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PAVLOVIAN OCCASION-SETTING, ATTENTION AND OBSERVING

by

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Six pigeons were exposed to a procedure in which they could peck a white key to "observe" a 6-s keylight (CS) that was immediately followed by food 50% of the time. Another keylight (occasion-setter) was correlated with food 100% of the time, and illuminated at some point prior to food. The interval separating the onset of the occasion-setter from the opportunity to observe the CS was manipulated. The CS's temporal and probabilistic relationship to food, as well as the occasion-setter's probabilistic relationship to food, remained unchanged. Subjects were exposed to a set of conditions each of which arranged a different interval separating the occasion-setter from the opportunity to observe the CS. When the interval separating the occasion-setter from the CS was large, subjects pecked at higher rates to observe the CS following the onset of the occasion-setter than during its absence. The differential observing corresponded with higher rates of CS pecking on occasion-setting trials. Also, different occasion-setting presentations (trace and continuous) established differential observing. When the interval separating the occasion-setter presentations from the opportunities to observe the CS was reduced, rates of pecking to observe the CS, and rates of pecking the CS, were lower or became undifferentiated. The results support an interpretation of occasion-setting as a procedure which implicitly arranges for the differential reinforcement of "attending" to the CS.

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CHAPTER I

INTRODUCTION

In conditioning theory stimuli are usually viewed as evoking specific responses. Discriminative and conditioned stimuli exemplify evocative functions. In some Pavlovian conditioning procedures, however, stimuli may acquire the ability to modulate another stimulus's ability to evoke behavior. The novel stimulus function is called occasion-setting (Holland, 1983; 1985) or facilitating (Rescorla, 1985; 1986) because it sets the occasion or facilitates behavior to a conditioned stimulus.

In a typical occasion-setting procedure a stimulus, such as a light, is presented which signals that another stimulus, a tone, will be followed by food. At other times the tone is presented alone without food (see Figure 1). Under these conditions the tone will become a conditioned stimulus (CS) that evokes conditioned behavior, but only on trials when the light has been presented first. Thus, the light sets the occasion for the tone to evoke behavior but does not evoke behavior itself (Holland, 1983; 1985; Rescorla, 1985; 1986; 1987).

Something like an occasion-setting effect also occurs in everyday situations. To illustrate, imagine a mother and her young son taking a trip in a car. At some point the mother says, "OK, it's time for lunch; look for a place to eat." The son then begins to look for signs of restaurants and tells the mother when he sees these signs. Although many such signs along the side of the road were available as stimuli during their travel, they did not evoke the son's response until after the mother said it was time to eat. The mother's statement, indicating it was time to eat, changed the way the roadside signs affected the son's behavior. The mother's statement appears to function in the same way that an occasion-setter does. As the light seems to prime behavior to the tone, so the mother's statement seems to prime her son's behavior to the road signs.

The occasion-setting effect may be even more broadly related to phenomena variously referred to as attention or mental set (Woodworth, 1934). Changing an individual's mental set or directing an individual's attention also appears to involve priming the individual to be sensitive to particular stimuli. The result is that an individual responds differently to those events than before. Further investigation of Pavlovian occasion-setting may provide a better understanding of these kinds of phenomena.

Occasion-Setting and CS Functions

Stimulus functions are usually defined jointly by the kind of effect the stimulus has on behavior and by the operations that produce this effect. For example, a Pavlovian CS acquires the ability to evoke behavior, and it does so because of its correlation with an unconditioned stimulus (US). An occasion-setter appears to differ from a CS in both of these respects. First, the essential effect of an occasion-setter is not to evoke behavior directly but to affect the ability of another stimulus to evoke behavior. Second, in the procedure to produce the occasion-setting effect one stimulus, the occasion-setter, signals when another stimulus, a CS, will be followed by the US.

One line of research in Pavlovian occasion-setting has attempted to determine if an occasion-setting function is indeed a novel stimulus function different from a CS function. The general strategy has been to use procedures that are known to have reliable effects on the ability of a stimulus to function as a CS, and then to see if those procedures have a similar effect on the ability of a stimulus to function as an occasion-setter.

One such manipulation entails exposing an occasion-setter to an extinction procedure. This manipulation is designed to test the hypothesis that the occasion-setting effect is actually a CS effect. This hypothesis is plausible because each presentation of the occasion-setter is followed by a US, and so the occasion-setter could function as a signal of the US. If so, it should be possible to eliminate the occasion-setting effect by presenting the occasion-setter without the US in a separate extinction session. In this way the occasion-setter would no longer signal the US. If, however, the occasion-setting effect derives from the occasion-setter's signalling when a CS will be followed by a US, the extinction manipulation should have no effect. Several versions of this experiment have been conducted (Rescorla,1986; 1985; Holland,1985; Ross & Holland, 1982) with the consistent result that the occasion-setter continues to modulate the CS despite the intervening extinction. This result suggests that the occasion-setter does not derive from its signalling relation with the US. And so it seems different from the CS function.

Another type of manipulation used to compare the occasion-setting process with those (associative) processes that produce a CS entails first making a stimulus a CS by having it signal a US. Then an attempt is made to convert that stimulus to an occasion-setter by placing it in an occasion-setting arrangement (Rescorla, 1988; Ross, 1983). If an occasion-setter is derived from the same processes that generate a CS, then a CS should easily acquire occasion-setting properties. The results, however, show that the prior pairing with the US actually retards the development of the occasion-setting function. Apparently the evocative effect of a CS function of a stimulus competes with the priming effect of an occasion-setting function of the stimulus.

Thus the occasion-setting function and the CS function are not similarly affected when both stimuli are exposed to the same manipulations. Also, other manipulations that would be expected to have particular kinds of effects if the occasion-setting function was derived from CS processes do not produce the expected results (Rescorla, 1986; 1988; Holland, 1985). The general conclusion reached by such research is that the occasion-setting function is a novel stimulus function, one not represented in traditional, associative theories of conditioning.

Despite these results it is nevertheless possible that the occasion-setting effect is derivable from other familar controlling relations. The following discussion explores this latter possibility.

Response-Based Interpretation of Occasion-Setting

Recall that an occasion-setting stimulus is thought not to evoke behavior directly but rather to prime the ability of other stimuli to evoke behavior. Such priming effects are what is often meant by attentional phenomena.

Since such phenomena are not always overt, their properties have to be inferred. Due to the hypothetical nature of these processes, there is more than the usual amount of disagreement concerning their appropriate conceptualization. Nevertheless, two different approaches can be discerned. According to one approach the attentional processes may follow different laws from those that describe overt behavior. Many cognitive theories exemplify this approach. According to the second approach the inferred attentional processes follow the same laws that apply to overt behavior. Some behavioral theories of attentional phenomena (Schoenfeld & Cummings, 1963; Dinsmoor, 1983; 1985; Lawrence, 1963; Spence, 1936) exemplify this second approach. These theories postulate covert responses that mediate the relation between the overt stimulus and the overt response. A concrete example will be helpful at this point.

According to this approach (Spence, 1936; Dinsmoor,1983; 1985) the priming effect is due to operant-like adjustments that alter the sensory contact with stimuli. In some cases these adjustments are overt receptor-orienting responses. In other cases the adjustments are covert processes "occurring further along in the sequence of events, presumably in the neural tissue..." (Dinsmoor, 1985). In either case the adjustments follow the laws of operant behavior.

Imagine a pigeon in an occasion-setting procedure. The occasion-setter, a red light, comes on for 15 s, and during the last 5 s of this interval the CS, a green response key, is illuminated. Immediately after the 5-s interval the occasion-setter and the CS are turned off, and food is presented. On other trials the CS key is presented alone for 5 s without food. As a result of this arrangement, the CS (green keylight) will evoke more of the conditioned response if the occasion-setter (red light) was presented first. (With pigeons, the conditioned response is pecking the CS as if it were food. This effect is called autoshaping or sign-tracking (Brown & Jenkins, 1968; Hearst & Jenkins, 1974). Thus, for pigeons the rate of pecking a signal for food is analogous to the amount of salivating by a dog to a signal for food (cf., Locurto, Terrace & Gibbon, 1981).) The differential rate of pecking to the same CS key controlled by the presence and absence of the occasion-setter is the priming effect of the occasion-setting function (Rescorla, 1985; 1986; 1987; Jenkins, 1985).

The problem to be addressed is this: The same physical stimulus (namely, the green key) sometimes functions as a CS for keypecking and sometimes it does not. The prior presentation of the red light (occasion-setter) determines which effect the green key will have. What is the best way to conceptualize the function of the red light in this procedure? The red light does not appear to evoke behavior, it is the green key that evokes behavior. Nevertheless, according to the response-mediation view the red light does evoke overt and covert attentional adjustments that are operant-like, although usually unmeasured. This idea can be grasped more easily by considering the kinds of peripheral adjustments that might occur.

What kind of adjustments might be relevant to produce the enhanced pecking to the CS (green key) and what is the operant reinforcement for these adjustments? Suppose sometimes the pigeon makes preparatory adjustments that enhance contact with the CS when it is presented. For example, the pigeon might turn its head toward the location where the green keylight will come on and focus its eyes toward that location so that when the green keylight comes on, it will maximally stimulate the pigeon. Suppose at other times the pigeon does not make these adjustments. The reactivity to the green keylight (enhanced pecking) will be greater when those adjustments have occurred than when they have not occurred. Thus, behavioral adjustments can produce different reactivity to the same physical stimulus. Since these adjustments are preparatory and affect reactivity to another stimulus, we may call them attentional adjustments or observing behavior (Wycoff, 1952; 1969; Dinsmoor, 1983; 1985).

The next step in the argument will be to show how these behavioral adjustments (observing behaviors) can be controlled by the occasion-setter. Imagine what happens when observing occurs in the presence versus in the absence of the occasion-setter (red light). When observing occurs in the presence of the red light, the consequence is rich sensory contact with the green key (CS), which on these occasions is followed by food. When observing occurs in the absence of the red light, the consequence is again contact with the green key, but on these occasions the green key is never followed by food. The former consequence should become a conditioned reinforcer for observing, and the latter consequence should become a conditioned punisher for observing (Dinsmoor, 1983; 1985). Consequently, observing will be strengthened in the presence of the occasion-setter (red light) and weakened in its absence, and so the occasion-setter will come to evoke observing.

To this point the account is speculative for at least two reasons. First, many of these attentional adjustments are covert and central, and so are necessarily inferred in the absence of new measurement techniques. Second, even the peripheral attentional adjustments, such as just described, are difficult to measure. Thus it is hard to know whether they do in fact occur differentially in relation to the occasion-setter and whether they are in fact differentially reinforced or punished by the CS as the interpretation implies.

Thus, to test the response-mediation interpretation of attentional phenomena some investigators have arranged an analog of these kinds of attentional adjustments so that their occurrence can be readily measured and their consequences manipulated (Wycoff, 1952; 1969; Dinsmoor, 1983; 1985). The central idea of this approach is to require some readily measured response, called an observing response, to make contact with stimuli. In this procedure the observing response does not produce food but only produces stimuli predictive of food. This procedure was first developed for an analysis of a simple discrimination procedure (Wycoff, 1952; 1969). The present research extends that methodology to the interpretation of occasion-setting.

Purpose of Study

The present experiment arranged an occasion-setting procedure with the modification that the pigeon had to peck a key (the observing key) to see the CS. Just as natural attentional adjustments are assumed to alter contact with the CS, the arbitrary attentional adjustments (pecks to the observing key) necessarily and measurably alter contact with the CS. Thus, the observing response in this procedure is an analog of the hypothesized attentional adjustments that are assumed to alter effective contact with, and thus the reactivity to, the CS. The purpose is to find out if the arbitrary observing response will be controlled by the occasion-setter in the way that the response-based interpretation implies.

All trials began with the illumination of the observing key. Each trial was 60 s long, and during the final 6 s of the trial a peck to the observing key turned on the CS (right keylight) for the remainder of the 6 s. At the end of the trial either food was presented followed by an intertrial interval (ITI) or just the ITI was presented. Whether or not food would be presented at the end of the trial was signalled by the illumination of the left keylight during the trial. Thus, the illumination of the left keylight was the occasion-setter.

If the observing key was not pecked, food and the ITI or just the ITI still would be presented as scheduled at the end of the 60-s trial. Thus, pecking the observing key had no effect on food availability. The only effect of the pecks to the observing key was to illuminate the CS key during the last 6 s of a trial. Although it might seem inefficient for the bird to peck the observing key, the present interpretation predicts that the pigeons should come to produce the CS by pecking the observing key, but mainly on trials during which the occasion-setter light is presented. Testing this implication is the first purpose of this experiment.

If observing is indeed generated, a second purpose will be to examine the effect of manipulating the interval separating the onset of the occasion-setter from the CS. The rationale for this manipulation follows.

When the occasion-setter is presented simultaneously with the CS, the occasion-setting effect does not occur. Instead the "occasion-setter" functions as a CS, and the "CS", is ignored (Holland, 1983; 1985). This empirical result implies that differential observing of the CS should not occur when the occasion-setter and the CS are simultaneous. The present study will arrange an analog of the simultaneous procedure to see if differential observing does indeed drop out. Such a result would demonstrate that a variable known to eliminate the occasion-setting effect also eliminates differential observing. Such a correspondence between occasion-setting and observing is implied by the model.

In addition the response-mediation model makes comprehensible why differential observing, and thus the occasion-setting effect, would drop out under the simultaneous arrangement. Under the usual occasion-setting procedure, attentional adjustments that occur when the occasion-setter has been presented are reinforced by contact with the CS which is followed by food. The CS thus acquires conditioned reinforcement properties when preceded by the occasion-setter because the CS is the best temporal signal of food. If, however, the occasion-setter is presented simultaneously with the CS, then the occasion-setter is now just as good a temporal signal of food as the CS is. And since the occasion-setter is also perfectly correlated with food, the "occasion-setter" is a better probabilistic signal than the "CS". Thus the occasion-setter should come to function as a CS evoking food-related conditioned responses which would compete with its ability to evoke observing responses, and differential observing of the "CS" should drop out.

A third aspect of the experiment was to determine the importance of having the occasion-setter overlap the CS. In some conditions the occasion-setter stayed on overlapping (continuous presentation) with the scheduled CS.

In other conditions the occasion-setter was turned on only for a short duration (trace presentation) not overlapping with the CS. The occasion-setting effect has been obtained with each type of presentation (Rescorla,1985; 1986; 1987; Ross & Holland, 1981). If each type of presentation can establish an occasion-setting effect then they each should be able to maintain differential observing. This result would also be predicted by the response-mediation model.

According to the response-mediation model, differential observing is established because preparatory adjustments that increase contact with the CS are reinforced by contact with the CS, but only on occasion-setting trials. If so, then the type of occasion-setter presentation should not matter and, consequently, differential observing should be established.

CHAPTER II
METHOD

Subject

Six male White Carneaux pigeons were deprived of food and maintained at 80% of their free-feeding weights for the duration of the experiment. Grit and water were freely provided in their home cages.

