A COMPLEX FEATURES ACCOUNT OF THE OCCASION SETTING EFFECT

by

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The findings of transferability and irreversibility of stimulus function following occasion setting training have been detrimental to compound-stimulus accounts of the occasion setting effect. The purpose of the experiment was to demonstrate that those data which have supported the existence of an occasion setting stimulus function are predictable and interpretable in terms of one version of a compound-stimulus account, the complex features model. A basic assumption of the complex features model is that all stimuli contain obvious and nonobvious features which become conditioned exciters or inhibitors according to the same set of principles which describes all Pavlovian stimulus control. Successful transfer and reversal following occasion setting training will be possible to the extent that the evocative features of the trained occasion setting compound are present in the tested compounds as well. Arranging contingencies favorable for transfer or reversibility requires only that the training procedure itself be arranged in such a way that features common to the training and test compounds are made more evocative than any features exclusive to the training compound, without also disrupting the occasion setting effect.

Five pigeons were trained in three main occasion setting training conditions which differed in (1) the duration of the occasion setter presented; (2) the probability of food following the occasion setter; and (3) the number and colors of stimuli presented. Tests for transfer and reversal of stimulus function were conducted following training and rates of responding during training and testing compared. Transfer of the occasion setting effect to a new target stimulus was demonstrated following one of the training procedures -- one in

which the occasion setting stimulus was sometimes presented alone without food (i.e., the positive patterning procedure). Reversal of function was demonstrated for test compounds comprised of trained target stimuli in the position of both the occasion setter and the target stimulus following training with multiple occasion setting compounds. Manipulating the evocative strength of the color feature of the occasion setter relative to the transition seems to increase the likelihood of successful transfer and, to a limited extent, reversal.

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This dissertation is dedicated to the memory of my mother, Arline.

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CHAPTER I

INTRODUCTION

A distance runner waits at the starting blocks for the call of the race: "Ready, set, go!" A child listens to the words of the game leader, "Simon says, touch your nose." While seemingly simple, these two examples introduce a recurrent problem in the area of stimulus control, namely, how best to account for the effect that "Ready, set..." and "Simon says..." have on behavior. A stimulus-response formulation could be posited to account for the runner's going at the word "go" and the child's touching his nose upon hearing, "touch your nose." But, anyone familiar with the game, "Simon says," could counter that performing what is asked by the game leader is only the correct response when the request is preceded by "Simon says." Although no overt behavior appears to occur to "Simon says," it does nevertheless affect the probability that a response will be emitted to "touch your nose." Similarly, no overt behavioral changes occur when the runner hears, "Ready, set...," yet its presence or absence affects the likelihood that the runner will run when he hears "go!" Consequently, since there is no evidence of a direct, causal relationship between the stimuli "Simon says..." and "Ready, set..." and their corresponding responses, a stimulus-response interpretation is inadequate to account for the observed behavioral effect.

A prevailing alternative to a stimulus-response account postulates that, by affecting the probability that a behavior will be emitted without also evoking the behavior, phrases such as "Ready, set" and "Simon says" are functioning as higher-order controlling stimuli. That is, they are priming or *facilitating* responding to the evocative stimuli, "go" and "touch your nose," in much the same way as a preparatory set functions. This notion of facilitation takes the form of the conditional discrimination, a four-term contingency in an operant paradigm, such that "Ready, set" and "Simon says" function as conditional stimuli, readying the runner and the child to respond in the presence of their respective discriminative stimuli, "go" and "touch your nose."[1]

Lashley (1938) conducted one of the earliest empirical tests of conditional discrimination in nonhuman subjects by requiring rats to jump toward an erect or inverted, white triangle to receive a food reinforcer. A jump to either of the two postures was correct (was reinforced) on half of the trials, but which posture was correct for any one trial depended on the background pattern of the stimulus. For a solid, black background, jumps to the erect triangle were reinforced. If the background was striped, however, only jumps to the inverted triangle were reinforced. Thus, having seen the background pattern (i.e., the conditional discriminative stimulus), the rats were primed to respond in the presence of the appropriate triangle posture (i.e., the appropriate discriminative stimulus). Even when the background

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[1]The most basic operant contingency is a two-term contingency, that is, the response-reinforcer relationship. A two-term becomes a three-term contingency with the addition of a discriminative stimulus which signals which two-term relationship is in effect. A four-term contingency requires the addition of yet another stimulus, the conditional discriminative stimulus, which essentially signals which three-term contingency is operating.

patterns were alternated within sessions, Lashley's rats consistently jumped to the correct triangle posture.

The purpose of the experiment presented here was to test some implications of an alternative account of facilitation that is based, in part, on the idea that "Ready, set, go!" "Simon says, touch your nose!" and Lashley's combination of triangles and background patterns comprise single, complex stimulus compounds, rather than higher-order controlling stimuli. Various versions of such a compound-stimulus model have been offered previously as alternatives for facilitation, but as yet none has been successful for reasons to be discussed below (also see discussions by Carter & Werner, 1978; Holland, 1985; Jenkins, 1985; Sidman, 1986). Given that a compound-stimulus model would have the important advantage of not requiring postulation of a new stimulus function, the attempt here to formulate and test a viable compound-stimulus model seems a worthwhile endeavor. First, however, it will be useful to further elaborate the notion of facilitation.

Occasion Setting

Although Lashley used an operant, conditional discrimination procedure, most of the research on facilitation in nonhuman species have used a Pavlovian, "serial, feature-positive" preparation.[2] In fact, it was through a comparison of results from two Pavlovian procedures -- the serial, feature-positive procedure and an almost identical simultaneous, feature-positive procedure -- that facilitation was first identified as a new type of stimulus function. To elaborate, the simultaneous, feature-positive

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[2]As such, responses are typically said to be elicited, rather than emitted, and stimuli are presented independently of responses.

procedure presents subjects with two stimuli simultaneously -- for example, a light (A_L) and a tone (B_T) -- followed at their offset by the presentation of an unconditioned stimulus, food. On alternate trials, B_T is presented alone, without A_L or food. Figure 1 presents a diagram of this *simultaneous*, feature-positive procedure, the results of which have shown that A_L and B_T together come to elicit responding while B_T alone does not (Ross & Holland, 1981).

However, although it is the compound that elicits behavior, the topography of that behavior suggests that subjects do not actually respond on the basis of the presentation of A_L and B_T in compound. Rather, the response takes the form[3] appropriate to the feature stimulus, A_L, suggesting that behavior is elicited according to the presence or absence of A_L only. Why this may be so becomes apparent when one considers the predictiveness of A_L relative to B_T. As shown in Figure 1, both stimuli are temporally contiguous with food, but only half of the B_T presentations, compared to all of the A_L presentations, are followed by food. Consequently, with the probability of food presentations following A_L at 100 percent, A_L is the more predictive of the two stimuli and, as a result, the response takes the form appropriate to A_L.

Figure 1 also presents a diagram of the *serial*, feature-positive procedure (known more commonly as the occasion setting procedure) in which A_L is presented for five seconds, followed by a short interstimulus interval (ISI), and then by a five second

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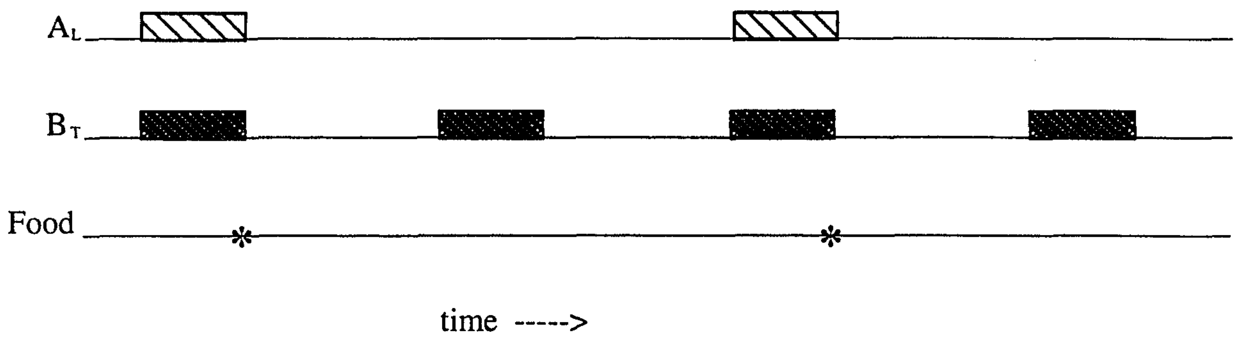
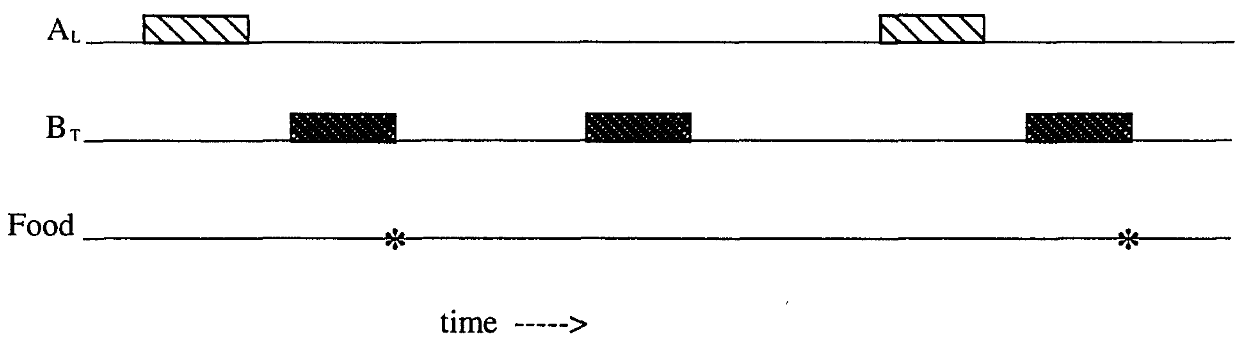
[3]Using topographical differences in behavior, Ross and Holland (1981) have been able to determine which stimulus is eliciting behavior. Lights used as conditioned stimuli tend to elicit either rearing or approach to the food magazine while tone conditioned stimuli elicit head jerking and startle behaviors. Which behavior is elicited can be a reasonable indicator of which stimulus is doing the eliciting (see also Holland, 1977).

