

Higher order occasion setting

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Higher order occasion setting with serially presented stimuli was investigated in an appetitively motivated, discrete-trial operant study with rats. Reinforcement of barpressing during an occasion-setting light (a discriminative stimulus) was contingent on immediately preceding second-order occasion setters (i.e., a click train or a buzzer served as a conditional discriminative stimulus). Moreover, the meanings of the clicks and buzzer were themselves indicated by a third-order occasion setter that preceded them (i.e., a white noise acted as a second-order conditional discriminative stimulus). Subjects responded more frequently and had shorter latencies to the first response in the presence of the light on trials during which barpressing was reinforced than on trials during which barpressing was not reinforced. The likelihood that the subjects solved the problem by responding to unique compound stimuli was minimized by the insertion of a 5-sec gap between the different controlling stimuli presented on each trial. Thus, these subjects appear to have mastered a second-order conditional discrimination, which is equivalent to third-order occasion setting if the discriminative stimulus (light) is viewed as a first-order occasion setter. Although the subjects learned to respond appropriately to each of the compound stimuli, differences in responding to specific stimuli were consistent with a higher order feature-positive effect. Some implications of higher order occasion setting are discussed, including the issue of independence between the different levels of occasion setting signaled by a single stimulus.

An operant occasion setter (i.e., a discriminative stimulus) signals to the subject when responding will be reinforced (Skinner, 1938), and a Pavlovian occasion setter signals to the subject when a conditioned stimulus (CS) will be reinforced (Holland, 1983, 1985). Occasion setters from these two learning paradigms appear to have common properties in that occasion setters from one paradigm have the potential to transfer their conditional properties to the other paradigm (Davidson, Aparicio, & Rescorla, 1988). These phenomena are comparable to the well-documented transfer of occasion setting that is seen within a single paradigm. In positive occasion setting, the presence of the occasion setter predicts reinforcement of the CS or instrumental response, and in negative occasion setting, the presence of the occasion setter predicts nonreinforcement of the CS or response (Holland, 1985). The recent resurgence of interest in occasion setting has been due largely to the apparent independence of a given stimulus's role as a Pavlovian excitator from its role as an occasion setter. That is, the occasion-setting attribute of a stimulus does not substantially influence the ease with

which the stimulus can be made into a Pavlovian excitator, and the Pavlovian excitatory attribute of a stimulus does not influence the ease with which the stimulus can be made into an occasion setter (Holland, 1983, 1985, 1990; Rescorla, 1985, 1986, 1987; Ross, 1983). These observations suggest that there may be a family of phenomena for occasion setting that is parallel to, but largely independent of, the well-known phenomena of simple excitatory learning (e.g., acquisition, extinction, blocking [but see LoLordo & Ross, 1990], overshadowing, stimulus generalization, and discrimination).

One should not infer from the preceding remarks that we have a complete understanding of occasion setting at this time. Further research is needed to determine the boundary conditions for most of the preceding phenomena. Of particular concern is whether or not occasion setting produced with different procedures is equivalent (e.g., serial vs. simultaneous occasion setting, operant vs. Pavlovian). However, the present experiment tentatively presumes such an equivalence and focuses on demonstrating what we call *higher order occasion setting*.

Traditional occasion setters (i.e., first-order occasion setters) tell a subject what event will follow a CS or response. Analogously, subjects may be able to learn that a higher order occasion setter signals whether a first-order occasion setter is a positive or negative occasion setter (this would constitute second-order occasion setting). Similarly, a third-order occasion setter might signal whether another stimulus is a positive or negative second-order occasion setter for a first-order occasion setter (which in the present case was a discriminative stimulus). The present study was designed to determine whether rats

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could master tasks that hinged on information provided by second-order and third-order occasion setters.

We were encouraged in our efforts to obtain higher order occasion setting by a number of earlier studies that may have demonstrated higher order occasion setting. However, most of those experiments presented the putative higher order occasion setters simultaneously with the first-order occasion setter, and consequently allow alternative explanation in terms of simple stimulus control of behavior by a unique cue composed of the compound of the simultaneously presented cues. For example, in one study, Nevin and Liebold (1966) taught a pigeon to solve an oddity problem with keylights during the presence of a diffuse yellow light, and to solve a matching task using the identical keylights in the absence of the yellow light. Although the subject clearly solved both problems, the simultaneous presentation of the yellow light and keylights invite explanation in terms of stimulus control by a unique cue composed of the different lights. Numerous other reports provide evidence that the ability to solve such discriminations occurs across numerous species and specific procedures (e.g., Asratyan, 1961; Lashley, 1938; Nissen, 1951), but in most of these studies the simultaneous presentation of the putative first-order and second-order occasion setters again invites interpretation in terms of configuring as a viable alternative to higher order occasion setting.