Apparatus

Two modified Coleman coolers were used as experimental chambers. Each cooler had two compartments which were divided by a metal panel. One of the compartments consisted of electrical and mechanical support used to supply power to the the food hopper, keylights, and houselight. The other compartment (the experimental space) had internal dimensions of 27 cm wide, 31 cm high, and 21 cm long. Three translucent pecking keys through which various colors could be projected, were mounted behind holes through the metal panel. The three response keys were mounted 21 cm above the floor and 8 cm apart. An overhead houselight located on the ceiling near the front wall provided low-level general illumination. The houselight remained on at all times during the session except during feeder operation. Centered below the response keys and 10 cm above the floor was a rectangular opening which provided access to mixed grain when the food hopper was raised. When the food hopper was raised, the feeder opening was illuminated and the keylights and the houselight were darkened. An externally mounted fan provided masking noise and ventilation. The experimental manipulations and data collection were controlled by electromechanical equipment located in an adjoining room.

Procedure

Magazine Training. All subjects were given one day of magazine training. Magazine training consisted of placing a bird in the chamber and lowering and raising the grain hopper repeatedly until the bird began to eat quickly after the food hopper was raised. None of the response keys was illuminated during magazine training. Subjects were exposed to the experimental conditions on the day following magazine training.

Observing Response Contingency. The center key was the observing key, and pecks to this key were observing responses. The right keylight was the CS. The CS could be produced on each trial by an observing key peck after 54 s had elapsed in the trial. Thus, on each trial the CS keylight could be illuminated for a maximum of 6 s. A peck to the observing key was only effective during the last 6 s of each trial. Pecks to the observing key before 54 s had elapsed were recorded to determine the rate of observing but had no other programmed consequences.

The first peck to the observing key after 54 s had elapsed in the trial illuminated the CS keylight for only the time remaining in the trial. For example, if the effective peck occurred after 58 s had elapsed in the trial, the CS keylight would be illuminated for the two seconds left until the trial ended. If the observing key was not pecked during the final 6 s of the trial, the observing key remained illuminated until the end of trial, and the CS keylight would not be produced on that particular trial.

Occasion-Setter and CS-Alone Trials. There were two kinds of trials--food versus no-food. On no-food trials the 6-s opportunity to observe the CS was followed by a 60-s variable-time intertrial interval (ITI). On food trials the 6-s opportunity to observe the CS was followed by 4-s access to food prior to the initiation of the ITI. After completion of the ITI, a new trial began (see Figure 2).

The type of trial (food vs. no-food) was signalled by the illumination of the left key--the occasion-setter. On occasion-setting trials the left side-key was illuminated at some point (see below for specific temporal presentations) during the trial, and the trial terminated in 4-s access to grain followed by the ITI. When food was not presented--CS-alone trials--the left key was not illuminated at all during the trial.

Subjects did not have to peck any key at any time in this procedure to receive grain nor did pecking affect the time of food delivery. Grain was presented immediately after 60 s had elapsed during occasion-setting trials. If the observing key was pecked during the 6-s period in which the CS key could be produced, the CS light came on for whatever time remained in the 6-s interval. Then food was presented immediately after the 6-s period had elapsed and the CS key was turned off. If the observing key was not pecked during the CS portion of the trial, the observing key remained illuminated until the scheduled food was delivered immediately after the scheduled opportunity to produce the CS had elapsed. Thus the only effect of pecks to the observing key was to illuminate the CS keylight, not to affect food deliveries.

For three subjects the CS keylight was red, and the occasion-setter keylight was yellow. For the other three subjects the CS keylight was yellow and the occasion-setter keylight was red. The observing key was white for all subjects.

To summarize, on each trial the observing key was illuminated, and, if the observing key was pecked during the final 6-s of the trial, the CS was illuminated. This was common to each type of trial. On CS-alone trials the occasion-setter was not illuminated and the trial ended without food and just the initiation of the ITI. On occasion-setting trials, the occasion-setter was illuminated during the trial, and the trial ended with food followed by the ITI. Each session consisted of 50 trials. Half were CS-alone trials and the other half were occasion-setting trials. The 50 trials consisted of one block of a ten-trial sequence repeated five times. The sequence of trials within the block was changed daily.

Temporal Presentation of the Occasion-Setter. Each subject was exposed to a sequence of conditions with a different interval between the onset of the occasion-setter and the scheduled opportunity to observe the CS. The only difference between the conditions was when the occasion-setter keylight was turned on during the trial. For example, if the occasion-setter was illuminated at the begining of the trial--at the same time as the observing key--the interval between the onset of the occasion-setter and CS opportunity was 54-s (designated as the 54-s Condition). A 12-s interval consisted of turning on the occasion-setter 18-s prior to grain (and 42-s after observing key illumination). A 0-s interval, analogous to a simultaneous procedure, consisted of presenting the occasion-setter during the final 6-s of the trial. In this condition the occasion-setter was presented only during the portion of the trial in which the opportunity to produce the CS existed. Diagrams of the 54-s, 12-s and 0-s intervals are provided in Figure 3.

Continuous and Trace Occasion-Setter Presentations. Two kinds of occasion-setting presentations were used in the present procedure, continuous and trace. Under the continuous procedure, the occasion-setter keylight was turned on until food was presented at the end of the 60-s interval. Thus, the occasion-setter was illuminated during the portion of the trial in which there was the opportunity to produce the CS. Examples of continuous occasion-setter presentations are provided in the diagrams in Figure 3. All subjects were initially exposed to the continuous occasion-setter presentations.

Another set of conditions consisted of trace presentations of the occasion-setter. That is, the occasion-setter was illuminated for 6 s and then turned off. In contrast to the continuous procedure, the occasion-setter never overlapped the CS opportunity and was never contiguous with food presentation. In the trace procedure there was always a temporal gap between the offset of the occasion-setter and food presentations. A diagram of a trace procedure is provided in Figure 4.

Acquisition of Observing. The purpose of the first phase of the experiment was to determine under what interval, separating the occasion-setter from the CS, the observing response (pecking the center key) would be established without any supplemental training. Immediately after one session of magazine training each bird was exposed to one of the following occasion-setter and CS intervals: 54-s, 24-s, 12-s, or 0-s. Bird S1 was exposed to the 54-s Condition. Birds S2 and S5 were exposed to the 24-s Condition. Birds S3 and S6 were exposed to the 12-s Condition. Bird S4 was exposed to a 0-s Condition.

Only for Bird S1 was the observing response established in this initial condition--the 54-s Condition. For the other five subjects the observing response was not established and did not occur when the birds were subsequently exposed to the 54-s Condition. These subjects required supplementary training to establish pecks to the center key as the observing response. Once the observing response was established, the experiment proper began for that subject. The supplementary procedures used to establish the observing response are presented in the final section of the results so as to not detract from the thrust of the project which was to see if observing would come to be evoked by the occasion-setter and to determine the modification of the observing response under various intervals separating the occasion-setter and CS .

Systematic Manipulation of the Occasion-Setting Interval. Following the establishment of the observing response (pecks to the center key) in the 54-s Condition, subjects were exposed to the 12-s Condition. If differential observing and CS pecking were eliminated or disrupted, the bird was returned to a condition with a longer interval separating the occasion-setter from the CS. (See replication of differential observing below.) If differential observing was maintained in the 12-s Condition, the bird was systematically exposed to conditions which consisted of smaller intervals separating the onset of the occasion-setter from the CS (e.g., 6-s then the 0-s) until differential observing and the occasion-setting effect was extinguished or until the interval was 0-s (simultaneous condition).

Subjects remained in a condition for a minimum of 15 daily sessions. After 15 sessions were completed, a decision was made whether to continue or discontinue the subject in that condition. This decision was based on fluctuations of a differential observing index (an index indicating the degree of control over observing by the occasion-setter), and on whether the condition was anticipated to weaken or strengthen observing in the presence of the occasion-setter. For example, if a subject had a high differential observing index (e.g., .75) over the last 5 days in a condition in which the interval between the occasion-setter and CS was long, then the condition was discontinued. However, if a subject had a high differential observing index in a condition with a short interval and the predicted effect was to weaken observing, a subject was continued in this condition to insure that the changes in the reinforcing value of the CS had an opportunity to make contact with the observing response. After the minimum 15 days, evaluation of the data was done on a weekly basis. Thus, the number of sessions differed for each condition and each subject.

Replication of Differential Observing. After the occasion-setting effect and differential observing was disrupted or reduced, the interval separating the onset of the occasion-setter from the CS opportunity was increased to see if the occasion-setting effect and differential observing could be recovered. (See Table 1 for the order of conditions and the number of sessions a subject was run under each condition.)

CHAPTER III
RESULTS

Response Measures

The response measures used in this experiment were the rate of pecking the observing key and the rate of pecking the CS key. In Pavlovian conditioning procedures, pecking a keylight that signals food indicates that the keylight has acquired a CS function (Locurto, et al., 1981). In Pavlovian occasion-setting procedures pigeons peck the CS key at a higher rate on occasion-setting trials than on CS-alone trials--this is the occasion-setting effect.

In the usual occasion-setting procedure the CS key is presented, independently of the pigeon's behavior, for the same amount of time on CS-alone and occasion-setting trials. The rate of CS pecking is calculated by dividing the total number of CS pecks by the total amount of time the CS was presented. In the present procedure, however, the amount of time the CS key was presented depended on the pigeons pecking the observing key to produce the CS key. The actual contact time with the CS would be expected to be lower on CS-alone trials than on occasion-setting trials. (According to an observing analysis, the natural adjustments would also be expected to produce this pattern in the typical occasion-setting procedures, but those procedures are not designed to permit measurement of such differences.) So, in order to allow comparisons between the results of the present procedure and those of the more typical occasion-setting procedures, the rate of pecking the CS was calculated by dividing the total number of pecks by the amount of time the CS would have been produced if it had been "observed" on each trial for the maximum amount of time. This calculation provided a measure of CS pecking comparable to the measure of CS pecking used in more typical occasion-setting procedures.

The rate of pecking the observing key evoked by the occasion-setter and the rate of pecking the observing key in the absence of the occasion-setter provided measures of the absolute rates of observing. For the procedures in which the occasion-setter was presented continuously, the rate of pecking the observing key evoked by the occasion-setter was calculated by dividing the total number of pecks to the observing key after the onset of the occasion-setter by the amount of time the observing key was on (until the CS key was produced).

The rate of pecking the observing key evoked by the absence of the occasion-setter was calculated by dividing the total number of pecks when the occasion-setter was not on by the total amount of time the observing key was illuminated in the absence of the occasion-setter. This calculation included pecks to the observing key which preceded occasion-setter presentations on occasion-setting trials as well as pecks to the observing key on CS-alone trials. (There were no differences in trends when these two measures were calculated and separately compared to the rate of observing during the occasion-setter.) This combined calculation was done for all conditions except the 54-s Condition during which the occasion-setter was illuminated at the begining of the trial.

In the trace procedure, the rate of pecking the observing key evoked by the occasion-setter was calculated by dividing the total number of pecks to the observing key by the amount of time the observing key was illuminated following the onset of the occasion-setter. Included in this calculation were pecks that occurred after the occasion-setter had been presented and turned off. The rate of observing evoked by the absence of the occasion-setter was calculated in the same manner as that described for the continuous procedure.

An index of differential observing was also calculated by dividing the rate of pecking the observing key evoked by the occasion-setter by the sum of the rates of pecking the observing key evoked by the presence and absence of the occasion-setter. A value above 0.5 indicates higher rates of observing evoked by the occasion-setter as compared to rates of observing evoked in its absence.

Occasion-setting and Observing

The left column of graphs in Figure 5 shows data from each daily session of the condition in which the occasion-setter came on 54 s before the CS. Each bird's data are presented on a separate page.

The graph at the top of the left column shows the rates of pecking the CS during occasion-setting trials (closed points) and during CS-alone trials (open points). This graph shows the occasion-setting effect. Five out of six birds pecked the CS at a higher rate during occasion-setting trials than during CS-alone trials. The lone exception (Bird S3) rarely pecked the CS on any trial. Observation of Bird S3's behavior in the experimental chamber revealed that there was differential pecking to the CSs (in the same direction as the other five birds), but that most pecks were not of sufficient strength to operate the key.

The higher rates of CS pecking during occasion-setting trials than during CS-alone trials is consistent with the differential CS pecking found in more typical Pavlovian occasion-setting procedures. The development of the occasion-setting effect suggests that the present procedure models important aspects of the more typical Pavlovian occasion-setting procedures.

If higher rates of CS pecking during the occasion-setter trials result from attentional adjustments evoked by the occasion-setter, then rates of pecking the observing key should be higher during the presence of the occasion-setter than during its absence. In other words, if there is more CS pecking during the occasion-setting trials than on CS-alone trials--the occasion-setting effect--then there should also be more pecking to the observing key when the occasion-setter is on than when it is off.

The middle graph in the left column displays the absolute rates of pecking the observing key plotted for each session in the presence of the occasion-setter (closed points) and in the absence of the occasion-setter (open points). The bottom graph of the left column shows the differential observing index plotted for each session.

All birds pecked the observing key even though pecking it had no effect on the delivery of food. Although most of the birds initially pecked the observing key at higher rates during the absence of the occasion-setter than during its presence, all six birds eventually pecked the observing key at a higher rate when the occasion-setter was on than when it was off. For five out of the six birds these differences were quite large by the end of training (see the differential observing index shown in the bottom graph of the left column). For Bird S5, however, the differences were small despite extensive exposure (over 100 sessions) to this condition.

All subjects that pecked the CS more during occasion-setting trials than during CS-alone trials also pecked the observing key more during occasion-setting trials than during CS-alone trials. Although Bird S3 rarely made effective pecks to the CSs, he also pecked the observing key more when the occasion-setter was on than when it was off.

The maintenance and differentiation of the arbitrary observing response under these conditions (54-s occasion-setter presentation) is consistent with the interpretation that the CS in the occasion-setting procedure reinforces attentional adjustments in the presence of the occasion-setter. Moreover, the correspondence between differential CS pecking (the occasion-setting effect) and differential observing is consistent with the view that the attentional adjustments to the CS result in the occasion-setting effect.

"Simultaneous" Presentation of the Occasion-Setter

The next phase of the project made the onset of the occasion-setter temporally closer to the 6-s opportunity to observe the CS to determine if differential observing and the occasion-setting effect would be eliminated. In the more typical occasion-setting procedure, if the occasion-setter is presented simultaneously with the CS, then the occasion-setting effect does not occur (Ross & Holland, 1981). The novel contribution of the present study is to see if the occasion-setter loses its ability to evoke observing when the occasion-setter is presented closer to food. The model predicts that the rate of observing in the presence of the occasion-setter should decline, and that the differential observing index should fall toward 0.5, which would indicate that rates of pecking the observing key are equal in the presence and absence of the occasion-setter.

Once the occasion-setting effect and differential observing was established and maintained for a subject, the interval between the occasion-setter and the CS was systematically reduced for each subject over blocks of sessions until the differential observing index dropped below 0.5, or, until the interval between the occasion-setter and CS was 0-s (simultaneous presentation). For Birds S4 and S3 that interval was 12-s. For Birds S1, S2, S5, and S6 that interval was 0-s. The middle column of graphs in Figure 5 provides the data from the daily sessions of this condition.

