 95.5%, 76.5%, and 99.4% for Subjects 7172, 1403, and 6840 respectively. During Phase III, the mean percent of trials with responses on the treadle only after presentation of the CEO were 95.1%, 95.7%, and 100% for Subjects 7172, 1403, and 6840 respectively. Subjects' performance throughout Phases II and III closely resembled performance during the last 5 days in

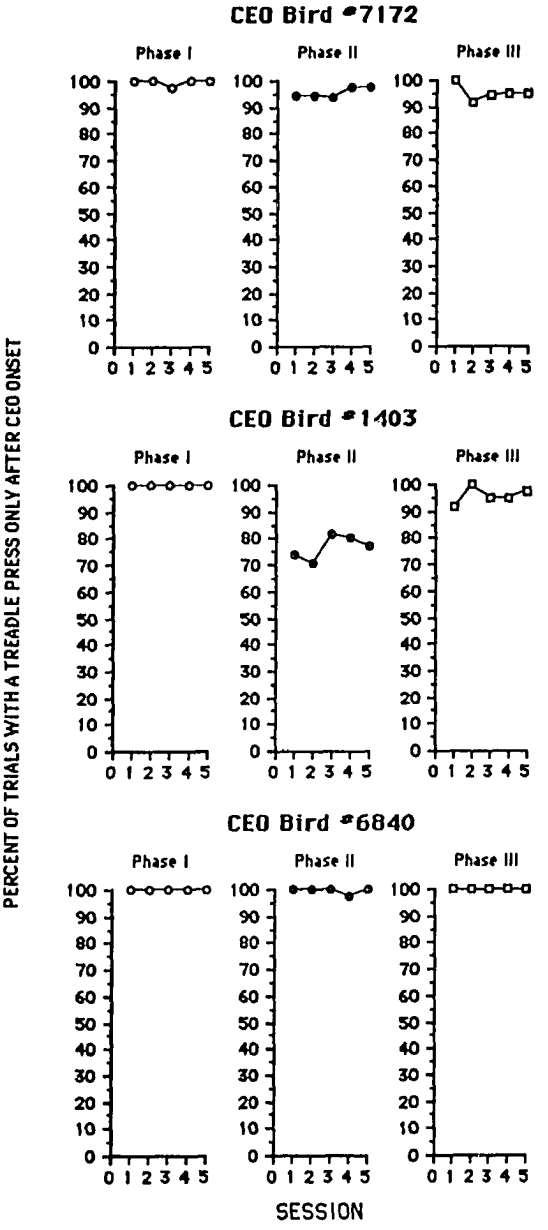

Figure 2. Control by the Purported CEO at the End of Each Phase.

Percent of trials on which a treadle press occurred only after onset of the supposed CEO are represented. Data from the last five sessions of each phase are depicted for all subjects.

each condition (i.e., data from the last five days in Phases II and III are indicative of performance throughout Phases II and III respectively).

Discussion

The control demonstrated by the houselight in Phase I of the present experiment was greater than control by supposed CEOs in previously reported research (McPherson & Osborne, 1986,1988). This may be due to a treadle press, rather than a key peck being the response of interest in the present experiment. To the extent that the treadle press controls for the possibility of elicited responding, improved control by the purported CEO would be expected. Moreover, the procedure used in the present experiment controlled for preparatory responding, which has been overlooked in past investigations of CEOs (McPherson & Osborne, 1986, 1988). The results from Phase I were consistent with the notion that the houselight was functioning as a CEO.

Phase II of the present experiment involved removing the conditioned reinforcer from the response chain developed in Phase I. According to Michael (1982), to function as a CEO the houselight should exert its control by altering the effectiveness of the conditioned reinforcer. Phase II was performed in an attempt to determine if in fact the houselight was functioning as a CEO, or if it was functioning more like an S^D for a chain of behaviors maintained by food presentation. Removal of the conditioned reinforcer in Phase II had little, if any, effect on the number of trials in which a treadle press occurred only after presentation of the purported CEO. The results of Phase II suggest that in Phase I the houselight was not altering the reinforcing effectiveness of the conditioned reinforcer, but that the houselight was acting more like an S^D for a response chain. However, advocates of the CEO argument might contend that, through prolonged exposure to the two response chain, kinesthetic stimuli produced

by pressing the treadle had been established as effective conditioned reinforcers. Further, advocates of the CEO argument might suggest that during Phase II the houselight was altering the reinforcing effectiveness of these kinesthetic stimuli. This would effectively explain the failure of Phase II to result in significantly reduced control by the houselight, and leave the possibility that the houselight was, in fact, functioning as a CEO.

Future research might attempt to separate the kinesthetic stimuli out using a different procedure. For example, a procedure requiring a variable-ratio of treadle presses prior to onset of the conditioned reinforcer would weaken the correlation between food and the kinesthetic stimuli involved in treadle pressing, while maintaining the correlation between food and onset of the conditioned reinforcer. If the conditioned reinforcer was then removed from the procedure (similar to what was done in the present experiment) one could determine whether the purported CEO was functioning as suggested by Michael (1982), or as an S^D for a response chain which was intermittently reinforced.

The procedure used in the present experiment closely resembles the procedure suggested by Michael (1982) for demonstrating control by a CEO. Indeed the procedure used allowed for clear control of behavior by the houselight (the purported CEO); however, the exact nature of this control remains unclear.

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