A study by Thomas, Curran, and Russell (1988) stands out as particularly suggestive that apparent higher order occasion setting is not merely behavioral control by configured stimuli. They trained pigeons on a series of operant conditional discriminations (i.e., potentially second-order occasion setting) using discriminative stimuli that were either diffuse or localized in space and time. Similarly, the conditional discriminative stimuli were either diffuse or localized. Their results, although complicated, suggested that conditional discriminations were acquired most readily when the conditional cue and the discriminative stimulus have different temporal features, that is, diffuse cues proved to be the most effective occasion setters for localized discriminative stimuli, and localized cues proved to be the most effective occasion setters for diffuse discriminative stimuli. Thus, occasion setting appears to be easiest to achieve under exactly those conditions that are thought to *minimize* configuring of the stimuli (Rescorla, Grau, & Durlach, 1985). The present research attempted to demonstrate higher order occasion setting by using serial presentation of the stimuli with gaps between cues so as to make configuring relatively implausible.

Perhaps the greatest impetus for the present research came from prior experiments that demonstrated conditional discriminations, particularly when testing was delayed relative to the conditional discriminative stimulus (i.e., symbolic delayed matching-to-sample), thereby rendering particularly implausible a unique cue explanation (e.g., Edwards, Miller, & Zentall, 1985; Maki, 1979). However, studies of delayed matching-to-sample have traditionally focused on memory structure and capacity, in contrast to the emphasis placed on levels of oc-

casione setting in the present research. If we tentatively viewed delayed matching-to-sample as an example of occasion setting, it would be categorized as second order, in contrast to the third-order occasion setting that we examined in the present experiment.

In our experiment, barpressing was reinforced in the presence of stimulus L (a light). Not all L trials led to reinforcement; rather, stimuli B1 and B2 (a click train and a buzzer) preceded L trials, thereby signaling availability or unavailability of reinforcement during the light. For example, if stimulus B2 indicated that water was available during stimulus L, stimulus B2 was termed a second-order positive occasion setter. If stimulus B2 signaled that barpressing would not be reinforced during stimulus L, stimulus B2 was termed a second-order negative occasion setter. To make this a third-order occasion-setting preparation, stimuli B1 and B2 were themselves sometimes preceded (and occasion set) by another stimulus, stimulus A, which was a white noise. Stimulus A signaled whether stimuli B1 and B2 were second-order positive or second-order negative occasion setters. Specifically, when stimulus A preceded stimulus B1, B1 was a second-order positive occasion setter, and when stimulus A preceded stimulus B2, B2 was a second-order negative occasion setter. In the absence of stimulus A, the meanings of stimuli B1 and B2 were reversed; that is, stimulus B1 became a second-order negative occasion setter and stimulus B2 became a second-order positive occasion setter.

An alternative explanation for the phenomenon referred to as occasion setting is that the animal is treating the totality of the stimuli presented on any one trial type as a unique stimulus. In order to make this unique cue hypothesis less plausible, we presented the stimuli serially and then, after apparent higher-order occasion setting had already been displayed, we inserted temporal gaps at the points of interface between the stimuli.

The present discrimination could in principle have been solved by rats simply barpressing once each time the light was presented, and if that response was reinforced then continuing to barpress for the remainder of the light presentation. Such a strategy would not require any knowledge of the meanings of the other conditional stimuli. To determine whether or not the rats were using this strategy, latencies to the first barpress during each light were recorded, because the first response during each light preceded any possible feedback from reinforcement on that trial. At issue was whether subjects were faster in making the first barpress in the presence of each reinforceable light than in making the first barpress in the presence of each nonreinforceable light.