Figure 1. Diagram of the Simultaneous and Serial, Feature-Positive Procedures

Simultaneous, Feature-Positive Procedure:



Serial, Feature-Positive Procedure:



presentation of B_T. Food follows immediately after the offset of B_T when it is preceded by A_L; nonreinforced presentations of B_T alone occur on alternate trials. The only difference between the simultaneous and serial, feature-positive procedures, then, is the change in the relationship of A_L to food due to the delayed onset of B_T that results from the interstimulus interval. That is, with the addition of the interstimulus interval between the onset of A_L and B_T, A_L is no longer temporally contiguous with food presentations as it was in the simultaneous procedure.

In comparing the results of the two procedures, Ross and Holland (1981) found a puzzling difference. While in the simultaneous procedure, behaviors characteristic of A_L, the more predictive stimulus, were elicited, mainly tone-specific behaviors characteristic of B_T were elicited in presentations of $A_L \rightarrow B_T$ in the serial procedure. B_T was eliciting behavior when it was preceded in time by A_L even though the likelihood of food following B_T was only 50 percent. Rescorla (1985) showed a similar result with pigeons trained with a tone and a keylight.[4] Like the rats, pigeons came to respond to the keylight only when it was preceded by the tone.

In attempting to account for their results, both Holland (1983) and Rescorla (1985) agreed that the first stimulus presented in the serial compound (A_L) seemed to be functioning in a manner different from a simple Pavlovian excitatory stimulus. That is, although A_L acquired some excitatory power of its own, its primary function was not to elicit behavior but to augment responding to the excitatory stimulus (B_T): the presence of A_L set the occasion for B_T to be excitatory (Holland, 1983; 1986; 1989).

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[4]Diffuse stimuli, such as a tone, correlated with a positive reinforcer, tend to evoke increased general activity in pigeons without also evoking a directed response, such as a keypeck.

The Occasion Setter as a New Stimulus Function

Support for the idea that the serial, feature-positive procedure generates a new facilitative, or "occasion setting," function comes from several experimental outcomes. The first, as just discussed, is the observation of modality-specific behaviors to two different stimuli. Presentations of lights and tones in a serial compound elicit modality-specific behavior with proportionally more behavior elicited by the temporally contiguous yet less predictive stimulus. In contrast, presentations of lights and tones in a simultaneous compound elicit behavior specific to the stimulus that is both temporally contiguous with and 100 percent predictive of food.

Other experimental results have also suggested that the first stimulus in the serial compound, the "occasion setter," is serving a new stimulus function. The first of these comes from tests for transferability of stimulus function following serial, feature-positive, or occasion setting, training. The logic of the transfer test is that, if an occasion setter can facilitate responding to the "target stimulus" used in training ($A_O \rightarrow B_T$), perhaps it may also be able to facilitate responding to a new target stimulus. If so, the occasion setter must have some functioning independent of both its training situation and the target stimulus with which it was associated.

Transfer in the serial, feature-positive procedure has been demonstrated to a limited extent. For example, an occasion setter has been shown to augment conditioned responding to transfer targets that were themselves trained with other occasion setters (Rescorla, 1985) and to transfer targets with a history of excitatory conditioning followed by extinction (Rescorla 1985; 1986). Successful transfer in these studies seemed to suggest that the occasion setter has the ability to augment responding to targets from other training situations and, therefore, displays a stimulus function different from a conditioned excitor (Rescorla, 1985).

The results of tests for reversibility of stimulus function have also supported the idea that training in the serial, feature-positive procedure generates a new stimulus function (occasion setting). According to Rescorla (1985; 1986), if the occasion setter were simply an evocative stimulus, it should be able to function in the position of the target stimulus and, likewise, the target stimulus should be able to function as an occasion setter in the serial compound. That is, if the order of A_O and B_T, trained as $A_O \rightarrow B_T$, is reversed and tested as $B_T \rightarrow A_O$, behavior should still be elicited by the second member of the compound (A_O). If, however, the stimuli have acquired different types of functions (i.e., occasion setting versus evocative), then responding should not be evoked by the compound when the stimuli are presented in reversed order.

Several of Rescorla's experiments have examined reversibility of function following occasion setting training. For example, following training with two different occasion setter-target pairs ($A_O \rightarrow B_T$ and $C_O \rightarrow D_T$), Rescorla (1985) evaluated responding to each of the stimuli when presented alone (A_O, B_T, C_O, D_T), when preceded by the occasion setter from the other stimulus pair ($C_O \rightarrow B_T$, $A_O \rightarrow D_T$), and when preceded by the target from the other stimulus pair ($B_T \rightarrow C_O$, $D_T \rightarrow A_O$). He found that, while occasion setters can augment responding to a target other than that used in training ($C_O \rightarrow B_T$, $A_O \rightarrow D_T$), they cannot themselves act as targets for other targets ($B_T \rightarrow C_O$, $D_T \rightarrow A_O$). These results are consistent with those from another study in which prior excitatory conditioning of a stimulus interfered with its ability to be subsequently trained as an occasion setter, but enhanced its ability to act as a target (Rescorla, 1986).

In light of these empirical results, there seems to be support for the notion of a new occasion setting stimulus function. Modality-specific behaviors, transferability, and the lack of reversibility all suggest that the occasion setting procedure generates two stimulus types with exclusive functions: the facilitative occasion setting stimulus and the evocative target stimulus. Moreover, from the evidence presented, it is already possible to identify those issues which an alternative, compound-stimulus account must address in order to be considered feasible. Ultimately, a compound-stimulus model will have to identify a possible stimulus compound that is, by itself, able to generate what has appeared to be control by two different stimulus functions.

A Complex Features Model of Stimulus Control[5]

Given the preceding discussion, it is entirely reasonable to conclude that "Ready, set" and "Simon says" are functioning as occasion setters for their respective target stimuli. Still to be considered, however, is a compound-stimulus interpretation which suggests that the occasion setter and target stimulus function as part of a single, compound stimulus rather than as two independent and different types of stimulus

[5]Use of the term "complex features" is not meant to imply that some features are more or less complex than others. Any functional feature can act as a stimulus; the goal of the complex features model is to reveal which specific features are evoking behavior.

functions. Accordingly, conditioned responding is evoked by the stimulus compound, not facilitated by an occasion setter and elicited by a target.

Although the idea of control by a single compound is certainly not a new one (Razran 1939, 1971; see Kehoe & Gormezano, 1980, for a review), no version has yet succeeded in accounting for the occasion setting effect. It would seem, too, that the failure of some compound-stimulus models has led to a blanket rejection of all such accounts. As stated earlier, to be able to treat the occasion setting stimulus as part of a compound has the important advantage of not requiring the postulation of a new stimulus function. It will, therefore, be valuable to construct a compound-stimulus model which can, in fact, account for the evidence favoring occasion setting.

The premise for one such compound-stimulus model is taken from Skinner's (1953) treatment of the runner's performance: "Although the instructions given...to the runner starting a race are complex, the effect upon behavior is due to the simple, three-term contingency with an added temporal specification" (p. 126). For Skinner, "Ready, set, go!" is a single, compound stimulus in the presence of which running the race will be reinforced. However, while stimulus compounds are typically assumed to contain interchangeable members, reversibility is not a characteristic of the compound, "Ready, set, go!" (Imagine the effect that "Go, ready, set!" or "Set, go, ready!" might have on the desired behavior.) Rather, Skinner adds a temporal specification, that is, an order feature, which further defines the stimulus compound, narrowing the range of potentially evocative compounds to the one compound, "Ready, set, go!" The order feature is treated as a stimulus feature just like any other (e.g., color, size, shape).

The implication of the order feature suggested by Skinner is an important one: stimulus compounds contain features which can themselves evoke behavior or join with other features to evoke behavior (Ready, set, go!) or that, when absent, will fail to evoke behavior (Go, set, ready!).

In order to understand how control by stimulus features, such as order, develops, one must consider the relationship of one or more features in the compound to the unconditioned stimulus, *i.e.*, to food. As has already been discussed, in the serial, feature-positive procedure ($A_O \rightarrow B_T$), the occasion setter, A_O, is 100% predictive of food in that the probability that food will follow A_O is 1.00. But, at the same time, A_O is not a good temporal predictor of food. Rather, B_T is the better temporal predictor of food presentations since B_T is temporally contiguous with food, even though the probability of food being presented after B_T is only 0.50. Consequently, A_O and B_T each have a degraded or weakened relationship to food -- A_O due to the decreased temporal proximity to food and B_T due to the low predictability of food.

But consider how the strength of the contingency improves when the temporal ordering of A_O and B_T is treated as an evocative feature of the occasion setting compound. When "B_T follows A_O" is the feature, A_O is still 100% predictive of food, but its temporal predictiveness is improved by the subsequent presentation of B_T. Likewise, B_T is already temporally contiguous with food, but becomes part of a compound that is 100% predictive of food when "B_T follows A_O" is treated as an additional feature of the compound. Viewed in this way, the occasion setting compound, $A_O \rightarrow B_T$, has features that have a probability of being followed by food of

1.00 and that are temporally contiguous with food as well. Such a strong contingency favors control by the relatively complex order feature. The result is maximum conditioned responding to features of the compound, $A_O \rightarrow B_T$, and minimal responding to the target stimulus, B_T, presented by itself. That is, the result is the phenomenon that is described as occasion setting.