Four out of the five subjects that pecked the CS at higher rates during occasion-setting trials than during CS-alone trials under the 54-s Condition pecked at a lower rate or stopped pecking the CS (top graph of the middle column). Bird S1 was the lone exception. Bird S1 continued to show the occasion-setting effect even in the 0-s Condition. Bird S3 continued to not peck the CSs in the 12-s Condition.

The rate of observing on occasion-setting trials declined for all birds. Also, the index of differential observing eventually decreased toward 0.5 for five out of the six subjects (middle and bottom graphs of the middle column). In some cases, the index became more variable from day to day. This variability was the result of an overall decrease in the rate of observing. If the values of the response rates that enter into the formula for the index are low, small random fluctuations can produce wide swings in the index. In either case, the indication is that the ability of the occasion-setter to evoke observing was impaired by reducing the interval between the occasion-setter and CS presentation.

Although the overall rate of pecking the observing key decreased relative to the 54-s Condition, Bird S2 continued to differentially observe. Also, for Bird S1, at the end of training the rate of observing under the 0-s Condition is similar to the rate of observing under the 54-s Condition in the presence of the occasion-setter. Nevertheless, the rate of observing waxed and waned throughout exposure to this condition. And, the rate of observing in the absence of the occasion-setter increased, resulting in a differential index below 0.5 by the end of training. Thus, for these birds the effectiveness of the occasion-setter to evoke observing during occasion-setting trials was reduced but not completely eliminated.

Recovery of Pavlovian Occasion-Setting

The graphs in the right column of Figure 5 show the rates of pecking the CS and the observing key plotted for each session when the occasion-setter and CS interval was again increased. (Birds S1, S3, S4, and S6 were exposed to the 54-s Condition. Bird S2 was exposed to a 24-s Condition. Bird S5 was exposed to a 12-s Trace Condition.) The occasion-setting effect was re-established for four out of the five subjects that had pecked the CS. (Recall that Bird S3 rarely pecked the CSs during any condition.) Subject S5 pecked the CS at higher rates in the recovery condition compared to the 0-s Condition but did not peck the CS differentially in the recovery condition.

Five out of six subjects pecked the observing key at higher rates in the presence of the occasion-setter than in its absence in the recovery condition (middle graph of the right column). Again, Bird S5 was an exception. Although the overall rates of observing increased, relative to the 0-s Condition, differential observing was never reestablished for this subject. Note that this bird also had the smallest difference between rates of observing in the presence and absence of the occasion-setter under the initial 54-s Condition. Thus, whatever may have contributed to the difficulties in establishing differential observing initially for this bird may have contributed to the difficulty in establishing differential observing in the recovery phase.

The absolute rates of observing in the presence of the occasion-setter never reached the levels attained in the initial 54-s Condition for two subjects (Birds S4 and S6), but for all subjects the rate of observing increased relative to the "simultaneous" condition. This shows that the increase in the interval separating the occasion-setter from the CS opportunities produced an increase in the tendency to observe.

To summarize, when the interval was long, higher rates of observing occurred in the presence of the occasion-setter than in its absence. When the interval was short, the rate of observing evoked by the occasion-setter declined and the difference between the rate of observing in the presence as compared to the absence of the occasion-setter was reduced. The lone exception (Bird S2), who continued to differentially observe under the "simultaneous" condition, had a substantial reduction in the rate of observing during this condition. For this bird the rate of observing waxed and waned throughout exposure to this condition suggesting that the ability of the occasion-setter to evoke observing was weakened. Also, when Bird S2 was subsequently exposed to a 24-s Condition, rates of observing increased relative to the "simultaneous" condition, further suggesting that the evocative effects of the occasion-setter had indeed been weakened in the "simultaneous" condition. This general pattern of results is consistent with predictions derived from the response-mediation view.

Observing behavior was affected by the changes in the interval separating the occasion-setter from the opportunity to observe the CS. Once the "simultaneous" condition was imposed, the rate of observing evoked by the occasion-setter declined. As a consequence, the index of differential observing declined toward 0.5 but also became more variable due to the low absolute response rates. Despite the variability in the index, the trend was that differential observing was changed in the expected direction when the condition changed from an occasion-setting arrangement to the "simultaneous" arrangement, and then back, to an occasion-setting arrangement. This trend is indicated by the middle and bottom graphs of each column in Figure 5. This trend can also be shown by the group mean index of differential observing, which was calculated for the last five days of training for all subjects in the initial 54-s, the "simultaneous", and the recovery conditions. A Wilcoxin's Matched-Pairs Signed-Ranks Test was used to test the reliability of the differences between the conditions. The group mean index of differential observing for the 54-s Condition was .85 and was significantly different from that in the "simultaneous" condition which was .33 ($T=2$, $p<.05$). Also, the mean index for the recovery conditions was .87 which was significantly different from that in the "simultaneous" condition ($T=2$, $p<.05$). Thus, differentiation of rates of observing changed significantly when the interval separating the occasion-setter from the CS was changed: When the interval was long the index of differential observing was significantly higher than when the interval was short.

This pattern of results is consistent with the hypothesis that a long interval separating the occasion-setter from the CS establishes the CS as a conditioned reinforcer for attending to CS presentations when the occasion-setter was presented. Furthermore, when the interval is shortened, the ability of the occasion-setter to evoke attending is impaired, perhaps due to the occasion-setter's favorable signalling relation to food.

The Effect of the Occasion-Setter - CS Interval on Pavlovian Occasion-Setting Iland Observing

Subjects were exposed to a set of conditions each of which arranged a different interval separating the occasion-setter presentation from the opportunity to observe the CS. Several subjects were also exposed to a trace presentation of the occasion-setter. Under the trace procedure, at some point during the occasion-setting trial, the occasion-setter was illuminated for a 6-s duration.

Figure 6 contains the summary data from each subject for each condition, including the conditions shown in Figure 5. The top graph provides the mean, calculated over the last 10 daily sessions, for rates of pecking the observing key evoked by the occasion-setter and for the rates of pecking the observing key in its absence. The bottom graph for each subject contains the mean rates of pecking the CS on occasion-setting and CS-alone trials. Data from the replication of conditions are presented as separate functions on the same graphs. The results of the trace procedure are included as unconnected, separate data points on the same graphs.

Usually, rates of pecking the observing key evoked by the occasion-setter increased as a function of an increase in the interval between the occasion-setter and CS presentations. Rates of pecking the observing key in the absence of the occasion-setter decreased or increased slightly (while never exceeding the rates of observing evoked by the presence of the occasion-setter) as a function of an increase in the interval. Also, rates of CS pecking on occasion-setting trials usually increased as the interval increased. Rates of CS pecking on CS-alone trials usually remained low across all conditions. Both the trace and continuous occasion-setter presentations established differential observing.

Establishment of Observing

Recall that five of six subjects pecked the observing key at very low rates, if at all, when initially exposed to the occasion-setting procedure. Consequently, Birds S2, S3, S4, S5, and S6 were exposed to various supplemental procedures with the intent of establishing pecking to the observing key. The results of the procedures described in this section preceded the data described previously. The manipulations used were derived from the observing model as likely to be effective for the development of observing. Following exposure to each of the supplemental procedures, subjects were exposed to the 54-s Condition to see if that manipulation was successful in establishing the observing response.

Based on an observing analysis the CS must be a conditioned reinforcer in order to strengthen the observing response. Thus, one manipulation was designed to establish the CS as a conditioned reinforcer. Each subject was exposed to separate sessions in which the CS keylight was paired with food. Although all subjects began pecking the CS under this procedure (suggesting that the CS had acquired conditioned reinforcing properties), observing failed to occur when the subjects were subsequently exposed to the 54-s Condition. The observing response did not occur at a rate high enough to produce the CS on occasion-setting trials, and thus the observing response could not be reinforced by the production of the CS. This result suggested that the observing response needed to be established at a sufficient rate so that it could make contact with the CS's relationship with food.

Each of the five birds was then exposed to a condition designed explicitly to strengthen the observing response. Each subject was exposed to a nondifferential observing procedure. That is, all aspects of the observing procedure described earlier were in effect except that the occasion-setter was not presented. Half of the trials were followed by food presentations. All subjects except Bird S3 pecked the observing key in the nondifferential procedure. When subjects were subsequently exposed to the 54-s Condition, only Bird S2 began pecking the observing key on occasion-setting trials (see the left hand column of Figure 5 for data from the initial 54-s Condition).

Birds S4, S5, and S6 pecked the observing key on CS-alone trials but did not peck the observing key when the occasion-setter was presented. This pattern of observing suggested that the occasion-setter was evoking behavior that interfered with the evocation of observing. One possibility was that the occasion-setter had acquired the ability to evoke conditioned behavior as a CS. The next manipulation was designed to weaken any CS effects that may have been caused by the occasion-setter's relationship with food. Birds S4, S5, and S6 were exposed to separate extinction sessions during which the occasion-setter was presented for 60-s durations alone without food presentations. Subsequent exposure to the 54-s Condition produced some pecking to the observing key on occasion-setting trials. Nevertheless, rates remained too low to make contact with the CS on occasion-setting trials.

Thus following the extinction sessions, Birds S4, S5, and S6 were exposed to trace presentations of the occasion-setter to further weaken the association between the occasion-setter and food while at the same time allowing the observing response to make contact with the CS on occasion-setting trials. In this condition the occasion-setter was turned on at the begining of the trial for 30 s and then turned off. All aspects of the observing procedure were in effect except that there was a trace interval of 24 s between the offset of the occasion-setter and the opportunity to observe the CS on occasion-setting trials. Birds S4, S5, and S6 began pecking the observing key and contacting the CS on occasion-setting trials under this trace manipulation. Also, they continued to peck the observing key under the 54-s Condition when the occasion-setter was presented for the entire trial--that is, until the CS was produced (see left hand column of Figure 5 for data from the initial 54-s Condition for Birds S4, S5, and S6).

Due to the absence of any pecking to the observing key, Bird S3 was exposed to separate sessions in which the observing key was presented and pecking was reinforced by food on a variable-interval 60-s schedule. Subject S3 began pecking the observing key under the variable-interval schedule and also subsequently pecked the observing key under the 54-s Condition. (See left hand column of Figure 5 for data from the initial 54-s Condition for Bird S3).

To summarize, the observing response was ultimately established for each subject. Different types of experiences were needed to establish the observing response for different subjects. Some subjects (Birds S2 and S3) only required manipulations which explictly strengthened pecks to the center key so that pecking it occurred at a high enough rate to make contact with the observing contingencies. Other subjects required additional manipulations that weakened the occasion-setter's relationship with food before pecks to the center key made contact with the observing contingencies. Once the observing response was established to the point where it would produce the CS on occasion-setting trials, the observing response was maintained for all birds in the initial 54-s Condition and subsequently.

CHAPTER IV
DISCUSSION

The occasion-setting effect was established under the present procedure. The ability of the present procedure to generate the occasion-setting effect suggests that this procedure models important elements of the more typical occasion-setting procedures.

Also, all subjects pecked the observing key. It is impressive that the observing key was pecked at all by any bird in the present procedure because it was not a requirement to receive grain nor did it affect the time of grain delivery. Indeed, it seems it would have been advantageous for the birds just to sit and wait for the grain to be presented. That the birds did peck the observing key indicates that the CS functioned as a conditioned reinforcer for pecks to the observing key and supports the interpretation that attentional adjustments are reinforced by the CS in the occasion-setting procedure.

Differential rates of observing were established in the present procedure. Furthermore, differential observing occurred under the same conditions which generally establish an occasion-setting effect. In other words, when the interval separating the occasion-setter from the opportunities to observe the CS was long (e.g., 54-s), there were higher rates of pecking to the observing and CS keys evoked by the occasion-setter than evoked in its absence. When the occasion-setter was presented temporally closer to the CS, differential observing and usually the occasion-setting effect were weakened. That is, usually overall rates of pecking the observing and the CS keys decreased, became more variable, and/or became less differentiated. Indeed, two birds (Birds S3 and S4) eventually stopped pecking the observing and CS keys when the occasion-setter was presented close to (i.e., 12 s prior to) the opportunity to observe the CS. The presence of the occasion-setting effect when the interval (separting the occasion-setter onset from the CS) was long and the reduced occasion-setting effect when the interval was shortened is consistent with the results obtained in a more typical occasion-setting procedure when this interval was manipulated (Ross & Holland, 1981). The correspondence between differential observing and CS pecking when the interval was long and the weakening of differential observing and CS pecking when the interval was shortened is consistent with the interpretation that operant-like attentional adjustments mediate the Pavlovian occasion-setting effect.

A correspondence between differential observing and CS pecking was established under two kinds of occasion-setting arrangements; trace and continuous presentations of the occasion-setter. Both arrangements have generated the occasion-setting effect in other laboratories (Rescorla, 1985; 1986; 1987; Jenkins, 1985; Holland, 1983; 1985; LoLordo and Ross, 1987). The establishment of differential observing under the trace and continuous arrangements extends the generality of the response-mediation interpretation of occasion-setting.

The Observing Procedure and Attention

The observing response is intended as an analog of attentional processes. Much of attention may be adequately captured by the observing response conceptualization. That is, attentional processes are influenced in expected ways by operant contingencies. Nevertheless, some aspects of attention may be the result of central processes that are not operant-like. An observing interpretation of attentional phenomena allows specific predictions to be made concerning the development and maintenance of the particular attentional effect in question. A lack of correspondence between the predictions derived from an observing analysis and the results obtained when an observing response is added to the situation will more precisely delineate between those attentional processes that are operant-like and those that require other types of explanations.

On the other hand, a successful demonstration of a phenomenon may suggest refinements in the understanding of the phenomenon. For example, an observing analysis may help to interpret failures in the development of occasion-setting. Two factors emerged from the present study as being important for the development of differential observing and, consequently, the occasion-setting effect. First, if the observing response is not part of an established repertoire of observing behavior for the stimulus used as a CS, then the occasion-setting effect does not occur until the observing response is sufficiently established. Second, there appears to be competition between the occasion-setter's tendency to function as a CS and its ability to evoke observing behavior. Even if the observing response has been acquired, CS properties of the occasion-setter may interfere with its ability to evoke observing behavior. As a result the occasion-setting effect may not develop. Each of these factors are discussed below.

Acquisition of the Observing Response

There was some difficulty in establishing the arbitrary observing response under the occasion-setting procedure for several subjects. For two of these subjects differential observing occurred in the 54-s Condition only after exposure to extra sessions which explicitly strengthened pecks to the center key as the observing response. Subject S2 began observing under the 54-s Condition after exposure to a nondifferential observing procedure. Subject S3 required extra sessions during which the center white key (observing key) was turned on and pecking was reinforced by food. Following explicit reinforcement of pecking to the observing key by food, Bird S3 began observing in the 54-s Condition.

For these two subjects the observing response had to be established separately before it would occur under the present occasion-setting procedure. Strengthening the observing response allowed contact with the CS and its temporal relationship with food. Once the CS was produced (i.e., observed) and followed by food, it acquired conditioned reinforcing properties. The presentation of the CS followed by food reinforced observing behavior on occasion-setting trials and resulted in the occasion-setting effect.