METHOD

Subjects

The subjects were 24 (12 male and 12 female) naive adult Sprague-Dawley-derived rats bred in our colony. At the start of the experiment, the body weights of the males were 215-300 g and those of the females were 170-220 g. The subjects were individually housed in wire-mesh cages in a vivarium maintained on a 16-h-light/8-h-

dark cycle. Running was done roughly midway through the light phase. The subjects were allowed ad-lib access to food (Purina Lab Chow). A progressive water-deprivation schedule was administered over the week prior to the initiation of running, until water availability was limited to 10 min per day, given approximately 1 h after any scheduled treatment. All animals received identical treatment except for the counterbalancing of which auditory stimulus (clicks or tone) served as stimulus B1 and which served as stimulus B2.

Apparatus

The apparatus consisted of 12 operant chambers, each measuring $30.5 \times 26.0 \times 26.7$ cm ($l \times w \times h$). All chambers had clear Plexiglas ceilings and side walls (one hinged to serve as a door) and metal front and back walls. Chamber floors were constructed of parallel, stainless steel rods. Each chamber contained a liquid dipper (0.04-ml cup) that entered the chamber through the bottom of a 5-cm-diam, 2-cm-deep recess left-right centered on the front wall, with the bottom edge of the recess 1 cm above the floor. The front wall was parallel to the metal rods that constituted the floor. An operant bar was located on the front wall 2.5 cm to the side of the dipper recess and 3 cm above the floor. A 1.12-W shaded, incandescent houselight, located at the top of the front wall, could dimly illuminate the apparatus. In the center of the ceiling was a 7.5-W incandescent light that, when on, could serve as the discriminative stimulus for barpressing being reinforced with water. Each chamber was housed in a controlled environmental shell with an exhaust fan. The background sound in the chambers was a 76-dB(C) (SPL) hum from the ventilation fans. Each chamber was equipped with two 10-cm square, 45- Ω speakers that could deliver, respectively, a 3/sec click train 8 dB(C) above background and a white noise 6 dB(C) above background. Additionally, a buzzer 10 dB(C) above background was available. All auditory cue durations were 5 sec.

Procedure

Barpress training was done with the 7.5-W light on, using a sequence of increasingly demanding schedules of reinforcement (FT 120+CRF, CRF, and VI5). The subjects were shaped for one session per day until all subjects responded vigorously on the VI 5-sec schedule. Session length was 1 h.

Days 1-2. A reinforcement was made available to the subjects every 120 sec regardless of whether or not they barpressed. In addition, the animals received a reinforcement for each barpress they made (i.e., CRF concurrent with FT 120). The 7.5-W light was on throughout the session.

Days 2-5. The subjects received reinforcement only when they barpressed (CRF). The criterion for advancement to the next phase of training was 50 barpresses/h. The 7.5-W light was on for the entire session.

Day 6. All subjects were reinforced on a VI 5-sec schedule for barpressing. Again, the 7.5-W light was on throughout the session.

Days 7-37. The subjects were run on only 20 of these 30 days. Daily sessions were divided into 40 discrete 90-sec trials. On each trial, the last 30 sec consisted of a light presentation, during which all animals were on a VI 5-sec schedule. At all other times, barpressing was recorded but no reinforcer was available. Thus, the 7.5-W light served as a discriminative stimulus, that is, a first-order occasion setter. By the 12th day of this treatment, all animals met the criteria of at least 50 barpresses in the 1-h session and at least 3 times the number of barpresses per unit time during the 7.5-W light as during the nonlight periods within a trial. (Since the animals spent twice as much time in the nonlight as in the light periods, the number of barpresses during the nonlight periods was divided by 2 before the barpress frequency discrimination ratio was calculated.) Upon reaching these criteria, all animals received 8 more days of training in order to stabilize the discrimination.

Days 38-55. Higher order discrimination training was given. Three 5-sec auditory stimuli were used in addition to the light, which was now reduced in duration to 30 sec. The auditory cues were a white noise (A) and a click train and a buzzer (B1 and B2 counterbalanced across animals). During each session, the subjects experienced eight different trial types (see Figure 1) in a pseudorandomized order, with each trial type occurring six times per session. Trial Types 1-4 consisted of light presentations with barpressing during the light being reinforced or not reinforced as a function of the pattern of A, B1, and B2 stimuli that preceded it. Trial Types 5-8 consisted of stimulus A leading to B1 and B2 and presentations of B1 and B2 alone, with neither presentation of the light discriminative stimulus nor reinforcement being available. Trial Types 5-8 both served to decrease any simple excitatory strength that the auditory cues might otherwise have accrued, and allowed us to look for responding after the auditory cues in the absence of the light to determine if the auditory stimuli were simple excitors that elicited delayed responding. Offset of stimulus A coincided with onset of stimulus B1 or stimulus B2, and on Trial Types 1-4 offset of stimuli B1 and B2 coincided with onset of the light. The intertrial interval varied, averaging 47.5 sec during the session. Criterion performance was now defined as all subjects exhibiting at least a 3:1 discrimination ratio of barpress frequency during the 7.5-W light presentations that corresponded to reinforcement being available to barpress frequency during light presentations that corresponded to reinforcement being unavailable.