Advantages of a Complex Features Model

While defining a stimulus arrangement in terms of its features may increase the complexity of the stimulus event, such an approach offers an advantage over the alternative of occasion setting because, in treating the occasion setting compound, $A_O \rightarrow B_T$, as a single, multifeatured stimulus, postulation of a new occasion setting stimulus function is not required.[6] In addition, since the stimulus features are considered either excitatory or inhibitory, no new stimulus principles are required. For example, *blocking*, where the prior excitatory conditioning of a stimulus prevents (blocks) the acquisition of conditioned responding to a second stimulus when both stimuli are subsequently conditioned in compound, is still expected to occur, but at the level of the stimulus features. Similarly, the principles of excitation, inhibition,

[6]An alternative to both the configuration and occasion setting accounts is to approach the occasion setting phenomenon from the "response side," increasing the complexity of the response while maintaining a relatively simple stimulus. However, in order to account for behavior to a temporally extended stimulus like the occasion setter, it would be necessary to postulate some kind of intervening event, such as Dinsmoor's (1983) observing response or Lawrence's (1963) coding response. A subject would thus be said to emit a covert response in the presence of the occasion setter prior to any overt response to the target stimulus. But, while a complex response interpretation is certainly viable, the complex features approach has the advantage of identifying physical and manipulable environmental events with corresponding overt and measurable responses, rather than dealing with hypothetical and, ultimately, covert response forms.

overshadowing, trace conditioning, and so forth are also applicable to stimulus features as they are to the more traditional stimulus event.[7]

It must be kept in mind, too, that although the complex features model treats the occasion setting compound as multifeatured, such a conceptualization is not unfamiliar; even those stimuli which seem the least complex are multifeatured. For example, when a red keylight is presented in a red-green discrimination procedure, we assume that a subject differentiates a red keylight from a green keylight according to its most obvious feature, color (i.e., wavelength). But one may draw that conclusion only if subsequent empirical tests show that responding changes according to the change in wavelength, and not some other aspect of the stimuli, such as the lights' intensities. While superficially elemental, virtually all stimulus events may need to be conceptualized as complex, multifeatured stimuli.

The idea is that the complex features model may offer a parsimonious alternative to the occasion setting stimulus function, although it is important to recognize that judgments about parsimony are not always straightforward and simple. The complex features model, while maintaining the applicability of familiar Pavlovian principles, treats the stimulus as a multifeatured and, therefore, as a complex event. In contrast, occasion setting theory advocates a comparatively simpler stimulus but requires that a new set of principles be postulated to account for its function. Thus, they both promote parsimony, but in different ways. Ultimately, the advantage of one model

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[7]In fact, it is an empirical question whether any conditioning occurs at a level other than the stimulus features.

over another will depend upon the productivity of each model relative to other data and theoretical concepts.

Another advantage of a complex features model is that it helps to reveal excitatory (or inhibitory) features of an experimental preparation that may be less obvious, or perhaps even nonobvious, to the experimenter. For example, by denoting the occasion setting procedure as $A_O \rightarrow B_T^+ | B_T^-$, we, as experimenters, are identifying those stimulus features most salient and relevant to us: presentation of the occasion setting stimulus, A_O, for *x* seconds, followed by a time delay of *x* seconds, presentation of the target stimulus, B_T, for *x* seconds, and food for *x* seconds; presentation of the target stimulus, B_T, for *x* seconds, without food, time delay of *x* seconds. But it may be presumptuous to expect that the principal stimulus events denoted by $A \rightarrow B^+ | B^-$ are the most salient and relevant to a subject as well.

That nonobvious features of a stimulus can gain control of behavior is not a new idea. Malott and Malott (1970), for example, anticipated that line length would control pigeons' responding to the Mueller-Lyer illusion, as it does humans' responding. They discovered instead that their pigeons were responding to the area contained within the endpoints of the line display, a feature that was considerably less obvious to the experimenters. A complex features analysis can be particularly useful and enlightening when behavioral data, like that of Malott and Malott, are "consistently inconsistent" with an experimenter's expectations.

In the context of occasion setting, the lack of responding to the reversed order of the occasion setter and target stimulus is a reliable outcome and, in part, serves to identify the occasion setter as a new type of stimulus. But it is worth considering whether the observed inability of the reversed stimulus positions to evoke responding is indicative of a new stimulus function. Might it simply reflect conditioning of some less obvious feature in the occasion setting compound that is not present when the stimuli are presented in the reversed order? According to a complex features model, it should be possible to manipulate the evocative strength of the various features of the compound and thereby generate conditions where the reversed order does indeed evoke responding.

A Complex Features Approach to Occasion Setting

As already discussed, transfer and reversibility test results have favored the idea of a new, occasion setting stimulus function. Testing the viability of a complex features account of occasion setting, therefore, will require demonstration that the likelihood of obtaining transfer or responding evoked by the reversed order of the occasion setter and target stimulus can be changed by manipulating control by one or more features of the occasion setting compound. First, however, the possibly relevant features being conditioned during occasion setting training need to be identified.

Table 1 lists many of the possible features associated with the major stimulus events of occasion setting. The upper portion of the table diagrams a positive trial in its order of presentation: an intertrial interval followed by the occasion setter, an interstimulus interval, and finally the target stimulus (after which food is presented). Looking first at the intertrial interval, features include illumination -- a "houselight" may be illuminated in the experimental chamber although no other stimuli are

Table 1. Features of the Major Stimulus Events in Occasion Setting When Both the Occasion Setting and Target Stimuli Are Illuminated Response Keys

Positive, Occasion Setting Trial:

<table>
<tr><th>Intertrial Interval (ITI) →</th><th>Occasion Setter →</th><th>Interstimulus Interval (ISI) →</th><th>Target Stimulus</th></tr>
<tr><td rowspan="3">Long duration
Illumination</td><td>Color (wavelength)
Brightness (intensity)
Duration</td><td>Short duration
Illumination</td><td rowspan="3">Color (wavelength)
Brightness (intensity)
Duration</td></tr>
<tr><td colspan="2">Transition to ISI</td></tr>
<tr><td colspan="2">Occasion setter plus ISI</td></tr>
<tr><td colspan="2">Transition to occasion setter</td><td colspan="2">Transition to target stimulus</td></tr>
<tr><td colspan="2">ITI plus transition to occasion setter</td><td colspan="2">ISI plus transition to target stimulus</td></tr>
<tr><td colspan="3">ITI plus transition to occasion setter plus occasion setter plus ISI</td><td></td></tr>
<tr><td></td><td colspan="3">Occasion setter plus ISI plus transition to target stimulus</td></tr>
</table>

Negative, Target-Alone Trial:

<table>
<tr><th>Intertrial Interval (ITI) →</th><th>Target Stimulus</th></tr>
<tr><td>Long duration
Illumination</td><td>Color (wavelength)
Brightness (intensity)
Duration</td></tr>
<tr><td colspan="2">Transition to target stimulus</td></tr>
<tr><td colspan="2">ITI plus transition to target stimulus</td></tr>
</table>

presented -- and duration -- typically, intertrial intervals are of long durations relative to stimuli presented in the trial.

When both the occasion setting and target stimuli are presented as response keys illuminated with different colored bulbs, as they were in the experiment to be described below, both stimuli will have the features of color, brightness, and duration.[8] An interstimulus interval can be used to separate presentation of the occasion setter from the target stimulus. Like the intertrial interval, features of the interstimulus interval include illumination and duration. The experimental chamber may be either completely dark or illuminated with a houselight, but the interstimulus interval is typically of a markedly shorter duration than the intertrial interval.

In addition to features of the individual stimulus events, there are a number of relational features that could be conditioned in the positive occasion setting trial as well. One critical feature already mentioned is the order of presentation of the stimulus events, e.g., occasion setter plus short interstimulus interval or long intertrial interval plus occasion setter. Two experiments demonstrate how control by an order feature can be conditioned or not conditioned according to the experimental preparation used.

In the first experiment, Roitblat, Scopatz, and Bever (1987) demonstrated control by both the characteristics projected on the response key (e.g., color) *and* temporal ordering of three stimuli in compound by training pigeons to discriminate an A→B→C serial compound from any of the other 26 possible combinations of A, B, and C (*i.e.*,

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[8]Relevant features will, of course, vary with the nature of the stimuli.

3^3 - 1). That Roitblat et al.'s pigeons learned both the stimulus characteristics of A, B, and C and the correct ordering of the stimuli was evidenced by the amount of responding observed to combinations in which two of the three stimuli were in the correct ordinal positions. Responding was higher for the compounds, AB-, -BC, and A-C than for any other combinations of the stimuli, suggesting that stimulus control was due, in part, to contingencies involving the temporal ordering of the stimuli in compound.

However, it need not always be the case that the order of stimuli controls behavior as it did the behavior of Roitblat *et al.*'s pigeons. Thomas and Schmidt (1989) trained pigeons in an "if A then B" conditional discrimination procedure, then tested for responding to "if B then A." The key difference between the Roitblat *et al.* and Thomas and Schmidt procedures is that the former gave explicit inhibitory training with the "wrong" combinations of stimuli (did not reinforce behavior in the presence of the other 26 combinations), while the latter did not. Thomas and Schmidt found the level of responding to the A→B and the B→A stimulus compounds to be similar, suggesting that order was not a controlling feature of the A→B compound.

Another relational feature in the positive occasion setting trial is the transition between stimulus events. That is, "change" can be a stimulus feature that controls responding to some extent, independently of the characteristics of the "changed-from" and "changed-to" stimuli. As shown in Table 1, there are a number of transitions occurring during the trial, including those from the intertrial interval to the occasion setter, from the occasion setter to the interstimulus interval, and from the interstimulus interval to the target stimulus. How a stimulus transition can control behavior becomes apparent when one considers the behavior of a driver stopped at a red light. While watching for a change to the green light to continue through the intersection, one of the lights turns from red to a green arrow for a left turn. Having only observed the transition from red to green, the driver responds to the transition and begins to move his car, realizing only after moving that the transition was to the green left arrow and not to a green light. Typically, when asked to account for his behavior, the driver would report that he expected or anticipated a green light, not a green arrow. From a complex features account, however, we would say that his behavior was under control of the transition between lights acting as a stimulus feature, rather than the green light itself. The practical joke of starting a race with "Ready, set, stop!" provides another example of control by a transition. To the extent that control is by the transition feature, there may be little control by features specific to the changed-from and changed-to stimuli.

The lower portion of Table 1 diagrams the negative, target-alone trial, critical to occasion setting training, in which the target stimulus is presented by itself, following an intertrial interval. Because food is not presented during negative trials, any of the features of the negative trial will be inhibitory (i.e., will not elicit responding). The excitatory value of features associated with the stimulus events of the positive occasion setting trial can be expected to be tempered by the inhibitory effects of presentations of those same features in negative trials. For example, if the occasion setter is presented alone, without food or the target stimulus, on alternating trials with both the positive occasion setting and target-alone trials (known as the positive patterning procedure, a variant of the occasion setting procedure), the excitatory value of features associated with the "intertrial interval plus the transition to the occasion setter" will decrease since the features would be present on both positive and negative trials.