The importance of having an established observing response for a stimulus may also be true for more typical discrimination experiments. The stimuli used in typical discrimination procedures (e.g., tones and lights) are stimuli to which the subjects have had extensive pre-experimental exposure. Exposure to such stimuli during development could provide ample opportunity to develop observing responses with respect to these stimuli. The subjects thus enter the experiment with already well-established observing repertoires relative to the experimentally arranged stimulus. Consequently, the role of observing behavior is often overlooked. When an artificial observing response is required, it becomes apparent that prerequisite experiences are necessary to establish even the simplest discriminations.

Indeed, Mellon, Kraemer and Spear (1991) report that weanling rats do not discriminate between lights and tones early in development. Furthermore, they suggest that the pups have to acquire observing behavior with respect to lights and tones before they are able to discriminate between these types of stimuli. The need for a developmental history to establish observing responses for these commonly occurring stimuli suggest that a consideration of prerequisite observing behavior is paramount in understanding how more complex discriminations, such as conditional relations and concept formation, are established.

The Evocation of Competing Behavior by the Occasion-Setter

There are several observations from the present experiment that support the interpretation that the occasion-setter may acquire a CS function which interferes with the evocation of the observing response. First, the only subject that acquired observing initially was exposed to a 54-s interval between the occasion-setter and CS onset. The other five subjects who did not acquire observing initially were exposed to smaller intervals (e.g., 24-s, 12-s, and 0-s). If the occasion-setter's temporal relation with food, when it is presented closer to the CS onset, in conjunction with its probabilistic relation makes it the best possible signal of food, then the occasion-setter may acquire a CS function. This hypothesis was supported when three of these subjects (Birds S4, S5, and S6) began to observe during the presence of the occasion-setter only after exposure to several sessions where the occasion-setter was presented without food. Although the extinction sessions allowed for the observing response to occur subsequently during the occasion-setter presentations under the 54-s interval, the observing response was reliably established only after exposure to a trace manipulation. These subjects (Birds S4, S5, and S6) were exposed to an occasion-setter that was presented at the begining of the trial and was turned off 24 s prior to the CS opportunity. That is, there was a 30-s delay between the offset of the occasion-setter and food presentations.

Apparently, the extinction and trace manipulations reduced the occasion-setter's association with food and weakened its ability to function as a CS. When the CS function of the "occasion-setter" was finally weakened enough, less conditioned behavior was elicited, and the observing response could occur during occasion-setting presentations.

An additional observation is the lower rates of observing that occurred for some subjects in the recovery of differential observing. The "occasion-setter" could have acquired CS properties in the preceding simultaneous condition which then interfered with the evocation of observing behavior when the interval was increased.

The interpretation that a stimulus with a CS function interferes with the evocation of observing behavior is consistent with results from more typical occasion-setting procedures. Ross (1983), Ross and LoLordo (1986), and Rescorla (1985; 1988) have reported difficulty in establishing a stimulus as an occasion-setter if that stimulus was previously paired with food. That is, providing a stimulus with a CS function makes it harder for that stimulus to become an occasion-setter. Also, a stimulus that is presented as the "occasion-setter" in a simultaneous procedure has difficulty subsequently acquiring an occasion-setting function (Holland, 1989). Furthermore, Rescorla (1988) has shown that establishing a stimulus as a conditioned inhibitor (i.e., a stimulus which predicts the absence of a US) facilitates the development of the occasion-setting function for that stimulus. The results of these studies are consistent with the interpretation that the "occasion-setter" functioning as a CS, interferes with the establishment of observing behavior.

The possibilty that a CS function of a stimulus interferes with the evocation of observing and, consequently, the development of an occasion-setting effect suggests some potential differences between trace and continuous occasion-setter presentations in the development of differential observing and occasion-setting. Differential observing was established in the trace and continuous procedures suggesting that the type of presentation is not a fundamental variable affecting observing and the occasion-setting effect. But the type of presentation may affect the probability of a stimulus acquiring an elicitive function and, therefore, its ability to evoke observing behavior.

In the continuous procedure the occasion-setter overlaps the CS and always terminates in food deliveries. This association of the occasion-setter with food may increase the likelihood that the "occasion-setter" will function as a CS and interfere with the evocation of observing behavior as described above.

On the other hand, in the trace procedure the offset of the occasion-setter is always followed by a gap of time before food is presented. The delay between the offset of the occasion-setter and the presentation of food should reduce the likelihood of the occasion-setter functioning as a CS. Thus, given the same interval separating the occasion-setter from the CS, observing may be easier to establish in the trace procedure as compared to the continuous procedure. The manner of occasion-setter presentations (trace vs. continuous) may determine the specific intervals between the occasion-setter and CS presentations that produce the occasion-setting effect. But the manner of presentation does not change the basic function: As the interval gets longer the probability increases that the CS can reinforce observing behavior on occasion-setting trials and result in the occasion-setting effect.

The possibility that CS functions of stimuli interfere or compete with the ability of stimuli to function as occasion-setters suggest that the occasion-setting function of a stimulus is indeed different from the CS function. The following discussion explores some ways by which an occasion-setter may function in the occasion-setting procedure.

The Occasion-Setter as a Novel Stimulus Function

The interpetation of an occasion-setter as a modulatory, or a priming, stimulus which affects the ability of other stimuli to evoke behavior requires the explication of a new stimulus function and the development of principles not derivable from current behavior analytic concepts. Traditional stimulus functions, such as discriminative and CS functions, modulate the probability of some aspect of behavior. The interpretation of the Pavlovian occasion-setting effect as the result of operantly reinforced covert and overt attentional adjustments to a stimulus extends the operation of traditional stimulus categories in a theoretically consistent manner.

The observing response hypothesis is similar in principle to Schoenfeld and Cumming's (1963) "perceptual response" and Lawrence's (1963) "coding response" in which unobserved mediating responses were proposed to account for perceptual phenomena and concept formation. Thus, a consideration of the function of an occasion-setter is related to the manner by which stimuli affect these kinds of processes. There are at least two ways to describe the function of an occasion-setter that is consistent with a behavioral analysis: The occasion-setter may function as a discriminative stimulus or the occasion-setter may acquire a motivational function.

First, the occasion-setter may function as a discriminative stimulus to evoke behavior. That is, the occasion-setter is a discriminative stimulus in the presence of which operant-like attentional adjustments are reinforced by the presentation of the CS. The reinforcement of these attentional adjustments by the CS following the occasion-setter presentations increases the probability of observing responses being evoked by future presentations of the occasion-setter. The absence of reinforcement of observing by the CS (when it is not followed by food), on CS-alone trials, results in these adjustments not occurring when the occasion-setter has not been presented. Thus, attentional adjustments are evoked by an occasion-setter as a discriminative stimulus because attending was previously only reinforced when the occasion-setter was presented. This interpretation of the role of an occasion-setter requires no new principles.

Nevertheless, there are some difficulties with this interpretation. A discriminative stimulus evokes behavior that has produced a particular form of reinforcement in the past. The form of reinforcement produced, such as food, is equally effective in the presence or absence of the discriminative stimulus. That is, if the animal could produce food in the absence of the discriminative stimulus, it would do so. It is the past experience of a response producing the reinforcer only in the presence of a particular stimulus that eventually results in the response occurring in the presence of that stimulus and not in its absence. Nevertheless, in the occasion-setting procedure, the CS can be produced or observed just as easily in the presence as in the absence of the occasion-setter. But the probablility of the CS being observed is higher when the occasion-setter was presented. This suggests that the CS as a form of conditioned reinforcement is more effective when the occasion-setter is presented.

If the CS is a more effective form of reinforcement when the occasion-setter has been presented, then its ability to evoke behavior does not arise from the same conditions that give rise to discriminative stimuli. That is, the occasion-setter does not evoke behavior due to a history of differential reinforcement where the animal can only produce the effective form of reinforcement in the presence of one stimulus. Instead the occasion-setter appears to increase the reinforcing potency of the CS. This conceptualization of the occasion-setter is similar to the concept of establishing operations (Michael, 1982). Establishing operations, such as food and water deprivation, are thought to operate by evoking a class of responses that in the past produced the form of reinforcement, like food and water, that was made effective by that establishing operation. For example, a hungry bird may fly to areas where food was discovered in the past or turn over leaves where food has been found before. In the absence of food deprivation these food-seeking responses are less likely to occur. Analogously, an occasion-setter may operate by evoking behavior that has raised the probability of producing a stimulus, namely the CS, which in the past has been the best signal of food when the occasion-setter was presented. As a result, attentional adjustments are evoked by the occasion-setter because the presentation of the CS is a currently effective form of reinforcement, and these adjustments have produced effective contact with the CS before. In the absence of the occasion-setter, the CS is not a signal for food, and so is not a conditioned reinforcer. Thus, the occasion-setting procedure may be a procedure which establishes a stimulus (the occasion-setter) with the ability to evoke behavior in the way that food or water deprivation evoke behavior.

The interpretation of the occasion-setting procedure as an arrangement that establishes a stimulus with a motivational function would require refinements of present stimulus categories in behavior analysis. However, this interpretation is basically an extension of traditional concepts--that is, the occasion-setter functions in a way similar to the way establishing operations function. Others have also suggested the need for this type of acquired stimulus function (Miller, 1948; 1951; Michael, 1982; Kimble, 1961). The advantage of this interpretation of occasion-setting is that it would not require a new theory of behavior consisting of principles incompatible with traditional concepts.

BIBLIOGRAPHY

Brown, P. L., & Jenkins, H. M. (1968). Auto-shaping of the pigeon's keypeck. The Journal of the Experimental Analysis of Behavior, 11, 1-8.

Dinsmoor, J. A. (1983). Observing and conditioned reinforcement. The Behavioral and Brain Sciences, 6, 693-728.

Dinsmoor, J. A. (1985). Observing and stimulus control. The Journal of the Experimental Analysis of Behavior, 43, 365-381.

Hearst, E., & Jenkins, H. M. (1974). Sign-tracking: The stimulus-reinforcer relation and directed action. Monograph of the Psychonomic Society.

Holland, P. C. (1983). "Occasion-setting" in conditional discriminations. In M. Commons, R. Herrnstein, and A. R. Wagner (Eds.) Harvard Symposium on the Quantitative Analysis of Behavior: Discrimination Processes, Vol. IV, (pp. 183-206). New York, NY: Ballinger.

Holland, P. C. (1985). The nature of conditioned inhibition in serial and simultaneous feature negative discriminations. In R. R. Miller and N. E. Spear (Eds.), Information Processing in Animals: Conditioned Inhibition (pp. 267-297). Hillsdale, N. J.:Erlbaum.

Holland, P. C. (1989). Acquisition and transfer of conditional discrimination performance. Journal of Experimental Psychology: Animal Behavior Processes, 15, 154-165.

Jenkins, H. M. (1985). Conditioned inhibition of key pecking in the pigeon. In R. Miller and N. E. Spear (Eds.), Information Processing in Animals: Conditioned Inhibition, (pp. 327-353). Hillsdale, N. J.: Erlbaum.

Kimble, Gregory, A. (1961). Hilgard and Marquis' Conditioning and Learning, (pp. 395-435). Appleton-Century-Crofts: New York.

Lawrence, D. H. (1963). The nature of a stimulus: Some relations between learning and perception. In S. Koch (Ed.), Psychology: A study of a science, Vol. 5, (pp. 179-212). New York: McGraw Hill.

Locurto, C. M., Terrace, H. C., & Gibbon, John (1981). Autoshaping and Conditioning Theory. Academic Press: New York.

Mellon, Robert C., Kraemer, Philip J., & Spear, Norman E. (1991). Development of intersensory function: Age-related differences in stimulus selection of multimodal compounds in rats as revealed by Pavlovian conditioning. Journal of Experimental Psychology: Animal Behavior Processes, 17, 448-464.

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

Miller, N. E. (1951). Learnable drives and rewards. In S. S Stevens (Ed.), Handbook of Expermental Psychology, New York: Wiley.

Miller, N. E. (1948). Studies of fear as an acquired drive: I. Fear as motivation and fear reduction as reinforcement in the learning of new responses. Journal of Experimental Psychology, 38, 89-101.

Rescorla, R. A. (1985). Conditioned inhibition and facilitation. In R. R. Miller and N. E. Spear (Eds.), Information Processing in Animals: Conditioned Inhibition, (pp. 299-326). Hillsdale, N. J.: Erlbaum.

Rescorla, R. A. (1986). Extinction of facilitation. Journal of Experimental Psychology: Animal Behavior Processes, 13, 3-16.

Rescorla, R. A. (1987). Facilitation and Inhibition. Journal of Experimental Psychology: Animal Behavior Processes, 13, 250-259.

Rescorla, R. A. (1988). Facilitation based on inhibition. Animal Learning & Behavior, 16, 169-176.

Ross, R. T., & Holland, P. C. (1981). Conditioning of simultaneous and serial feature-positive discriminations. Animal Learning and Behavior, 9, 159-162.

Ross, R. T. (1983). Relationships between the determinants of performance in serial feature positive discriminations. Journal of Experimental Psychology: Animal Behavior Processes, 9, 349-373.

Ross, R. T. (1982). Serial positive patterning: Implications for "occasion-setting." Bulletin of the Psychonomic Society, 19, 159-162.

Ross, R. T., & LoLordo, V. M. (1986). Blocking during serial feature-positive discriminations: Associative versus occasion-setting functions. Journal of Experimental Psychology: Animal Behavior Processes, 12, 315-324.

Ross, R. T., & LoLordo, V. M. (1987). Evaluation of the relation between Pavlovian occasion-setting and instrumental discriminative stimuli: A blocking analysis. Journal of Experimental Psychology: Animal Behavior Processes, 13, 3-16.

Schoenfeld, W. N., & Cumming, W. W. (1963). Behavior and perception. In S. Koch (Ed.), Psychology: A study of a science, Vol 5, (pp. 213-252). New York: McGraw Hill.

Spence, K. W. (1936). The nature of discrimination learning in animals. Psychological Reveiw, 43, 427-449.

Woodworth, Robert, S. (1934). Psychology, (3rd ed.) (pp. 418-434). New York: Henry Halstead Company.

Wycoff, L. B. Jr. (1952). The role of observing responses in discrimination learning: Part I. Psychological Review, 59, 431-442.

Wycoff, L. B. Jr. (1969). The role of observing responses in discrimination learning. In D. P. Hendry (Ed.), Conditioned Reinforcement, (pp. 237-260). Homewood, IL: Dorsey Press.

Table 1

The Sequence of Conditions for Each Subject.