Days 56-72. To reduce the likelihood that subjects were configuring stimuli to form a unique cue despite the serial presentation of the stimuli or that subjects were responding on the basis of the interfaces between stimuli (e.g., barpress during the light if there is a B2-light interface), temporal gaps were inserted between the stimuli within a trial. Consequently, on Days 56-63, all conditions remained as before except that 2.0-sec gaps were inserted between stimulus A and the B stimuli and between the B stimuli and the 7.5-W light. Thus, a trial would consist of the presentation or absence of stimulus A for 5 sec, a 2-sec gap, presentation of stimulus B1 or stimulus B2 for 5 sec, a 2-sec gap, and presentation or absence of the light for 30 sec. After Day 63, on which more than 80% of the subjects achieved discrimination ratios of 3:1 or greater between the reinforced and nonreinforced light presentations, the gaps were increased. On Days 64-72, the temporal gaps between stimuli within a trial were 5.0 sec.

Days 73-74. On Day 73, only the trials that did not include stimulus A were run. On Day 74, only the trials that included stimulus A were run. This was necessary because, due to limitations of our equipment, we had to assess responding on trials containing stimulus B1 separately from trials containing stimulus B2. All gaps between stimuli within a trial were 5 sec.

TRIAL TYPES

1) A --> B1 --> L+	5) A --> B1 --> -
2) B1 --> L-	6) B1 --> -
3) A --> B2 --> L-	7) A --> B2 --> -
4) B2 --> L+	8) B2 --> -

Figure 1. Trial types used on Days 38-72. Stimuli A (white noise) and B1 and B2 (clicks and tone counterbalanced across animals) were all 5 sec in duration. The discriminative stimulus L (light) was 30 sec. Responses during the light were either reinforced with water (+) on a VI5 schedule or not reinforced (-). Each trial type occurred six times per day.

Throughout the experiment, latencies to the first barpress during each light presentation were recorded. These data were used to determine whether the subjects were simply barpressing once at the onset of each light presentation to determine whether reinforcement was available and then predicating subsequent behavior on the outcome of this first barpress. If the subjects were indeed solving the problem through the use of this sampling technique, then there would be no need to invoke the notion of occasion setting. A comparison of reinforceable and nonreinforceable trials would find equal latencies to the first barpress on each type of trial if the animals were using the sampling technique but longer latencies on the nonreinforceable trials if the A and B stimuli were acting as higher order occasion setters.

RESULTS

Frequency Data

Mean barpress frequency discrimination ratios were calculated daily for each animal by dividing the number of barpresses made in the presence of the 7.5-W light during which barpresses were reinforced (R) by the number of barpresses made in the presence of the light during which barpresses were not reinforced (N). Ratios greater than 1 indicate more responding during reinforced light presentations than during nonreinforced light presentations. Random responding, or use of simple thumb rules such as "respond if the light is preceded by a specific number of auditory stimuli," would yield a ratio of 1. For statistical analysis, daily ratios for each animal were averaged over the last 4 days of training with each level of interstimulus temporal gaps before the across-days group averages were calculated. With no gap between stimuli (Days 51-55), the average ratio was 8.86 [$t(23) = 4.57, p < .01$]. With a 2.0-sec gap (Days 60-63), the average ratio was 12.01 [$t(23) = 2.61$ (decreased t reflects increased variance), $p < .01$]. A further widening of the temporal gap to 5.0 sec resulted by Days 69-72 (see Figure 2) in a ratio of 9.46 [$t(23) = 4.97, p < .01$]. Because there were two types of reinforced trials and two types of nonreinforced trials during which the light was presented, two separate frequency discrimination ratios were calculated on the basis of trials that included stimulus B1 (A → B1 → L+ and B1 → L-) and those that included stimulus B2 (B2 → L+ and A → B2 → L-). Both ratios were significantly greater than chance. For trials containing stimulus B1, the frequency discrimination ratio was 7.30 [$t(23) = 6.06, p < .01$]. For trials containing stimulus B2, the ratio was 4.63 [$t(23) = 4.49, p < .01$]. Thus, no single trial type was solely responsible for the significance of the overall discrimination ratio. However, it is interesting to note that the frequency discrimination ratio was higher on B1 trials than on B2 trials [$t(23) = 3.01, p < .01$]. As stimulus A was present on B1 trials with reinforcement available and on B2 trials with reinforcement unavailable, this tendency suggests a higher order feature-positive effect analogous to the traditional feature-positive effect (Hearst, 1978).