Given the list of features identified in Table 1, and the results of transfer and reversibility tests, it is possible to anticipate the significance of at least some of the features conditioned during occasion setting training. According to a complex features account, successful transfer implies that features that have been made excitatory during occasion setting training occur also during transfer tests (old occasion setter, new target). But these features are not present when the occasion setter and target stimulus are presented in reversed order. For example, the color of the occasion setting keylight seems to be a controlling feature since, when that color is presented first (training and transfer), responding characteristic of occasion setting has been observed, but not observed when the color was not presented first (reversal test).[9] Unlike the occasion setter, the fact that behavior could be elicited by a novel target stimulus in the transfer test suggests that color is not a critical feature of the target stimulus. That is, because the transition to the target stimulus occurs so closely in time to food, it becomes highly excitatory, effectively blocking control by the color feature of the target stimulus.

[9]For the sake of simplicity, the occasion setting and target stimuli discussed are both response keys illuminated with different colored bulbs. The stimuli may instead be a tone and illuminated response key as was used by Rescorla, or a tone and light as was used by Holland. The logic of the complex features analysis is the same regardless of stimulus modality.

Of course, it is probably not sufficient for the color of the occasion setter to merely be present somewhere in the occasion setting compound; if that were the case, then reversal tests should be successful regardless of the reversed sequence of stimuli in the compound. During occasion setting training, an order feature may also be conditioned such that the color of the occasion setter must be presented first in the order of stimulus events. But the order of presentation itself involves only particular features of the occasion setter. When, in the reversal test, the first stimulus presented (the target stimulus) has the same duration as the trained occasion setter but is of a different color, the occasion setting effect is again not observed.

The critical features of the occasion setting compound, therefore, seem to be associated with a set of stimulus events involving features of the occasion setter and the order of presentation, such as "occasion setter keylight color plus ISI" or "occasion setter keylight color plus ISI plus transition, regardless of color." When these are present, the compound will elicit responding; when the features are absent, responding will not be elicited. Changing the likelihood of successful transfer and reversal, therefore, should involve changing the excitatory value of these critical features of the occasion setting compound, according to the complex features model.

Implications of a Complex Features Model

The purpose of the experiment presented here was to determine whether the occasion setting effect may be accounted for within the framework of a complex features model. The procedures described below were designed to systematically manipulate the excitatory value of the keylight color of the occasion setting stimulus, predicted to be the most salient feature of the occasion setter, in order to obtain successful transfer and reversal test results. If the excitatory strength of the occasion setter's keylight color can be sufficiently lessened relative to other features that are present in the occasion setting compound during both training and testing (particularly the transition), tests for transfer and reversal should be successful.

Temporal Proximity of the Occasion Setter. As has been discussed, contingencies arranged in occasion setting training favor control by specific features of the occasion setter, including its color, in part because the occasion setter itself is presented in relatively good temporal proximity to food. To degrade the excitatory strength of the color of the occasion setter, therefore, requires changing the temporal relationship between the occasion setter and food. This can be accomplished in two ways. The first is simply to increase the duration of the interstimulus interval (ISI) of the occasion setting compound. According to the principles of trace conditioning, the excitatory strength of the color of the occasion setter should be negatively related to the length of the trace interval, that is, the time delay between the onset of the occasion setter and food. As the ISI is increased, the excitatory strength of the color of the occasion setter should decrease (Kaplan & Hearst, 1982).

Increasing the duration of the occasion setter in the occasion setting compound should also decrease the excitatory value of color as an occasion setter feature relative to the transition feature of the compound. According to Gibbon and Balsam (1981), the excitatory value of a stimulus event is inversely proportional to its duration in the conditioning interval. Presenting the occasion setter for the entire interval prior to the onset of the target stimulus, replacing the ISI, should significantly reduce the excitatory value of the color feature of the occasion setter relative to the transition. Since the transition is a common feature in training, the transfer test, and the reversal test, as it becomes relatively prepotent, responding during presentations of both the transfer and reversed compounds should be evoked.

The first condition of the present experiment was designed to determine whether manipulating the temporal relationship between the occasion setter and food can reduce control by the color feature of the occasion setter sufficiently to produce successful transfer and reversal test results. In the first procedure of the condition, subjects were trained with an occasion setting compound with a five-second occasion setter followed by a short interstimulus interval (ISI) of ten seconds, and a five-second target stimulus. The second procedure replicated the first except that the duration of the ISI was increased to a duration of 40 seconds. In the third procedure, the duration of the occasion setter was increased to 45 seconds and the ISI eliminated entirely. That is, the occasion setter keylight color remained illuminated until the target color was illuminated. Thus, the transition from the occasion setter to the target stimulus occurred five seconds before food. Relative to an average food-to-food interval of over six minutes (370 seconds), this represents an extremely favorable temporal signal. Transfer and reversal testing was conducted after training in each of these three procedures.

Positive Patterning. Another reason contingencies established during occasion setting training favor control by the color feature of the occasion setter is that the occasion setter itself has an associated probability of food of 1.00. Whenever the occasion setter is presented, food is also presented. Changing the excitatory strength of the occasion setter color feature, therefore, can be additionally accomplished by changing its correlation with food.

By design, the positive patterning procedure, one variation of the occasion setting procedure, decreases the probability of food following the occasion setter from 1.00 to 0.50. The positive patterning procedure is structured in essentially the same way as occasion setting with one exception: in positive patterning, inhibitory, occasion setter alone trials in which the occasion setter is presented alone, without the target stimulus or food (A_O^-), are alternated with inhibitory target alone trials (B_T^-) and excitatory occasion setter compound trials ($A_O \rightarrow B_T^+$). Thus, on the basis of probability, only the compound, and presumably features unique to the compound, become reliable signals of food while no single color is reliably correlated with food. The second condition of the present experiment tested for reversal following positive patterning training with occasion setters of 45-, 90-, and 120-second durations and for transfer following training with a 45-second occasion setter duration.

Multiple Keylight Colors. In positive patterning training using, for example, a green keylight for an occasion setter and a red keylight for a target stimulus, the order of events in the occasion setting compound is "green keylight plus transition to red keylight." In the transfer test, the order is "green keylight plus transition to some other color keylight." Despite changes in the temporal proximity and predictiveness of the occasion setter, it is possible that the positive patterning procedure still sets up contingencies favoring control by the specific color of the occasion setter. In order to obtain a successful reversal, the value of the color of the occasion setter must be minimized such that, "any keylight color plus transition" or "transition from any color to any color" becomes the controlling feature. Another way to accomplish this is to train subjects with more than one occasion setter-target stimulus pair. Doing so would reduce the correlation between any specific pair of colors and food.

The last condition of the present experiment trained subjects in a positive patterning procedure using two colors of occasion setters and two colors of target stimuli (four possible compounds), then tested for reversal to each occasion setting compound. In addition to the usual reversal test, moreover, two additional variations of the test were conducted. In the first, responding was measured when the tested occasion setting compound included only the previously trained occasion setters (i.e., $A_O \rightarrow C_O$) or only the previously trained target stimuli (i.e., $B_T \rightarrow D_T$). In the second test, responding was measured when the same stimulus served as occasion setter and target in the reversal compound (*i.e.*, $A_O \rightarrow A_O$; $B_T \rightarrow B_T$, $C_O \rightarrow C_O$ and $D_T \rightarrow D_T$). The rationale for these additional tests was that, if the evocative strength of the color feature has been sufficiently degraded relative to the transition, responding characteristic of the occasion setting effect should emerge regardless of which stimuli are presented, as long as the critical feature "any keylight color plus transition into any keylight color" is present.

The structure of the other multiple stimuli training procedure used in the last condition was the same as the four compound procedure described previously with an important difference: an attempt was made to increase the salience of the transition from the offset of the occasion setter to the onset of the target stimulus by increasing its duration to one second. Procedures which change the temporal relationship of the occasion setter to food (the temporal proximity condition) may, according to a complex features model, increase the excitatory strength of the transition to the target stimulus because they create a relatively better temporal and predictive relationship between the transition and food than between the occasion setter and food. Similarly, during positive patterning training, the transition is made yet more excitatory since it is not until the transition occurs that subjects can differentiate presentations of negative, occasion setter alone trials from positive, occasion setting compound trials. That is, the transition is the first salient stimulus event of the occasion setting compound that is predictive of food.

Because the transition into the target stimulus is present in both training and test compounds, the likelihood of successful reversal should increase as the excitatory strength of features of the occasion setter decrease relative to the transition. However, with a duration of only milliseconds, the transition is only discernible by the change in illumination of the response key (*i.e.*, from ISI to target or from occasion setter to target). Therefore, in order to make the transition a more salient stimulus event in the occasion setting training and test compounds, a "one-second transition" was incorporated between the offset of the occasion setter and the onset of the target stimulus. Although the one-second transition was structurally equivalent to any interstimulus interval, its purpose was to alert subjects to the transition into the target stimulus. In contrast, inclusion of interstimulus intervals of long duration in the temporal proximity procedures discussed above was intended to weaken control by the color feature of the occasion setter.

In summary, the training procedures used in the present experiment have been designed for the purpose of altering control by the color feature of the occasion setter, and possibly altering that control in favor of a feature of the occasion setting compound that is present in both training and test situations, namely the transition into the target stimulus. The effect of the manipulations should be an increasing likelihood of both successful transfer and reversal. Although transfer is predicted in some situations by the occasion setting literature, reversal following occasion setting training would weaken the case for a distinctive occasion setting stimulus function.

CHAPTER II

METHOD

Subjects

The subjects in the present experiment were five domestic pigeons[10], maintained at 80 to 85 percent of their free feed body weights by limiting access to food. Water and grit were continuously available in the home cage. All of the birds had previous experience in both response-dependent and response-independent procedures, but none of the birds had prior experience in an occasion setting procedure. At the beginning of a session, each subject was removed from its home cage and placed in the experimental chamber then returned to the home cage following each training or test session.