	Subjects					
Condtions	S1	S2	S3	S4	S5	S6
1	54 (20)	24 (22)	12 (18)	0 (20)	24 (20)	12 (21)
2	12 (19)	54 (41)	54 (30)	54 (26)	54 (115)	54 (40)
3	24 (40)	12 (40)	12 (30)	12 (78)	12[a] (9)	12 (45)
4	0 (40)	6 (37)	24 (30)	24 (40)	18TR (73)	6 (50)
5	54 (24)	0 (62)	54 (15)	54 (41)	12TR (50)	0 (30)
6	12 (31)	24 (30)	24 (45)		0 (25)	24 (40)
7	6 (58)	6 (31)	12 (30)		12TR (45)	54 (52)
8	0 (30)	24TR (25)	54 (15)			
9	24TR (30)					

Note. The conditions are designated by the number of seconds separating the occasion-setter from the CS. Trace presentations of the occasion-setter are indicated by TR. The number of sessions is indicated in parenthesis.

[a]Subject S5 became ill at the begining of this condition. Data for this condition are not presented. Following recovery he was exposed to the trace procedure to reestablish the occasion-setting effect.

Figure 1. Schematic of an occasion-setting procedure.

A Pavlovian Occasion-Setting Procedure

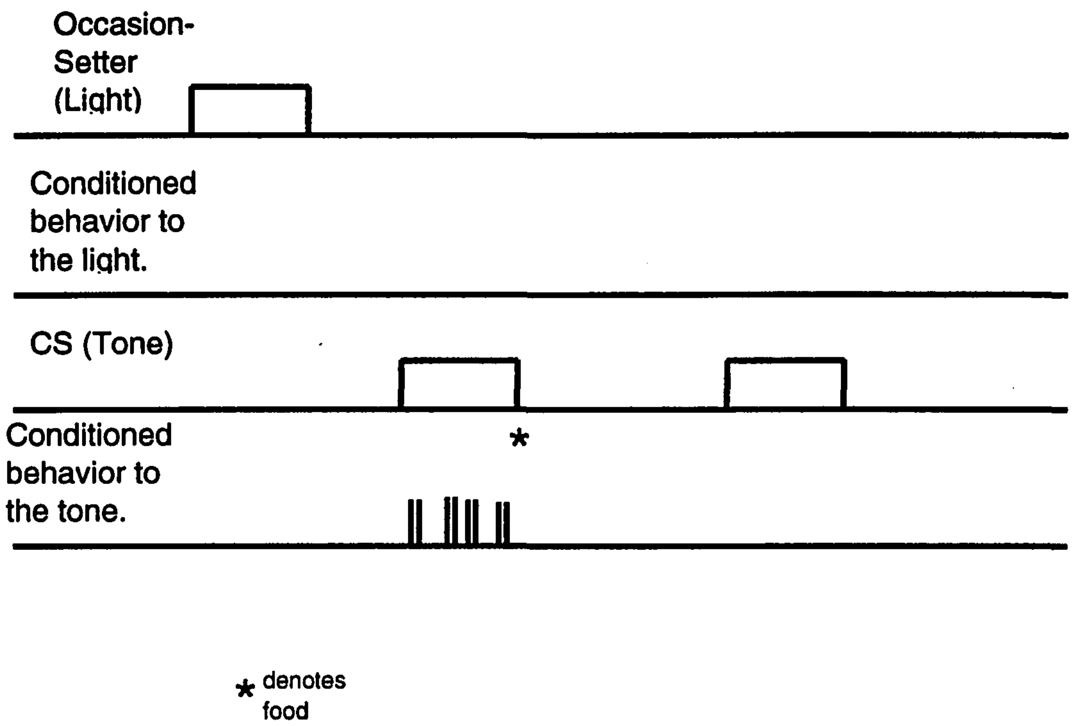


Figure 2. Diagram of the observing procedure. The two types of trials used in the procedure are illustrated. The labeled circles represent key lights illuminated in the procedure. Each trial is initiated by the illumination of the observing key. If it is an occasion-setting trial, the occasion-setter will be illuminated at some point during the trial. If it is a CS-alone trial, the occasion-setter is never illuminated. On each trial the CS-key is darkened and cannot be illuminated until 54s has elapsed in the trial. If the observing key is pecked during the 6s period before the trial ends, the CS-key will be illuminated. Food is presented on occasion-setting trials followed by the intertrial interval. No peck is required to produce food. On CS-alone trials, the end of the trial initiates the ITI.

Schematic of Occasion-Setting Procedure with an Observing Contingency

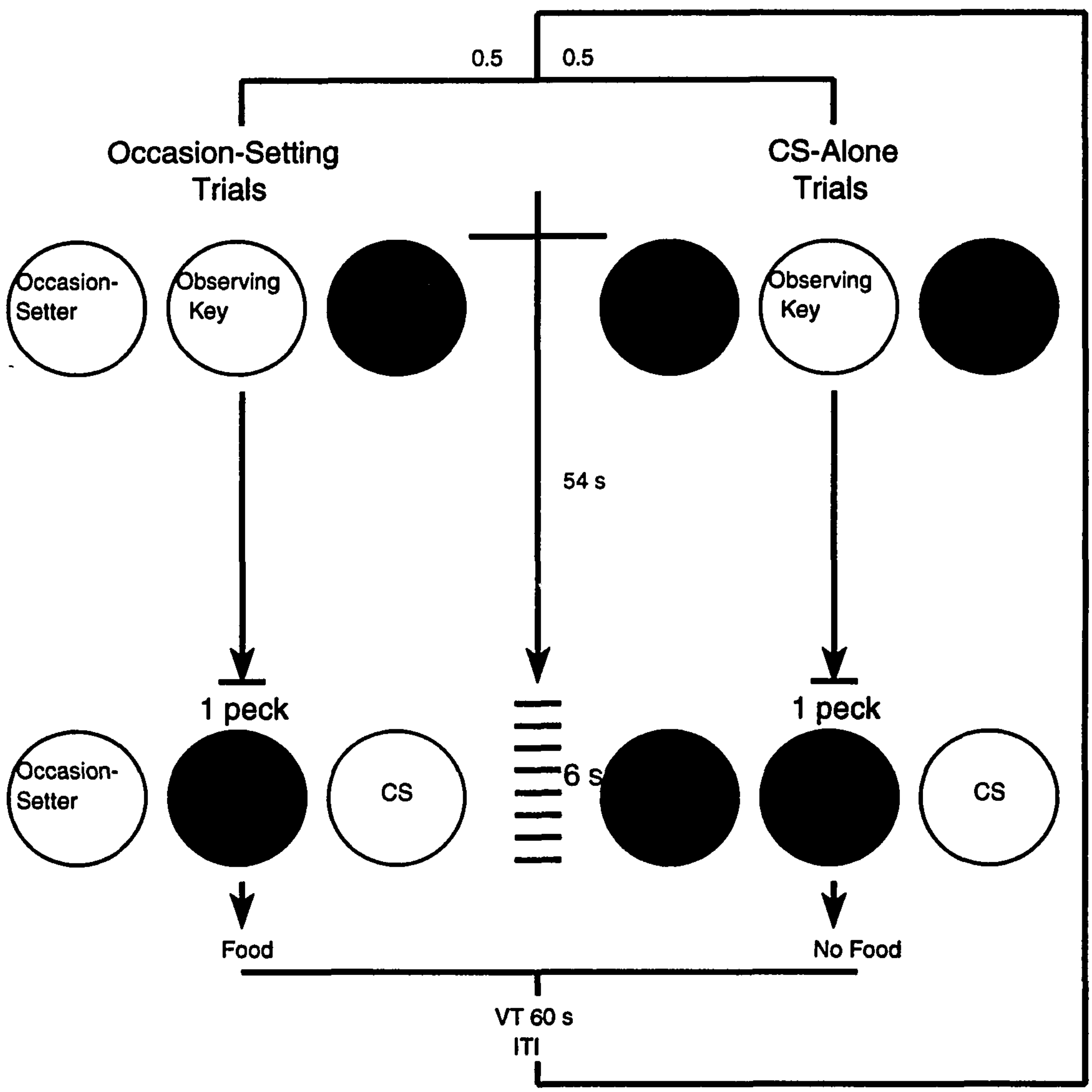


Figure 3: Temporal diagram of three intervals separating the onset of the occasion-setter from the CS. The dotted lines indicate that a peck must occur during that portion of the trial to turn off the observing-key and turn on the CS.

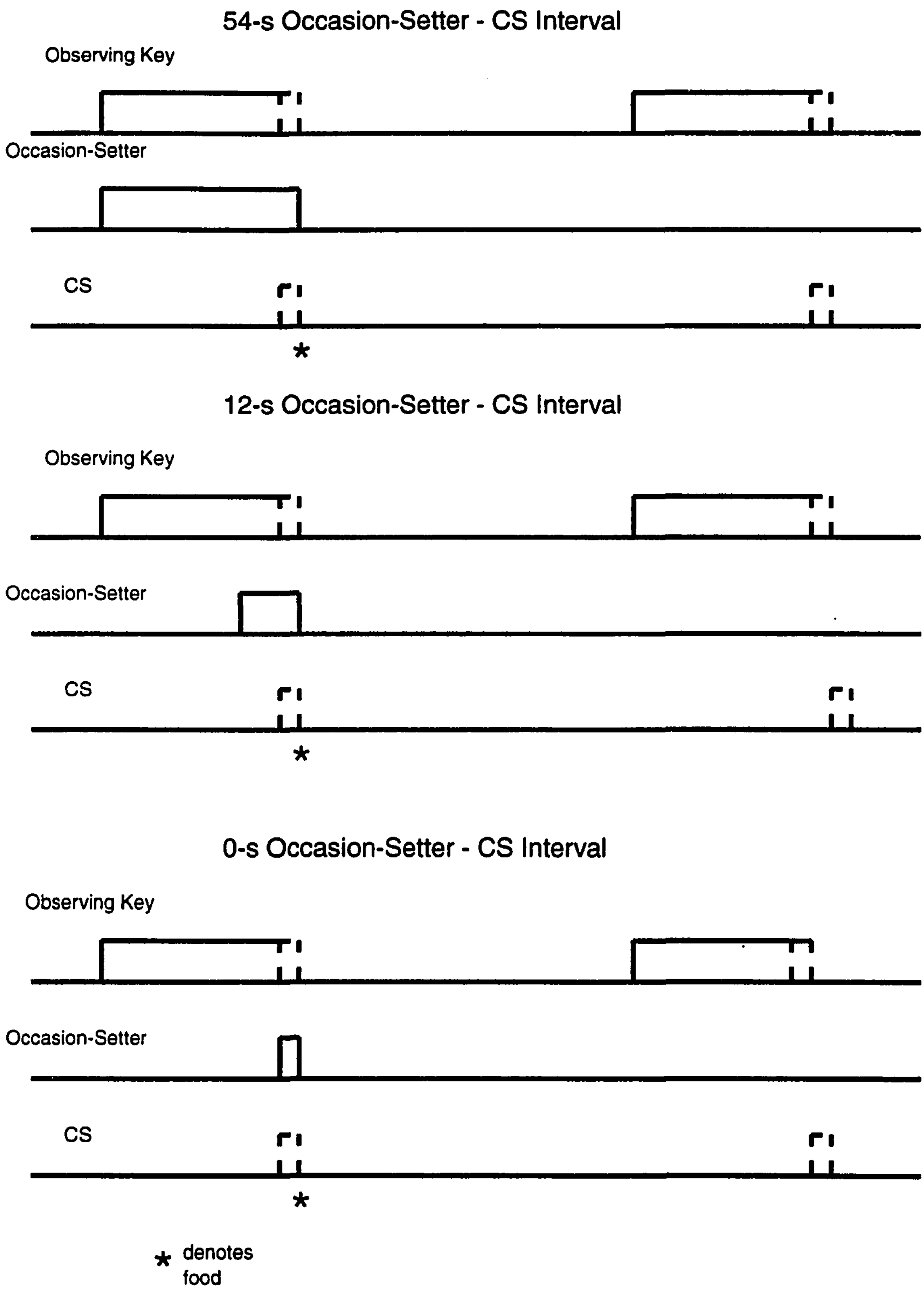
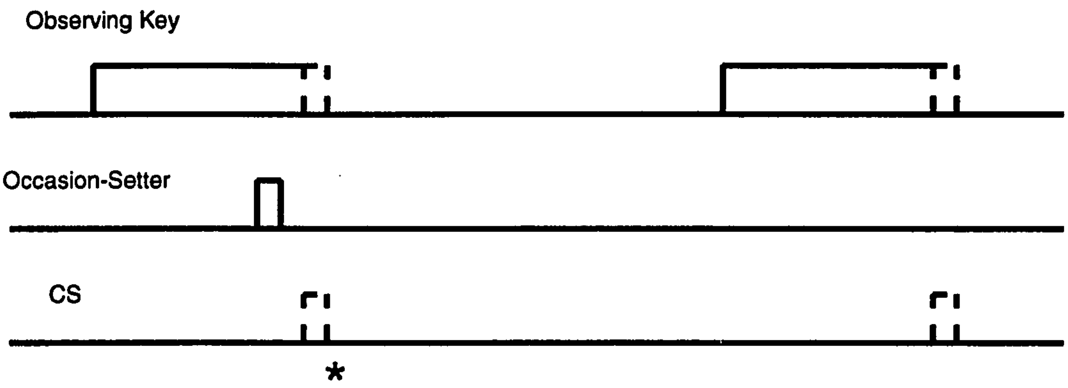

54-s Occasion-Setter - CS Interval
Observing Key
Occasion-Setter
CS
*
12-s Occasion-Setter - CS Interval
Observing Key
Occasion-Setter
CS
*
0-s Occasion-Setter - CS Interval
Observing Key
Occasion-Setter
CS
*
* denotes food

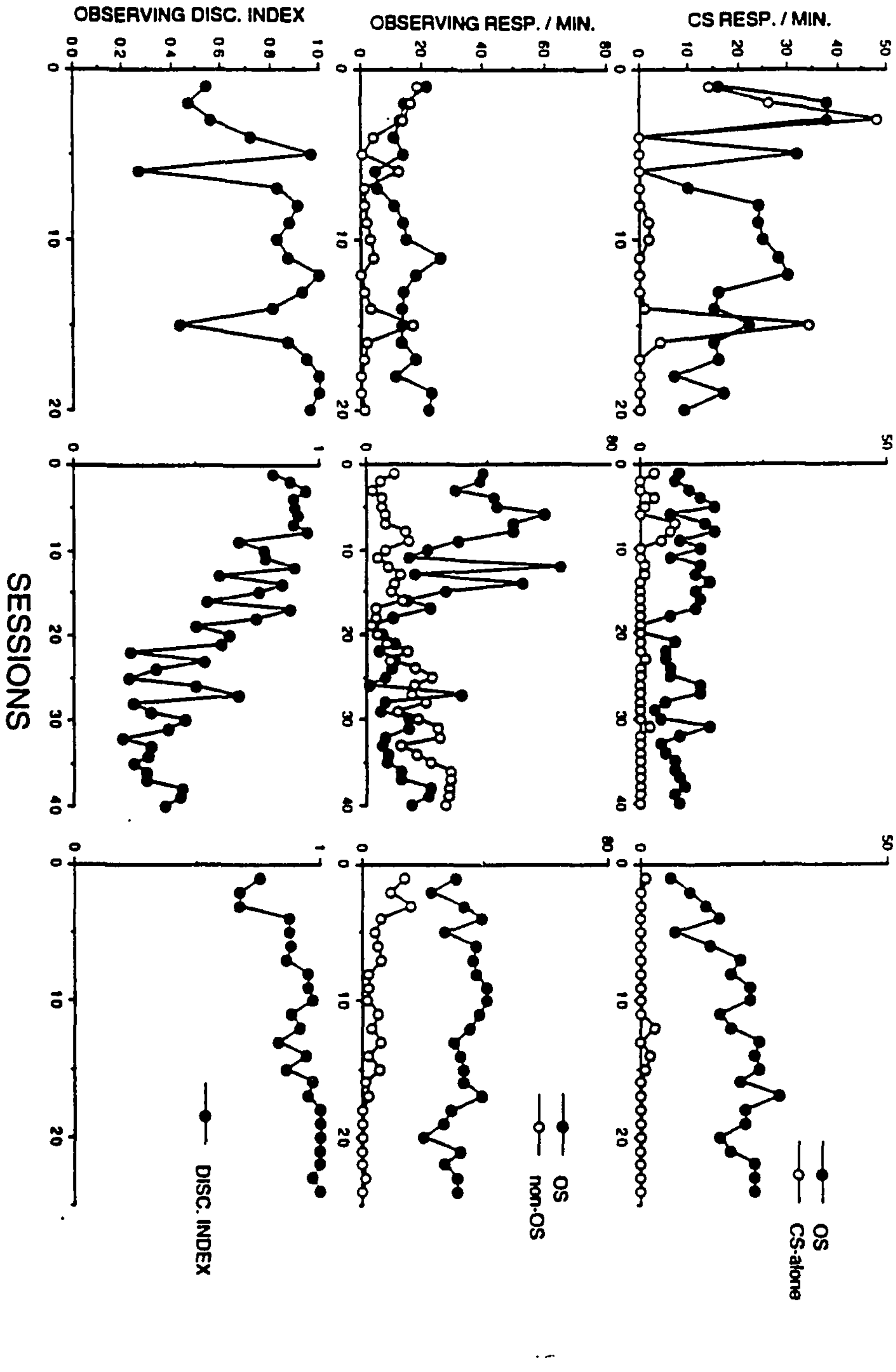
Figure 4: Diagram of a trace presentation of an occasion-setter.