Responding to the Occasion Setters

Consistent with the unavailability of reinforcement during presentations of the higher order occasion setters

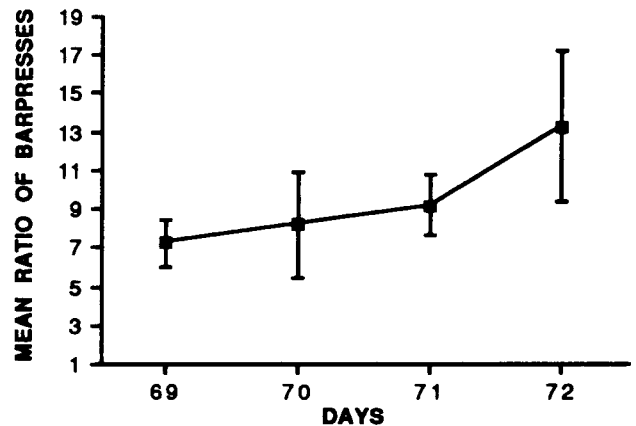


Figure 2. Mean discrimination ratios of barpress frequencies on Days 69-72. The ratio was calculated by dividing the number of barpresses made during the light presentations that announced the availability of reinforcement by the number of barpresses made during the light presentations that announced the nonavailability of reinforcement. Individual daily ratios were calculated for each animal, pooling responses from all 24 daily light trials. Data are from days on which there were 5.0-sec gaps between stimuli. Chance performance in the absence of a discrimination would correspond to a ratio of 1. Brackets represent the standard errors of the means.

(white noise, buzzer, and clicks), responding during these stimuli (as distinct from during the light common element) was minimal (mean of 0.2 barpresses per 5-sec cue presentation), except for one animal, which responded vigorously to white noise, buzzer, and clicks on practically all trials. Although this animal tended to respond to all stimuli, its frequency and latency discrimination ratios were well above chance performance. Moreover, almost no responding was observed on Trial Types 5 and 8 during the 35 sec that followed offset (see Figure 1). Thus, the putative occasion setters were not simple excitators that elicited delayed responding.

Latency Data

Within each day for each animal, mean ratios were calculated by dividing the latencies to first barpress during N trials by the latencies to first barpress during R trials. (Subjects not responding during a given light trial were assigned a ceiling latency of 30 sec.) These means were then averaged within animals over the last 4 days of each particular type of treatment and finally averaged across animals. The greater this barpress latency discrimination ratio, the more quickly subjects emitted their initial responses during the lights on R trials relative to N trials. After 18 days of training without a gap between stimuli, the subjects responded 14.03 times faster during lights that signaled reinforcement than during lights that signaled nonreinforcement [$t(23) = 3.71, p < .01$]. After 8 days of training with a 2.0-sec gap, the subjects responded 15.31 times as quickly [$t(23) = 3.44, p < .01$]. When the gap was widened to 5.0 sec for 9 days (see Figure 3 for the last 4 days' data), the subjects continued to emit their initial barpress on each trial 10.50 times faster on