Apparatus

Subjects were assigned to one of five experimental chambers prior to pretraining. Each chamber was approximately 35 X 34 X 31 cm in dimension. Within each chamber, translucent response keys were mounted on the front wall approximately 25 cm above the floor; only the right-most key was operative throughout the experiment. Reinforcement consisted of four to six seconds' access to mixed grain delivered by a food hopper through a hole centered on the front chamber wall, 12 cm from the floor. During hopper presentations, a light illuminated the grain.

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[10]Subject 2337 died at the end of the second procedure of the first condition. The four remaining subjects completed the entire experiment.

Throughout the experiment, the operative response key was illuminated from behind using white and colored bulbs or Lehigh Valley multistimulus rear screen projectors, according to the type of chamber. Keys were illuminated either white, blue, red, green, or yellow depending on the condition; the particular combination of keylight colors was varied by subject.[11] Except for illumination of the response key and of the hopper during food presentations, the chamber remained dark.

The measured response was a keypeck on the operative response key. Computer programming using ECBasic (Walter & Palya, 1984) recorded responses, and controlled the presentation and duration of the keylights and food hopper and the number and random presentation of trials. The number of responses during each stimulus presentation, intertrial interval, and interstimulus interval were recorded separately.

Procedure

Pretraining. Keypecking was initially trained on the operative response key, illuminated white, using a response-independent, autoshaping procedure. That is, following a 30-second intertrial interval (ITI), during which the chamber was dark, the response key was illuminated for five seconds.[12] At the offset of the keylight, food was presented. The number of keypecks to the response key was the dependent

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[11]Numerous studies (see Guttman & Kalish, 1956) have shown wavelength discrimination in pigeons to be approximately that of humans, i.e., about 360 nm to 760 nm.

[12]Selection of these ITI and stimulus durations, and those for all experimental conditions presented, was based on Gibbon and Balsam's (1981) context conditioning model which states that the associative strength of a conditioned stimulus (CS) is relative to that of the context in which it is presented. Consequently, as the duration of the context (ITI) increases relative to the duration of the CS, the excitatory value of the CS increases.

measure, but keypecks were not required for food to be presented. Each session consisted of 40 food presentations, and sessions were run daily at least five days per week. Once responding during illumination of the response key occurred on 90 percent of the trials within a session, occasion setting training was initiated.

Occasion Setting Training. After a subject was placed in the experimental chamber, a daily session would begin with the presentation of the first trial. Three trial types were possible:

(1) $OS \rightarrow T^+$ Trials: At the end of an ITI, the response key was illuminated for *x* seconds in the color corresponding to the occasion setting stimulus. In conditions containing an ISI, at the offset of the occasion setting keylight, the chamber remained dark for the ISI duration. Following the ISI, the response key was illuminated for 5 seconds in the color corresponding to the target stimulus. In conditions not containing an ISI, the response key was illuminated in the target key color immediately following the offset of the occasion setter. At the offset of the target keylight, food was presented for *x* seconds. Responses to the operative response key during each stimulus event were recorded.

(2) T^- Trials: Following an ITI, the response key was illuminated for 5 seconds in the color corresponding to the target stimulus. Food was not presented at the end of the 5-second duration. Responses during presentations of the target stimulus were recorded. The duration of the target stimulus remained at 5 seconds for the entire experiment.

(3) OS^- Trials: Following an ITI, the response key was illuminated for *x* seconds in the color corresponding to the occasion setting stimulus. Responses made during presentations of the occasion setting stimulus were recorded. Presentations of OS^- were included in the positive patterning, multiple stimuli, and replication conditions.

Seven ITI durations were preset for each procedure; which of the seven durations was imposed on any single trial was determined at random. During the ITI, the chamber was dark, no food was presented, and the response key was not illuminated, but any responses made to the operative response key during the ITI were recorded.

For each trial, the computer controller randomly determined the trial type to be presented. The number of positive trials presented for each session of a condition was predetermined in order to provide approximately 150 seconds' total access to food per session. Each condition consisted of a block of training sessions, conducted five days per week for at least fifteen sessions, followed by test sessions to assess transfer or reversibility. The specific number of training sessions conducted prior to the start of testing is shown in Table 2.

The conditions resulted from particular combinations of three principal manipulations of the occasion setting procedure:

(1) Temporal proximity of the occasion setter to food;

(2) Presence of trials in which the occasion setter was presented alone (positive patterning); and

(3) Use of multiple keylight colors, with and without a "one-second transition.

Table 2 also identifies the main aspects of each condition.

Manipulating Temporal Proximity. The basic occasion setting procedure (the serial, feature-positive procedure) was diagrammed in Figure 1 of Chapter I. A positive occasion setting compound trial ($OS \rightarrow T^+$) was presented on alternating trials with presentations of the target alone (T^-) without food. Initially, a five-second occasion setter was presented followed by a 10-second ISI and then a five-second target stimulus. (This procedure will be abbreviated TP5/10; the TP indicates that the primary manipulation is temporal proximity, the 5 indicates the duration of the occasion setter, and the 10 indicates the duration of the ISI.) After testing for transfer and reversal, the duration of the ISI was increased from 10 to 40 seconds (TP5/40).

Table 2. Overview of the Experimental Procedures

Condition	Procedure	ITI Duration (in sec)[1]	Occasion Setter Duration (in sec)	Duration of Food Hopper (in sec)	Number of Training Sessions
Temporal Proximity	TP5/10	30-90	5	4	80
	TP5/40	130-190	5	5	60
	TP45/0	130-190	45	5	25
Positive Patterning	PP45	130-190	45	5	25
	PP90	130-190	90	6	40
	PP120	130-190	120	6	35
Multiple Stimuli	MS0	130-190	120	6	30
	MS1	130-190	120	6	15
Replication	REP1	130-190	45	5	30
	REP2	130-190	45	5	25

[1]Seven intertrial interval durations were possible within the range specified to yield a mean ITI equal to the midpoint of the range. The ITI duration for any one presentation was selected randomly within each session from among the seven possible values.

Again after testing for transfer and reversal, the duration of the ISI was decreased to 0 seconds while the duration of the OS was increased to 45 seconds, corresponding to the same time span as the OS and ISI together (TP45/0). Transfer and reversal testing was performed after training.

Positive Patterning. The remaining conditions of the experiment involved a variation of the occasion setting procedure in that, in addition to the positive ($OS \rightarrow T^+$) and negative (T^-) trials of occasion setting, additional negative trials in which the OS was presented alone (OS^-) were also presented. The structure of the positive patterning trials was the same as that of the temporal proximity trials except that OS^- trials were also presented. In the first procedure, a 45-second occasion setter was presented (PP45), followed by tests for transfer and reversibility. The duration of the occasion setter in training was increased to 90 (PP90) and 120 seconds (PP120) in two subsequent procedures. Tests for reversibility were conducted after the PP90 and PP120 training procedures.

Training with Multiple Stimuli. There was one major procedural change made between the positive patterning and multiple stimuli conditions: whereas in the positive patterning procedures, one OS and one target stimulus were used, the multiple stimuli procedures used two occasion setting and two target stimuli. Consequently, training consisted of alternating presentations of four occasion setting compounds ($OS_1 \rightarrow T_1^+$, $OS_2 \rightarrow T_2^+$, $OS_1 \rightarrow T_2^+$, and $OS_2 \rightarrow T_1^+$), two target stimuli (T^-_1 and T^-_2), and two occasion setting stimuli (OS^-_1 and OS^-_2). Training was conducted, first, with occasion setting compounds containing a 0-second transition to the target stimulus

(MS0) and, second, with occasion setting compounds containing a 1-second transition to the target stimulus (MS1). The duration of the occasion setter in both the positive occasion setting compound trials and the OS^- trials remained at 120 seconds.

Testing. Test sessions were arranged in the same way for all conditions and types of tests: nonreinforced test trials were presented every ten trials, alternating between reversal or transfer trials and nonreinforced training test trials. Test trials were embedded within regular training sessions and structured in the same way as training trials with one exception: no food was offered following presentations of the occasion setting compounds in test trials. Durations of the stimulus presentations, ISIs, and ITIs in all test trials were the same as in training. A test session was continued until four presentations of each type of test trial was presented. Test sessions were run for five consecutive days. Response rates during the nonreinforced test trials were compared.

Tests for transfer of stimulus function, designed to evaluate responding to a novel target stimulus, were made following training in all temporal proximity procedures and the first procedure of positive patterning. A transfer test trial consisted of a nonreinforced presentation of an occasion setting compound containing the familiar, trained occasion setting stimulus followed by a novel target stimulus (novel color). For example, in TP5/10, the test trial presented the trained occasion setter keylight color for 5 seconds, followed by a 10-second ISI, and a 5-second presentation of the novel keylight color. The transfer tests conducted are listed in Table 3. Data from the transfer and training test trials were compared with those for responding to the trained target alone (from training) in analyses of transfer test results.

Table 3. Transfer Test Procedures

Procedure	Test
TP5/10	OS→T$_*$
TP5/40	OS→T$_*$
TP45/0	OS→T$_*$
PP45	OS→T$_*$

[1]T$_*$ denotes a novel transfer target stimulus.

Testing for reversibility of stimulus function, made following every procedure of the experiment, assessed responding during presentation of the occasion setting compound when the order of stimuli presented in the compound was reversed. For example, if a subject had been trained with a red occasion setter presented for 45 seconds and a green target presented for 5 seconds (TP45/0), the reversal test would have presented a green occasion setter for 45 seconds and a red target for 5 seconds. The reversibility tests performed are shown in Table 4.