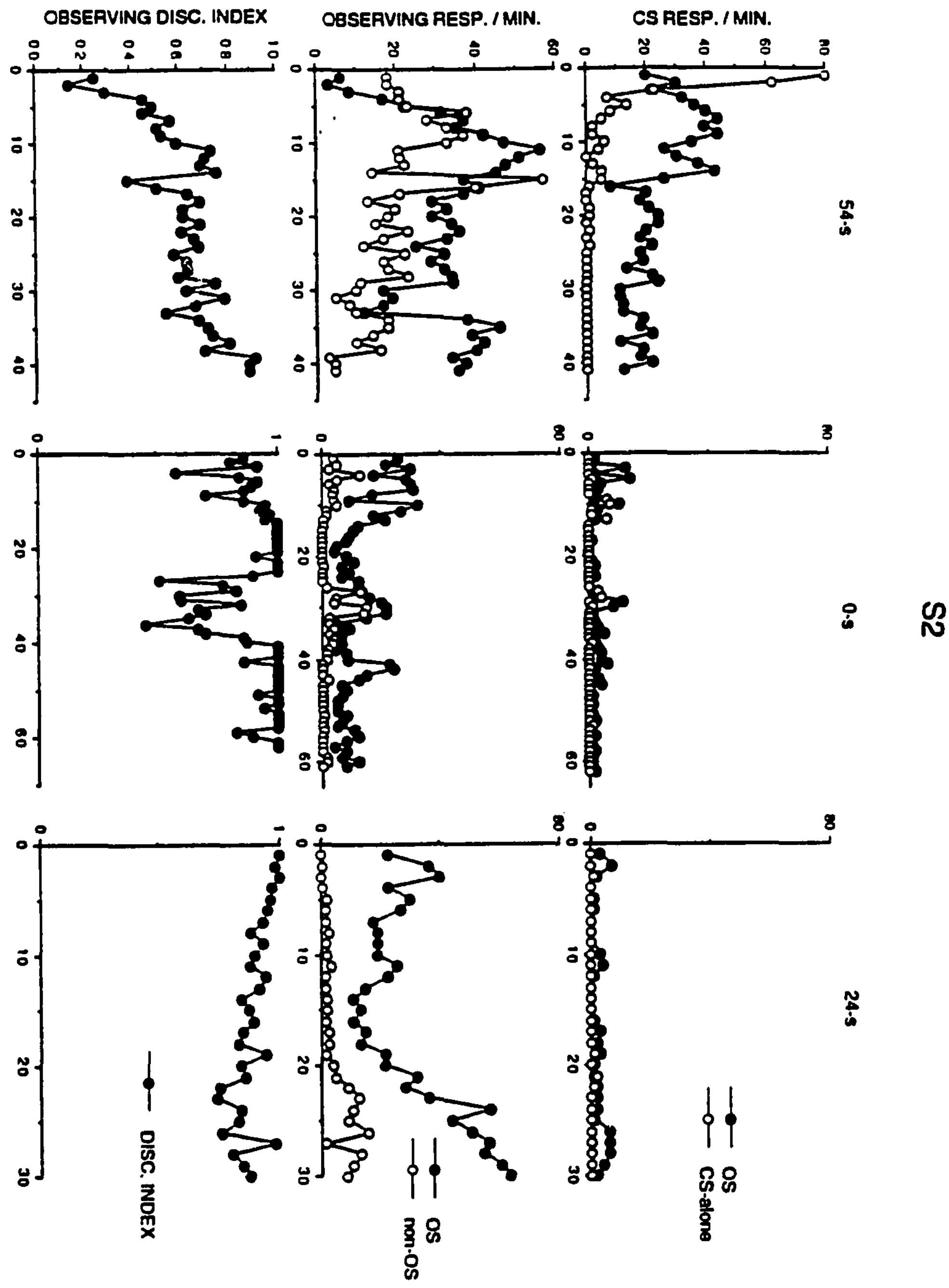
12-s Occasion-Setter - CS Interval
Trace Presentation