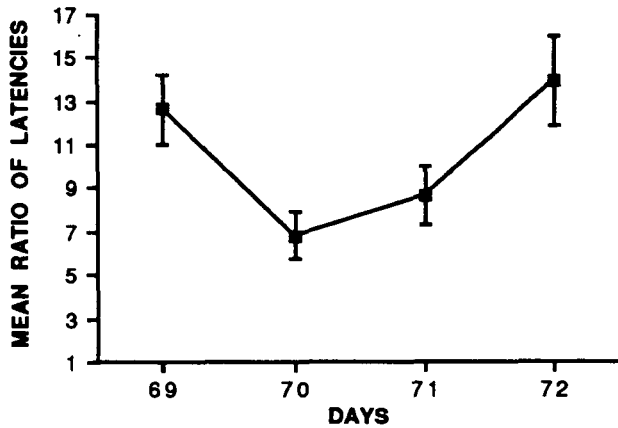


Figure 3. Mean discrimination ratios of latencies to first barpress on Days 69-72. The ratio was calculated for each animal by dividing the daily mean latency on light trials on which reinforcement was not available by the daily mean latency on light trials on which water was available. Data are from days on which there were 5.0-sec gaps between stimuli. Chance performance in the absence of a discrimination would correspond to a ratio of 1. Brackets represent the standard errors of the means.

R trials than on N trials [$t(23) = 7.25, p < .01$]. Notably, all 24 animals exhibited barpress latency discrimination ratios greater than 1 in each phase of the study in which latencies were recorded. As frustrative biting and pressing of the bar due to nonreinforcement on the immediate trial could not have influenced latencies to first barpress (i.e., before the first possible reinforcement of the trial), we are inclined to view the latency data as providing more compelling evidence than do the frequency data in indicating that the subjects mastered the discrimination through occasion setting. That is, the latency measure from each trial, unlike the frequency score, is not confounded by information concerning reinforcement that the subject obtained during the trial itself.

Latency discrimination ratios were calculated for each set of trial types on Days 73 and 74 to determine if the overall discrimination ratio was reflective of both B1 and B2 trials. On B1 trials ($A \rightarrow B1 \rightarrow L+$ and $B1 \rightarrow L-$), the mean ratio was 11.01 [$t(23) = 9.77, p < .01$]. On B2 trials ($B2 \rightarrow L+$ and $A \rightarrow B2 \rightarrow L-$), the mean ratio was 6.73 [$t(23) = 3.89, p < .01$]. Thus, all trial types contributed to the overall significance of the latency discrimination data. Although both trial ratios were above chance performance, subjects performed better on B1 trials than on B2 trials [$t(23) = 2.96, p < .01$]. Consistent with the frequency data, this indicates a feature-positive effect with higher order features.

DISCUSSION

Both frequencies and latencies of barpressing were consistent with the notion that our animals had solved these discriminations by using the white noise, buzzer, and clicks as higher order discriminative stimuli (i.e., higher

order occasion setters). Analysis of the latency data indicated that subjects made their first barpresses more quickly during light presentations in which reinforcement was available than during those in which reinforcement was unavailable. Latency to first barpress is uninfluenced by consequent reinforcement or nonreinforcement on that trial. Thus, this observation supports the conclusion that the subjects were employing the differential information provided by the stimuli rather than using a sampling strategy on each light presentation to see whether reinforcement was available. Additional support for this conclusion comes from the frequency data, which show that subjects barpressed more during reinforced light presentations than during nonreinforced light presentations. However, the latency data are more compelling because these measures are immune to a sampling-strategy interpretation.

As previously stated, Davidson et al. (1988) demonstrated the equivalence of occasion setters and discriminative stimuli (also see Colwill & Rescorla, 1990). The implications of those findings for the present observations are that the light can be regarded as a first-order occasion setter for the response-reinforcer association. This means that the buzzer and click train can reasonably have served as second-order occasion setters and the white noise as a third-order occasion setter.

Before an explanation of the present data in terms of higher order occasion setting is accepted, alternative interpretations must be considered. Although some discrimination problems lend themselves to solution by the counting of stimuli on each trial, in the present experiment this would not have been a viable strategy. Equal numbers of stimuli preceded the light on presentations during which barpressing would be reinforced and on presentations on which reinforcement was unavailable. Trials that began with the presentation of stimulus A ($A \rightarrow B1 \rightarrow L+$, $A \rightarrow B2 \rightarrow L-$) led to reinforcement of barpressing during the light equally as often as did nonreinforcement of barpressing during the light. This is also true for trials in which the first stimulus was stimulus B1 or stimulus B2 ($B1 \rightarrow L-$, $B2 \rightarrow L+$). During the light, responding was reinforced as often as it was not reinforced. The futility of a counting strategy adds plausibility to the view that the subjects learned a higher order discrimination and possibly higher order occasion setting.