The method of the reversal tests using multiple stimuli was the same as in all other reversal tests. However, three types of reversal compounds were tested. The first compound was the basic reversal compound used in all previous reversal tests except that, with four occasion setting compounds used in training, four combinations

Table 4. Reversal Test Procedures

Procedure	Test 1	Test 2	Test 3	Test 4
TP5/10	$T \rightarrow OS$			
TP5/40	$T \rightarrow OS$			
TP45/0	$T \rightarrow OS$			
PP45	$T \rightarrow OS$			
PP90	$T \rightarrow OS$			
PP120	$T \rightarrow OS$			
MS0	$T_1 \rightarrow OS_1$	$T_2 \rightarrow OS_2$	$T_1 \rightarrow OS_2$	$T_2 \rightarrow OS_1$
	$T_1 \rightarrow T_2$	$OS_1 \rightarrow OS_2$	$T_2 \rightarrow T_1$	$OS_2 \rightarrow OS_1$
	$T_1 \rightarrow T_1$	$OS_1 \rightarrow OS_1$	$T_2 \rightarrow T_2$	$OS_2 \rightarrow OS_2$
MS1	$T_1 \rightarrow OS_1$	$T_2 \rightarrow OS_2$	$T_1 \rightarrow OS_2$	$T_2 \rightarrow OS_1$
	$T_1 \rightarrow T_2$	$OS_1 \rightarrow OS_2$	$T_2 \rightarrow T_1$	$OS_2 \rightarrow OS_1$
	$T_1 \rightarrow T_1$	$OS_1 \rightarrow OS_1$	$T_2 \rightarrow T_2$	$OS_2 \rightarrow OS_2$

of reversal compounds were possible ($T_1 \rightarrow OS_1$, $T_2 \rightarrow OS_2$, $T_1 \rightarrow OS_2$, and $T_2 \rightarrow OS_1$). A total of 16 reversal and training test trials were presented in each daily test session.

The second type of reversal compound presented one occasion setter as the occasion setter in the test compound while the second occasion setter served as the target stimulus ($OS_1 \rightarrow OS_2$ and $OS_2 \rightarrow OS_1$); likewise, one trained target acted as occasion setter for the second trained target ($T_1 \rightarrow T_2$ and $T_2 \rightarrow T_1$). The third reversal compound presented the same stimuli serving as both occasion setter and target stimulus ($OS_1 \rightarrow OS_1$, $OS_2 \rightarrow OS_2$, $T_1 \rightarrow T_1$ and $T_2 \rightarrow T_2$). Sixteen presentations of each variation of the reversal compound were made within each test session. Comparisons were made among rates of responding obtained for the trained and reversed compounds, the trained target alone (from training), and the reversed target alone.

Replication. Following the last test of the multiple stimulus condition, Subjects 1, 2, and 3 were identified for participation in three replication procedures.[13] In the first replication (REP1), subjects were trained in a positive patterning procedure with a single, 45-second occasion setter and single, 5-second target stimulus (the same procedure as PP45). During the reversal test, the order of stimulus presentation was reversed. In the second and third replications, subjects were again trained with a 45-second occasion setter and 5-second target stimulus except that rather than a single occasion setting compound, the four compounds used previously in the multiple stimulus condition were presented. Testing consisted of a usual reversal test with the four possible combinations of the reversed occasion setting compound (REP2) and with occasion setting compounds made up of the two different occasion setters, the two different target stimuli, the same occasion setter, and the same target stimulus (REP3; equivalent to the reversal test variations of MS0 and MS1).

[13]Subject 4's training and test data during the main experiment were inconsistent and, therefore, the bird was excluded from the replication procedures.

CHAPTER III

RESULTS

Measuring Occasion Setting

Occasion setting training presents subjects with two different types of trials. On positive trials, the occasion setter is presented, followed by a target stimulus, then food. On negative trials, the target stimulus is presented alone, without either the occasion setter or food. One way to measure the behavior elicited during these positive and negative trials is simply to count the number of responses occurring during each stimulus presentation and report an overall mean number of responses by stimulus type. The problem with reporting the absolute number of responses, however, is that it ignores the temporal dimension of the stimuli. For example, if 120 responses are elicited by a 120-second occasion setter and 20 responses by a 5-second positive target stimulus, the occasion setter would seem the more excitatory stimulus since the number of responses it elicits is higher than that elicited by the target stimulus. It seems more appropriate, however, to consider the target to be the more excitatory stimulus because the rate of responding (measured in responses per minute) is considerably higher for the target stimulus (240 responses per minute) than for the occasion setter (60 responses per minute).

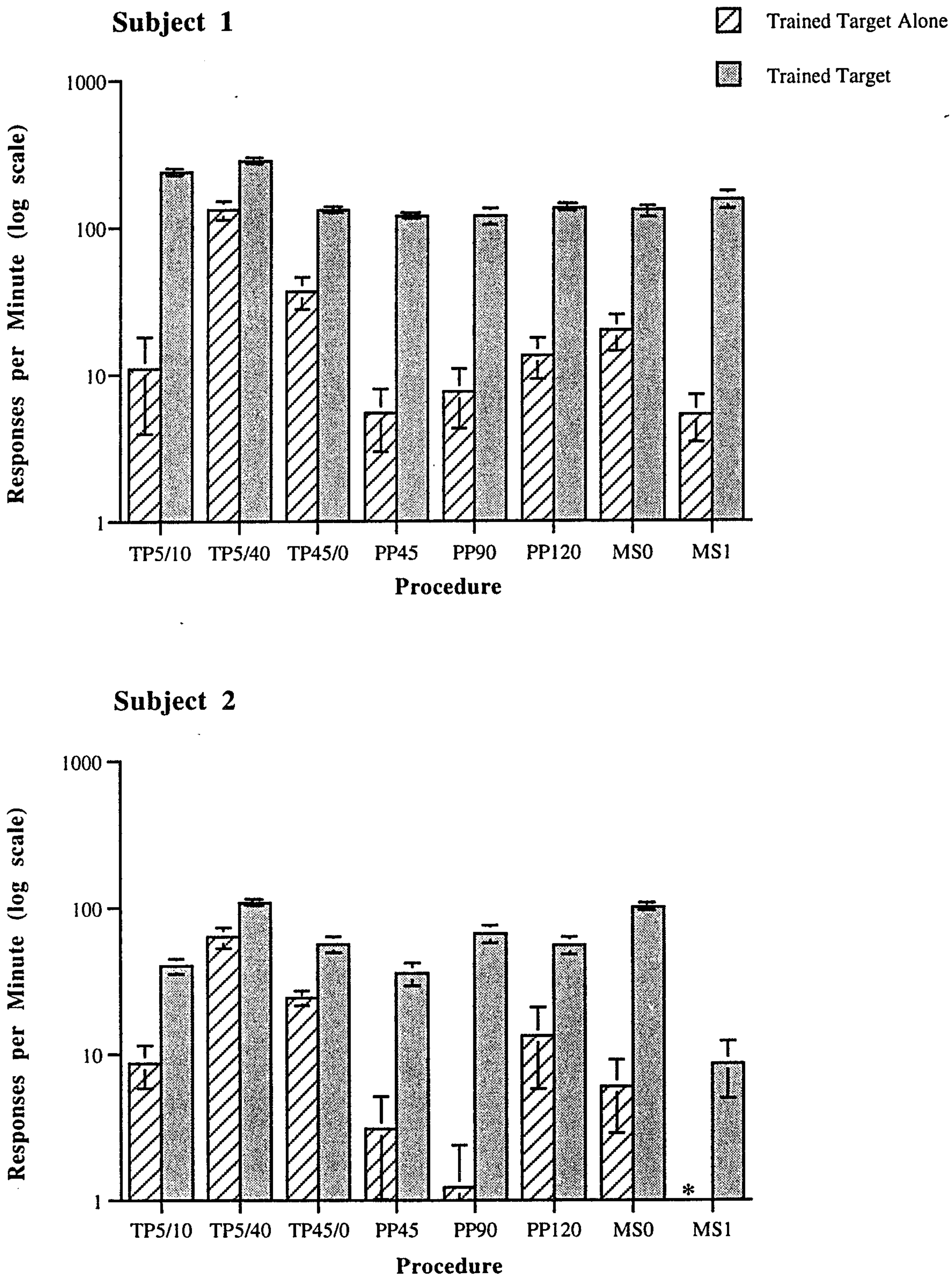
The level of behavior elicited by each stimulus in the present experiment, therefore, will be reported in responses per minute (rpm). Accordingly, occasion setting will be demonstrated when the rate of responding obtained during presentation of a target stimulus preceded by an occasion setter reliably exceeds the rate of responding obtained during presentation of the target stimulus alone. The higher response rate for the positive target, relative to the negative target, indicates that the presence of the occasion setter facilitates responding to the target stimulus.

Evaluating Occasion Setting Training

In the experiment reported here, three primary manipulations -- temporal proximity, positive patterning, and multiple stimuli with and without a one-second "transition" -- were made over eight training conditions. The results of each training procedure, presented on a log scale with 95 percent confidence intervals in Figure 2, are discussed below; these response rate data are presented in tabular form in Appendix A. Means and standard errors were calculated from response rates (responses per minute) computed for each individual trial in a training or test period. In the Figure, occasion setting is exhibited when the mean rate of responding for presentations of the target stimulus preceded by the occasion setter ("Trained Target") exceeds the rate of responding during presentations of the target alone ("Trained Target Alone"). Response rate differences were determined to be judged significant when there was no overlap in their respective confidence intervals; the intervals are provided as an indication of the observed variability in response rates.