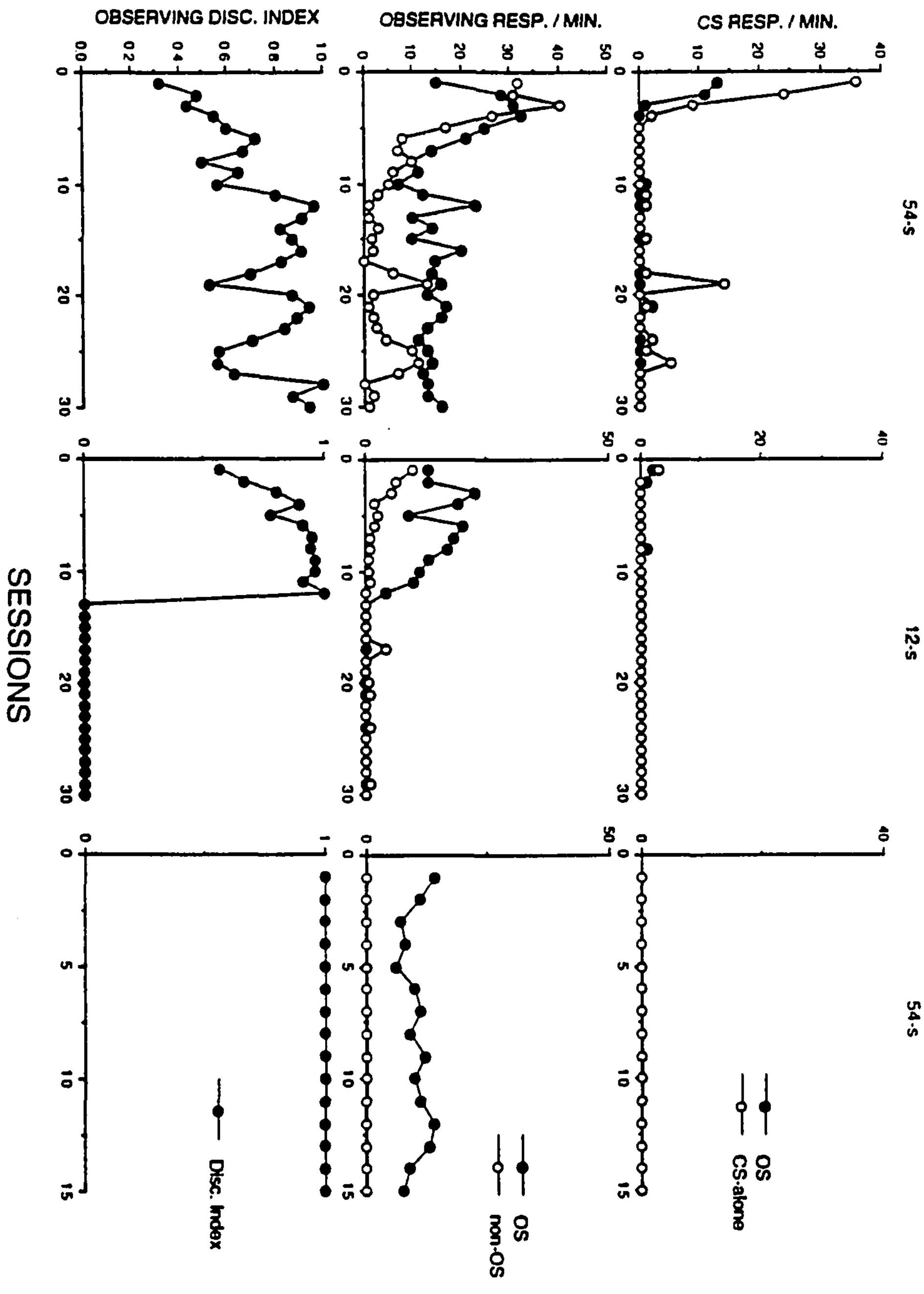


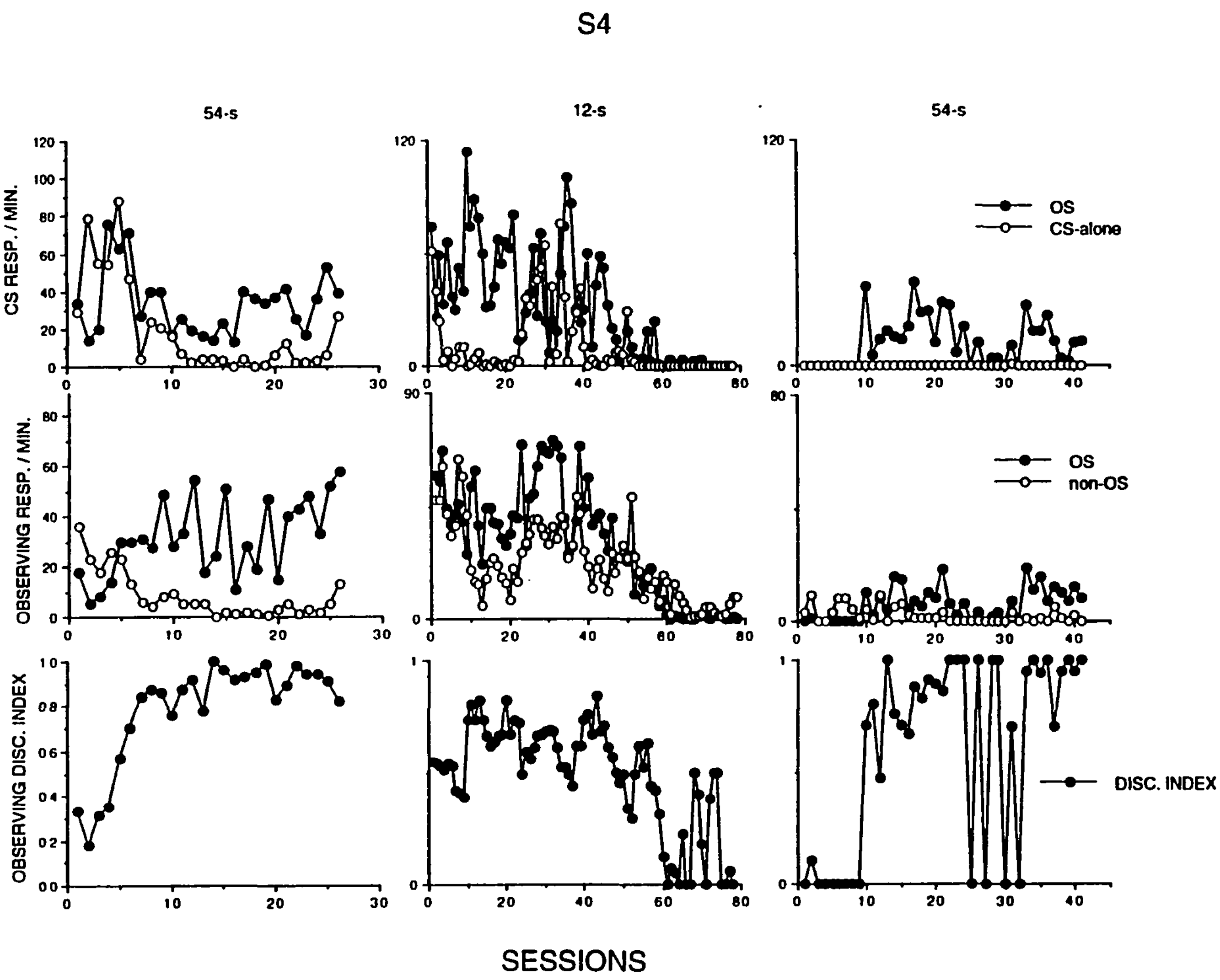
* denotes food

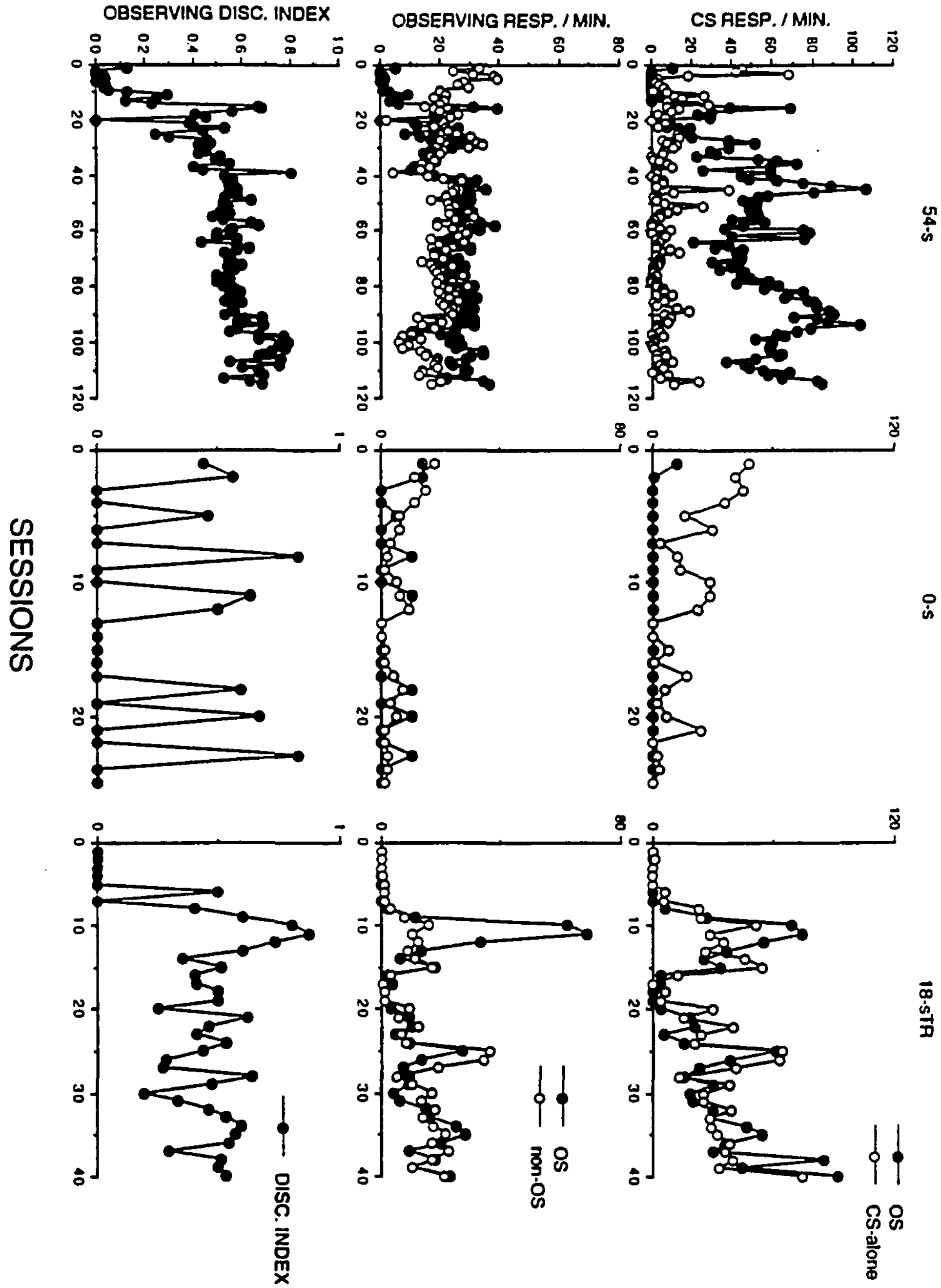
Figure 5. The daily rates of pecking the CS (top row), observing key (middle row), and the observing discrimination index. Each page shows the results for a different subject in the initial 54-s condition (left-hand column of graphs), the condition in which the occasion-setting effect was disrupted (middle column of graphs), and the replication of the occasion-setting effect (right-hand column of graphs).


S1
54-s
0-s
54-s
CS RESP. / MIN.
OBSERVING RESP. / MIN.
OBSERVING DISC. INDEX
SESSIONS
OS
CS-alone
OS
non-OS
DISC. INDEX


S2
54-s
0-s
24-s
CS RESP. / MIN.
OBSERVING RESP. / MIN.
OBSERVING DISC. INDEX
SESSIONS
OS
CS-alone
OS
non-OS
DISC. INDEX


S3
54-S
12-S
54-S
CS RESP. / MIN.
OBSERVING RESP. / MIN.
OBSERVING DISC. INDEX
SESSIONS
OS
CS-alone
OS
non-OS
Disc. Index


S4
54-s
12-s
54-s
CS RESP. / MIN.
OBSERVING RESP. / MIN.
OBSERVING DISC. INDEX
OS
CS-alone
OS
non-OS
DISC. INDEX
SESSIONS


S5
54-s
0-s
18-sTR
CS RESP. / MIN.
OBSERVING RESP. / MIN.
OBSERVING DISC. INDEX
OS
CS-alone
OS
non-OS
DISC. INDEX
SESSIONS

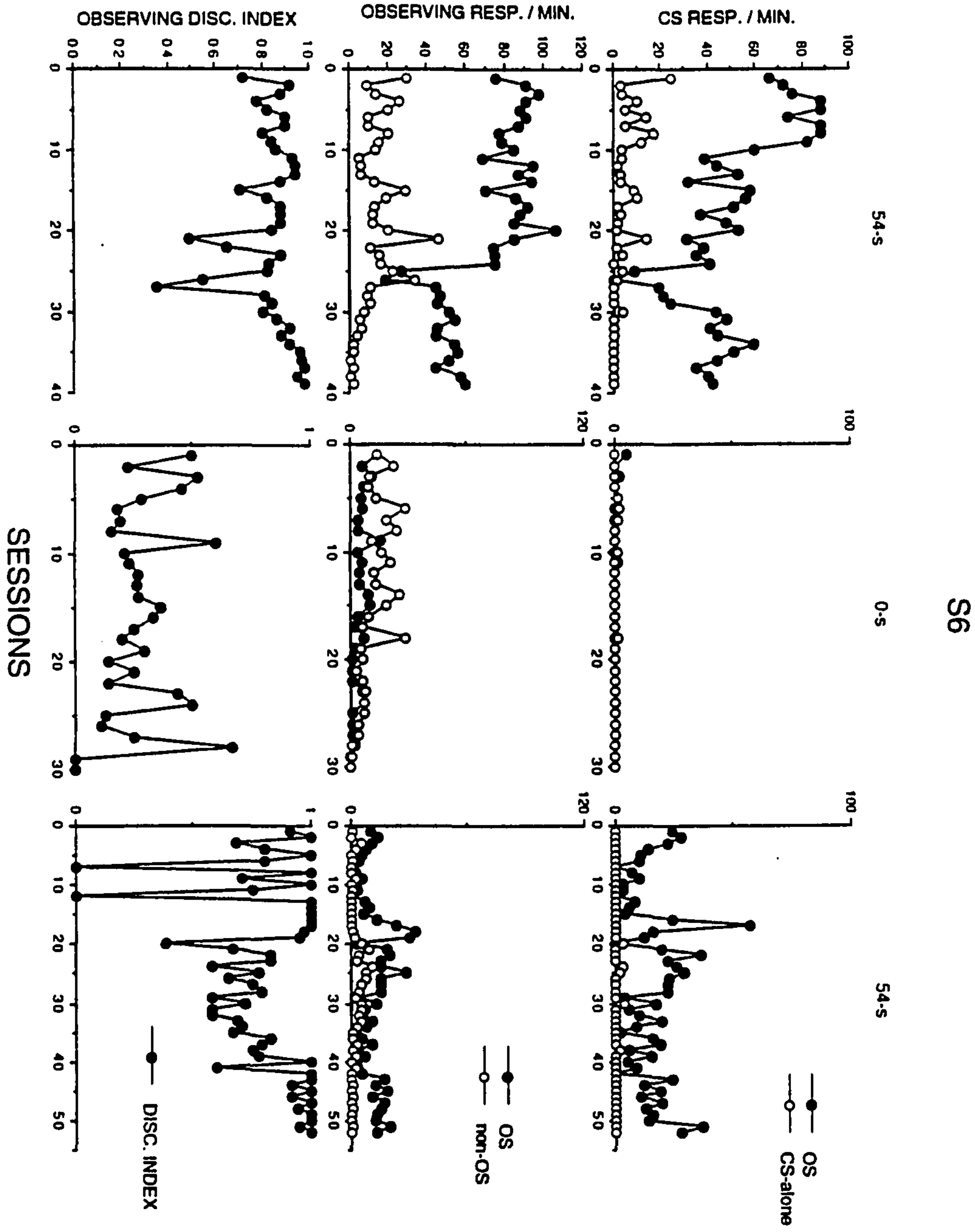
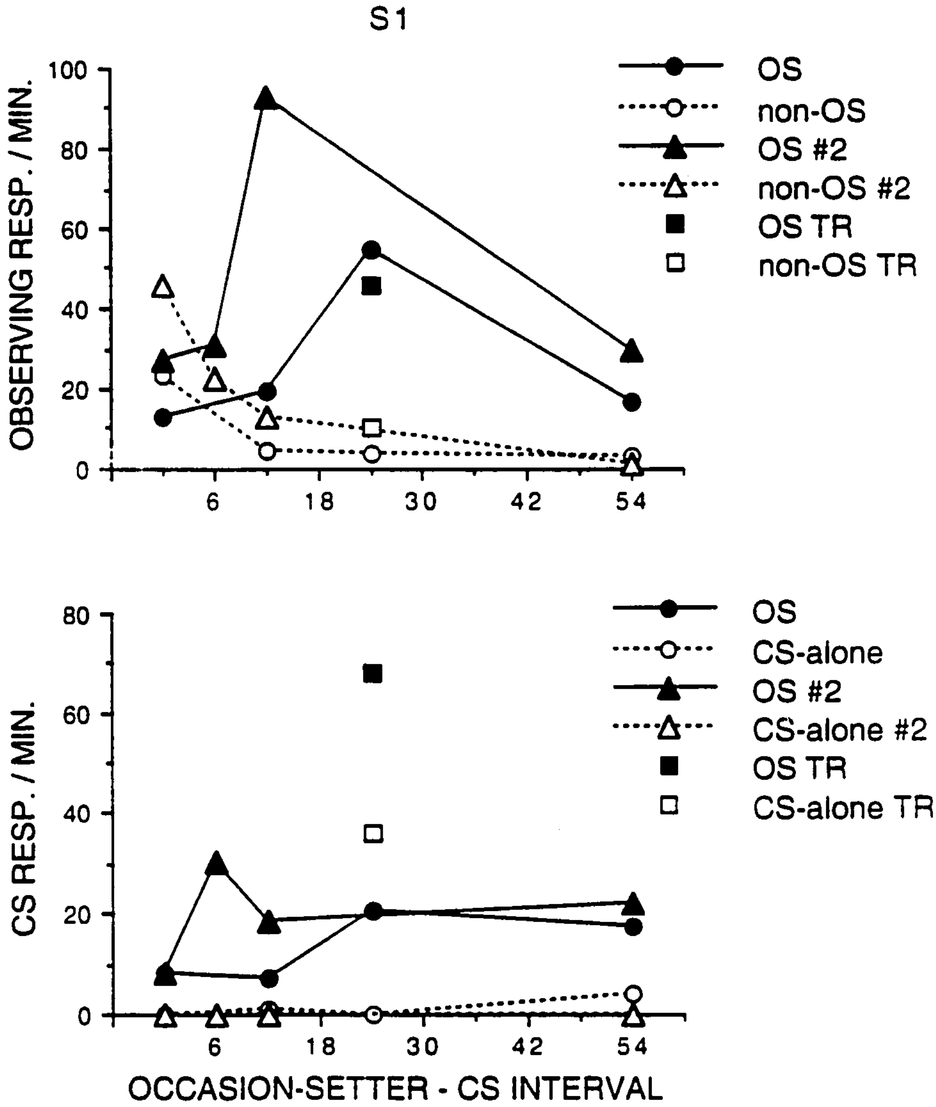
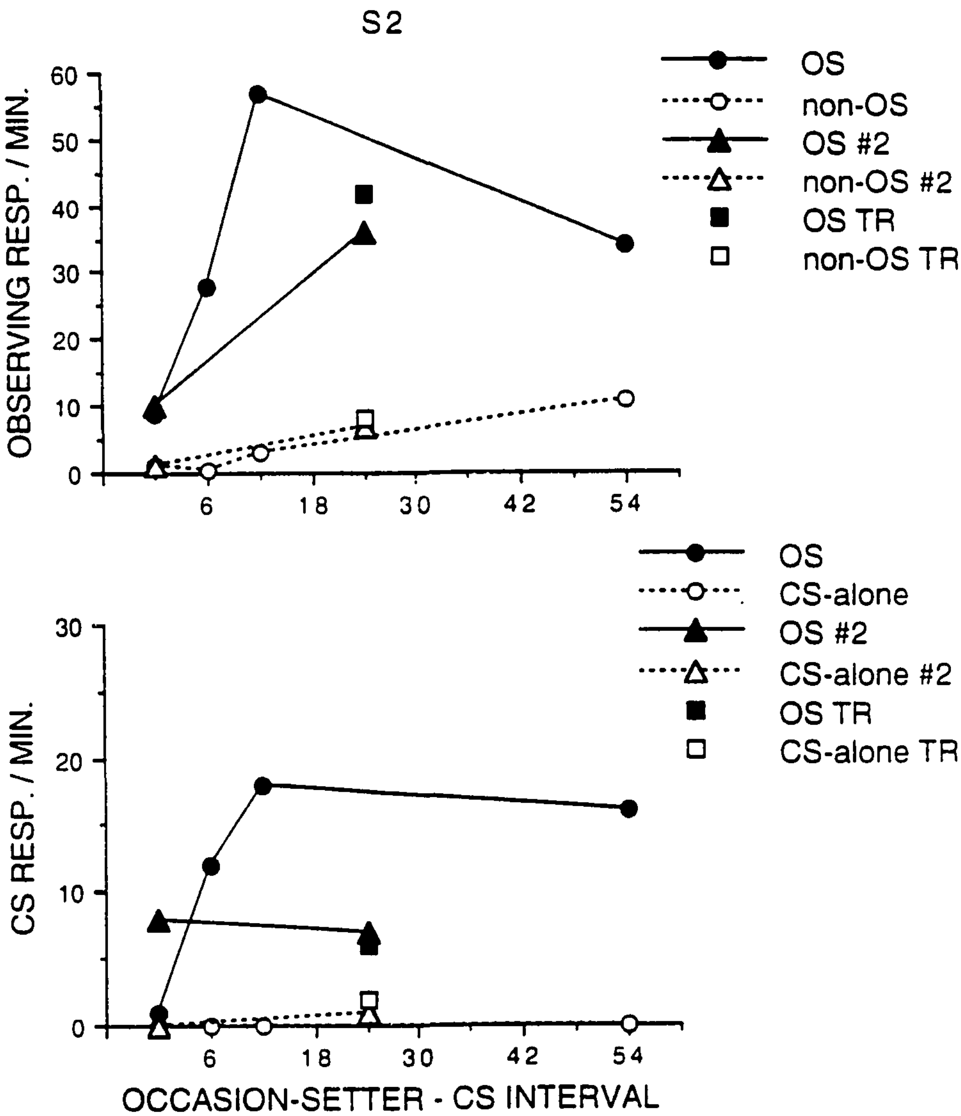
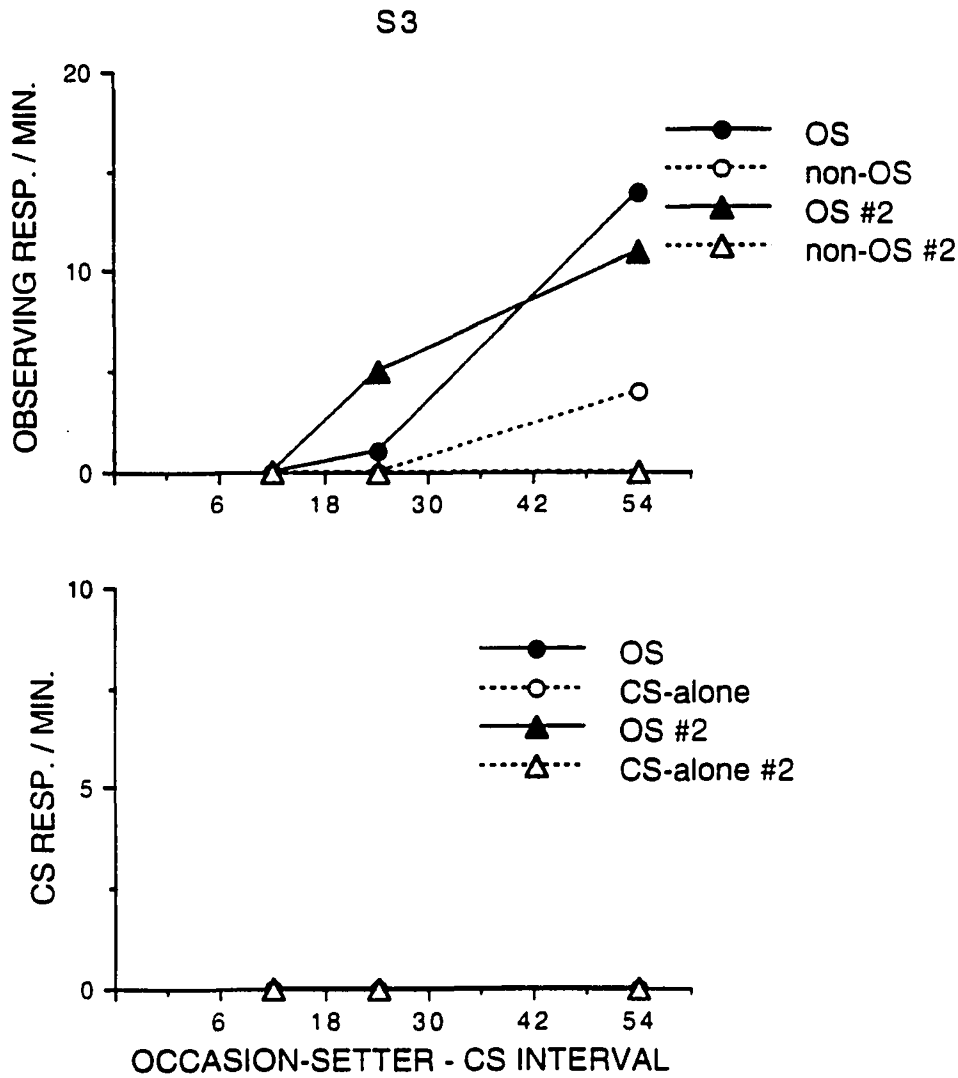
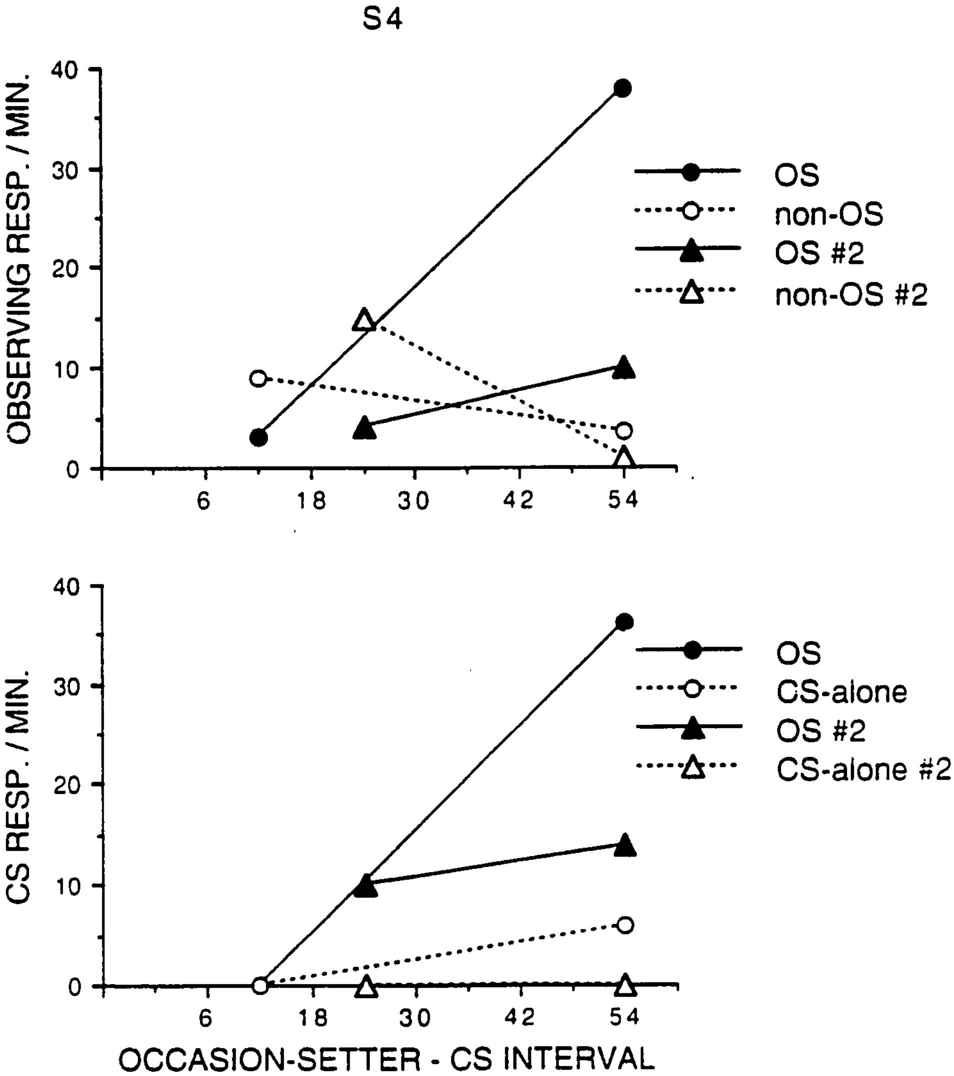