Any explanation of behavior based on occasion setting is subject to alternative interpretation in terms of unique stimuli (i.e., configuring of the excitator and putative occasion setter or, in this case, perhaps all three of the putative occasion setters). However, configuring is somewhat implausible when the various cues do not overlap in time, and even less plausible when appreciable gaps are inserted between the cues, as was done in the later phases of the present experiment. (Also see comments concerning Thomas et al., 1988, in the introduction.) However, an explanation based on unique stimuli, including stimulus aftereffects, cannot be categorically rejected with respect to the present experiment or with respect to any previ-

ously published study of occasion setting (e.g., see Wilson & Pearce, 1989).

The results of the present experiment are consistent with those of a prior study by Looney, Cohen, Brady, and Cohen (1977), who successfully trained pigeons on a conditional discrimination using a response-independent autoshaping procedure with serially presented stimuli. Their birds were able to maintain the discrimination when a gap of 7 to 10 sec was imposed between the occasion setter and the CS. As with our data, serial presentation of stimuli with an intervening gap makes configuring an unlikely explanation of their results. However, Looney et al.'s use of a Pavlovian procedure allow their studies to be viewed as first-order occasion setting of a CS, and consequently it does not speak directly to the occurrence of higher order occasion setting.

The present demonstration of third-order occasion setting is also consistent with previous apparent demonstrations of second-order occasion setting that are embedded in delayed symbolic matching-to-sample (e.g., Edwards et al., 1985; Maki, 1979), and suggests the possibility of yet higher orders of occasion setting. Additionally, several examples of what might well be regarded as higher order occasion setting using human subjects can be found in the literature (e.g., Biederman, 1972; Gollin, 1966). Sidman (1986) has discussed and Sidman, Kirk, and Willson-Morris (1985) have demonstrated sensitivity to a five-term contingency in humans, which is functionally equivalent to third-order occasion setting. Although Sidman et al.'s use of simultaneous stimuli may have facilitated subjects' solving the problem by attending to unique cues, subsequent transfer to novel combinations of cues renders a pure configuring explanation implausible. Our success in training rats to make higher order discriminations increases the generality of his results to nonhumans, and our use of serial cues with gaps between them argues against a unique cue explanation relative to higher order occasion setting.

The current demonstration of higher order occasion setting was achieved through protracted shaping; however, the necessity of this degree of protracted training was not established. Whether or not the discrimination could have been solved had these initial training conditions not prevailed (e.g., initial training with the light alone and then training without a gap between the stimuli within a trial) is not clear from our results. However, the fact that the purely serial discrimination with appreciable gaps was ultimately mastered indicates that rats can solve such problems even if it does not speak to the boundary conditions for the acquisition of such discriminations. However, other research suggests that distinctiveness of signals (e.g., Thomas et al., 1988), observing responses (e.g., Cohen, Looney, Brady, & Aucella, 1976), and differential outcomes (e.g., Spetch et al., 1981; Trapold, 1970) will all facilitate the solving of such discriminations.

Occasion setting is, in and of itself, nothing new. In the forms of conditional discriminations and transwitching, we have known about it for many years. What is

novel is the apparent orthogonality between the excitatory attributes of a stimulus and the occasion-setting attributes of the same stimulus (e.g., Holland, 1983; Rescorla, 1986). If the function of a stimulus as an excitor (in Pavlovian conditioning or a response in instrumental learning) is independent of the functioning of that stimulus as an occasion setter, and if the present research has demonstrated higher order occasion setting, the question arises as to whether or not first-order occasion setting is independent of second-order occasion setting, whether second-order occasion setting is independent of third-order occasion setting, and so on.

In demonstrating what appears to be higher order occasion setting, the present research suggests that these questions are meaningful, but it does nothing to answer them. Considerable research will be necessary before we know the full story about independence between levels of behavioral control by a single stimulus. Appropriate tests for independence between levels of occasion setting would probably include studies of transfer and blocking within and between levels of occasion setting. For example, independence between levels of occasion setting would be supported if the substitution of an n th-order occasion setter for another n th-order occasion setter resulted in positive transfer, but the substitution of an n th-order occasion setter for an occasion setter of any other order yielded neither positive nor negative transfer. There is much exciting work to be done.

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