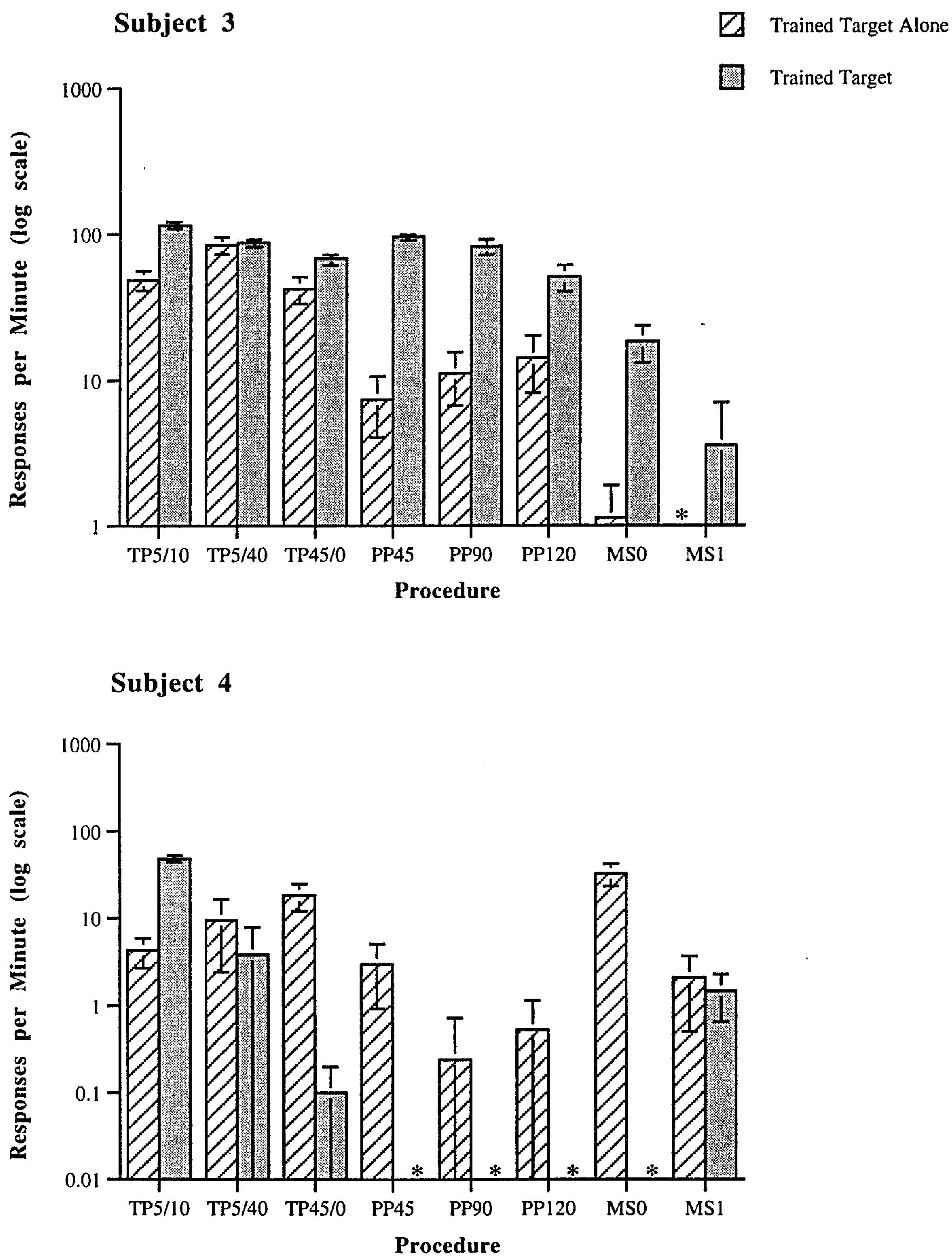
Based on mean response rates obtained during the last five days of each training condition, occasion setting was exhibited by all subjects, with the exception of Subject 3 in TP5/40 and of Subject 4, whose data showed a higher rate of responding to the

Figure 2. Responding to the Target Stimuli During Training



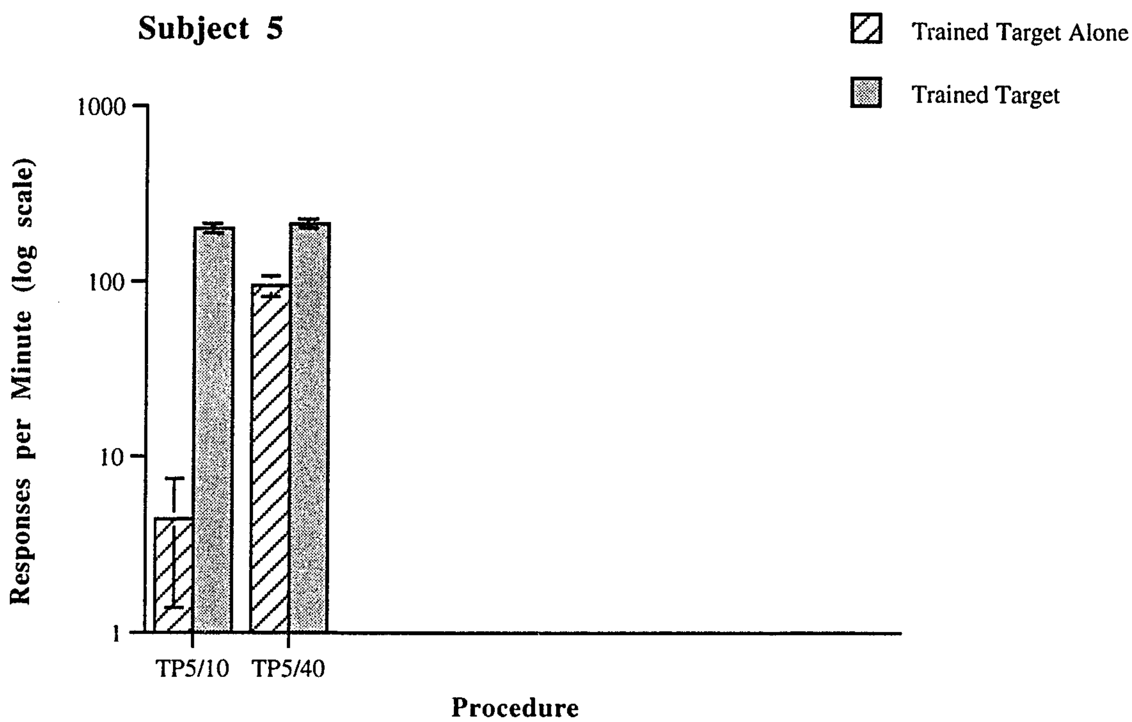
* **Value equals zero.**

Figure 2. Responding to the Target Stimuli During Training



* Value equals zero.

Figure 2. Responding to the Target Stimuli During Training



target stimulus presented alone than to the positive target for all but the first procedure (TP5/10). In general, variability in response rates was higher during presentations of the trained target stimulus preceded by the occasion setter than during the trained target alone, probably due to the absolute differences in the levels of behavior evoked by the two types of stimuli.

Temporal Proximity. Training with three different combinations of occasion setter and interstimulus interval (ISI) durations was conducted during the temporal proximity condition an effort to decrease control by the color of the occasion setter by decreasing the temporal proximity of the occasion setter to food. In both the first (TP5/10) and last (TP45/0) temporal proximity procedures, response rates during the positive target stimulus exceeded those for the negative target stimulus for all subjects, except Subject 4 in TP45/0.[14] In the second temporal proximity manipulation (TP5/40), which presented an occasion setter for the same 5-second duration as TP5/10 but with an increased ISI duration of 40 seconds, only Subjects 1 and 5 demonstrated the occasion setting effect. That all subjects showed an increased response rate on the negative target in TP5/40 was probably due to an inability to differentiate presentations of the target stimulus preceded by a 40-second ISI in the positive occasion setting compound from presentations of the negative target stimulus preceded only by the intertrial interval.

Positive Patterning. Positive patterning, in which trials presenting the occasion setter alone and without food (negative occasion setter) were alternated with all other

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[14]Subject 2 died at the end of testing for TP5/40.

occasion setting trials, was introduced during training to decrease the predictiveness of the occasion setter. That is, with the addition of negative occasion setter trials, the probability of food following presentation of the occasion setter decreased from 1.00 to about 0.50. The occasion setting effect was demonstrated reliably for all subjects following training in each of the three positive patterning procedures, which differed only in the duration of the occasion setter (PP45, PP90, PP120), again with the exception of Subject 4.

Multiple Stimuli. In the final condition of the experiment, training involved presentation of four, rather than two, occasion setter-target pairs. In the first procedure, the target stimuli were presented immediately following offset of each 120-second occasion setter (MS0). In the second procedure, a one-second "transition" separated presentations of the occasion setter and target stimulus in occasion setting compound trials (MS1). In both procedures, Subjects 1, 2, and 3 consistently demonstrated the occasion setting effect.

In summary, the occasion setting effect was demonstrated in each of the eight training procedures of the present experiment. Response rates during presentations of target stimuli preceded by occasion setting stimuli were reliably higher than rates obtained during presentations of the target stimuli alone, providing a consistent and robust demonstration of the occasion setting effect. Thus three of the four birds generated baseline occasion setting performances that will be used to address the primary experimental questions: can this same effect can be obtained when a novel target stimulus is presented in the transfer test and when the order of stimuli in the occasion setting compound is reversed in the reversal test? (Since Subject 4 did not produce a reliable occasion setting performance during most training conditions, there was no point in reporting transfer and reversibility of the occasion setting effect for the bird. These are available, however, in Appendix B.)

Tests for Transfer of Stimulus Function

In the transfer test, a new and unfamiliar target stimulus was presented in place of the trained target stimulus in the occasion setting compound in order to determine whether an occasion setter can facilitate responding to a novel target as well as to the familiar target stimulus. Demonstration of successful transfer requires that the response rate for the novel target stimulus preceded by the trained occasion setter exceed the rate of responding obtained for the target alone, indicating that the occasion setter is augmenting responding to a novel target stimulus above the level of the target alone.[15] Secondarily, the rate of responding obtained when the novel stimulus is presented with the trained occasion setter should be approximately equal to the rate obtained when the trained target stimulus is preceded by the occasion setter, although some degradation should be expected as a result of generalization decrement and extinction over the five days of testing (a decrease in the amount of conditioning obtained during transfer compared to that obtained during training; see Pearce, 1987 for a discussion).

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[15]The most obvious comparison would be between presentations of the novel target stimulus preceded by the occasion setter and of the novel target alone. However, inclusion of trials in which the novel target was presented alone might have imposed a conditioning history on the stimulus. Response rates obtained during presentations of the trained target alone, therefore, were used as a surrogate for the novel target alone.

Transfer tests were conducted following training in the three temporal proximity manipulations (TP5/10, TP5/40, TP45/0) and the first of the positive patterning procedures (PP45). The likelihood of obtaining successful transfer across these four procedures was expected to increase such that the positive patterning procedure with the 45-second occasion setter would have the greatest likelihood of demonstrating transfer. Results of the four transfer tests are shown in Figure 3. In the Figure, the response rates obtained during presentations of the trained target alone ("Trained Target Alone")[16] may be compared with those obtained when the trained target stimulus was preceded by the occasion setter ("Trained Target") and when the novel target stimulus was preceded by the occasion setter ("Novel Target"). For successful transfer, these latter two rates should be approximately equivalent and, at the same time, higher than rates for the target alone.