S6
54-S
0-S
54-S
CS RESP. / MIN.
OBSERVING RESP. / MIN.
OBSERVING DISC. INDEX
OS
CS-alone
OS
non-OS
DISC. INDEX
SESSIONS

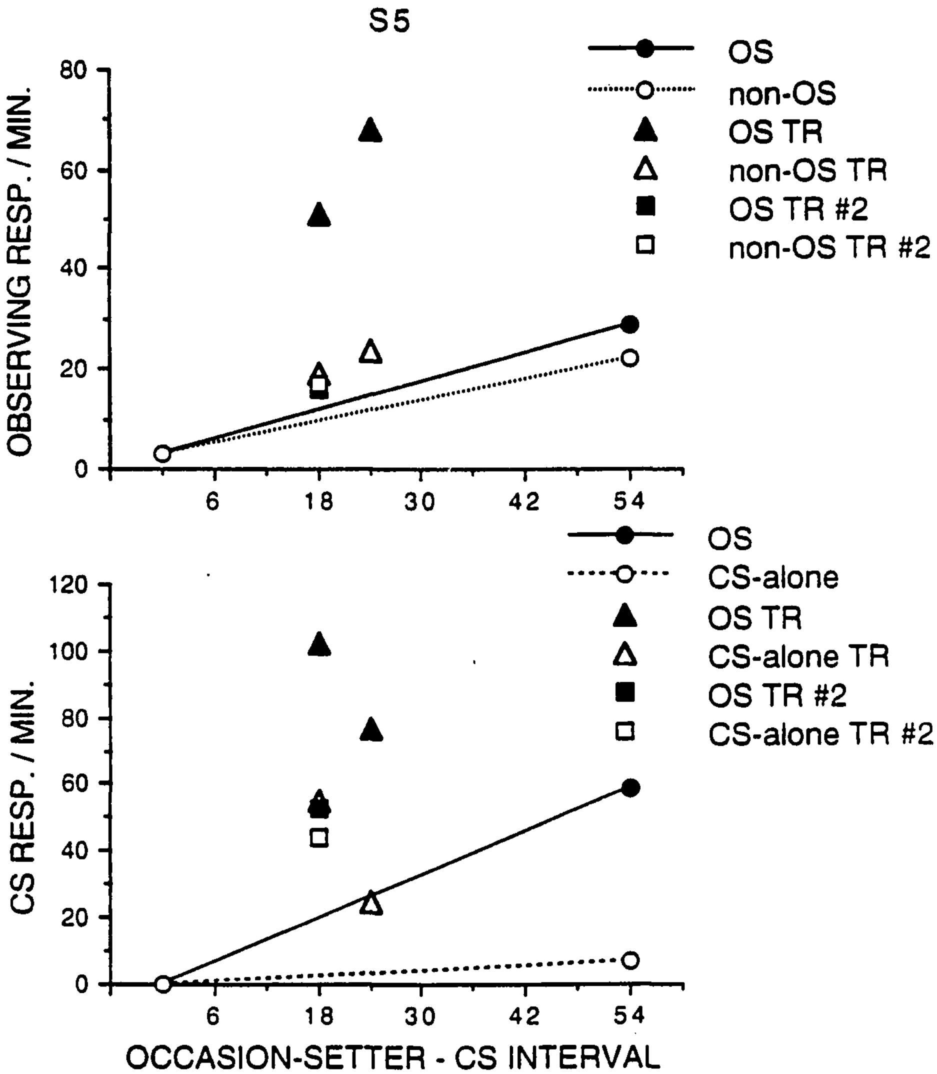
Figure 6. The mean rates of pecking the observing key and the CS-key plotted over the intervals to which each bird was exposed. Each point is the mean over the last 10 days of that condition. Separate functions are shown for the replication of conditions. The response rates for the trace procedure are presented as separate unconnected points.

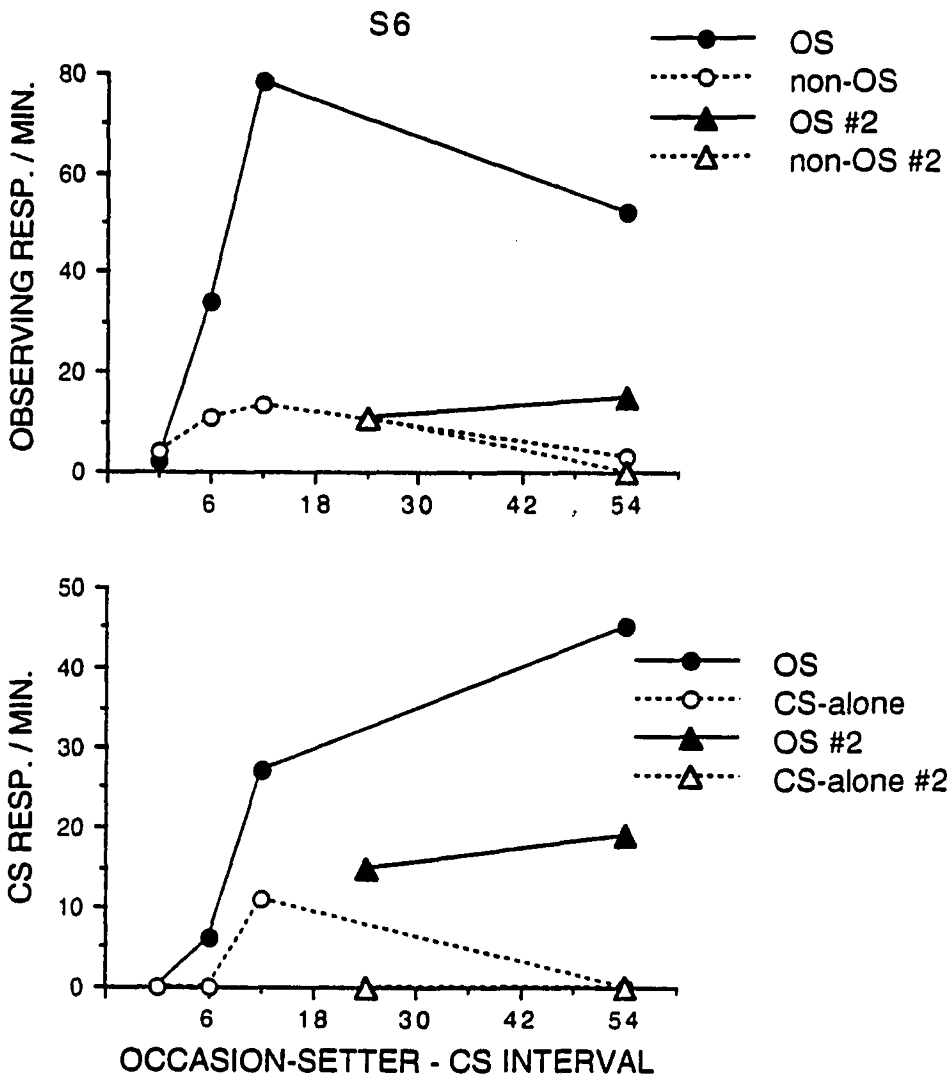

S1
OBSERVING RESP. / MIN.
100
80
60
40
20
0
6
18
30
42
54
OS
non-OS
OS #2
non-OS #2
OS TR
non-OS TR
CS RESP. / MIN.
80
60
40
20
0
6
18
30
42
54
OS
CS-alone
OS #2
CS-alone #2
OS TR
CS-alone TR
OCCASION-SETTER - CS INTERVAL


S2
OS
non-OS
OS #2
non-OS #2
OS TR
non-OS TR
OBSERVING RESP. / MIN.
60
50
40
30
20
10
0
6
18
30
42
54
OS
CS-alone
OS #2
CS-alone #2
OS TR
CS-alone TR
CS RESP. / MIN.
30
20
10
0
6
18
30
42
54
OCCASION-SETTER - CS INTERVAL


S3
OBSERVING RESP. / MIN.
20
10
0
6
18
30
42
54
OS
non-OS
OS #2
non-OS #2
CS RESP. / MIN.
10
5
0
6
18
30
42
54
OS
CS-alone
OS #2
CS-alone #2
OCCASION-SETTER - CS INTERVAL


S4
OBSERVING RESP. / MIN.
40
30
20
10
0
6
18
30
42
54
OS
non-OS
OS #2
non-OS #2
CS RESP. / MIN.
40
30
20
10
0
6
18
30
42
54
OS
CS-alone
OS #2
CS-alone #2
OCCASION-SETTER - CS INTERVAL


S5
OS
non-OS
OS TR
non-OS TR
OS TR #2
non-OS TR #2
OBSERVING RESP. / MIN.
80
60
40
20
0
6
18
30
42
54
OS
CS-alone
OS TR
CS-alone TR
OS TR #2
CS-alone TR #2
CS RESP. / MIN.
120
100
80
60
40
20
0
6
18
30
42
54
OCCASION-SETTER - CS INTERVAL


S6
OS
non-OS
OS #2
non-OS #2
OBSERVING RESP. / MIN.
80
60
40
20
0
6
18
30
42
54
CS RESP. / MIN.
50
40
30
20
10
0
OS
CS-alone
OS #2
CS-alone #2
6
18
30
42
54
OCCASION-SETTER - CS INTERVAL