Successful transfer of the occasion setting effect was obtained for all subjects following training in the last procedure, PP45, only. Looking at the right most set of bars in each graph, the rate of responding for the novel target stimulus preceded by the trained occasion setter exceeded the rate observed for the target stimulus presented alone, and was at about the same level as for the trained target preceded by the occasion setter. This relationship among response rates was consistent across subjects, despite individual differences in rates of responding, making it unlikely that the result was due simply to chance.

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[16]In order to minimize session durations during testing, test trials of the trained target alone were not included during the test period. Estimates for the trained target alone, presented with both the transfer and reversal test results, were taken from training data for the relevant procedure.

Figure 3. Responding to the Target Stimulus in the Transfer Test

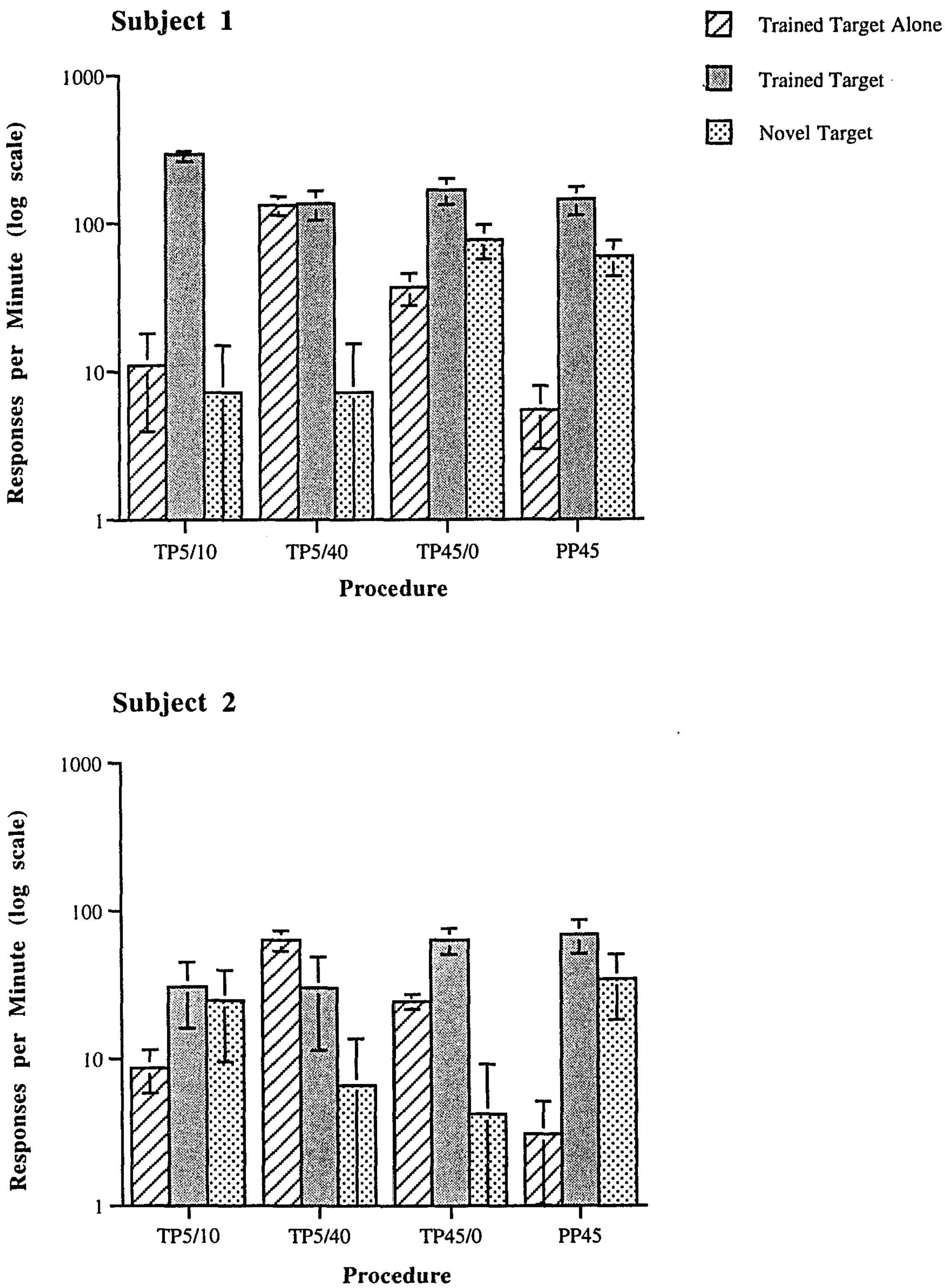
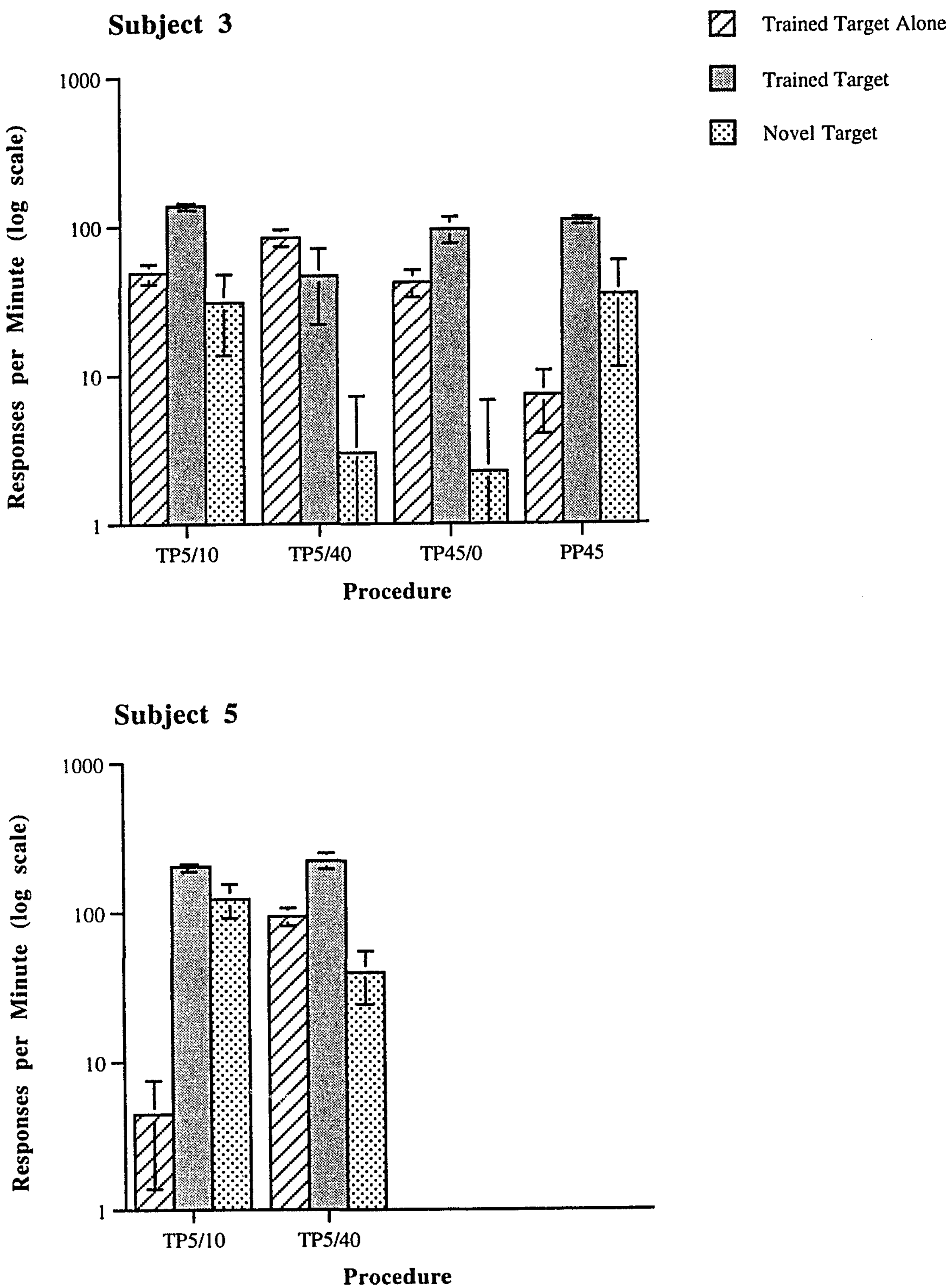


Figure 3. Responding to the Target Stimulus in the Transfer Test



It is worth noting, however, that the rate of responding evoked by the novel target was not statistically equivalent to the trained target, suggesting that an occasion setter may facilitate responding to a novel target but not to the same levels as the familiar, trained target (response rates were intermediate to those obtained for the trained target and trained target alone). It is also possible that there was some decline in response rates over consecutive test sessions due to presentation of the training and test compounds in extinction (i.e., without reinforcement).

Tests for Reversal of Stimulus Function

During reversal testing, the reversed compound presents the trained target stimulus first, in the position of the occasion setter (referred to here as the "reversed occasion setter"), followed by the trained occasion setter in the position of the target stimulus (i.e., the "reversed target").[17] One of the important properties of the occasion setter suggesting a distinctive role as a facilitative stimulus is that, once trained as such, the occasion setter should not be able to function in the position of the target as an excitatory stimulus. Likewise, the excitatory target stimulus should not be able to function as the occasion setter. Apparently, in tests of reversal following occasion setting training then, the positions of the occasion setter and target stimulus cannot be reversed and still obtain response rates characteristic of occasion setting training. According to a complex features model, however, an occasion setting effect

[17]In both the text and figures, the stimulus type identified following the term, "reversed," refers to the specific placement of the stimulus during the reversal test. The "reversed target stimulus," therefore, refers to the target stimulus for the reversal test which, by definition, is the trained occasion setter. Likewise, the "reversed occasion setter" refers to the trained target stimulus, presented as the occasion setter in the reversed compound.

may occur even when the order of presentation of the occasion setter and target stimulus is reversed if the controlling features of training are retained in the reversal test.

Like the transfer test, a successful occasion setting effect with the reversed occasion setter-target stimulus requires, most importantly, that the response rate obtained during presentations of the reversed target preceded by the reversed occasion setter be higher than the rate obtained when the reversed target stimulus is presented by itself. If the rate for the reversed occasion setting compound exceeds that for the reversed target alone, then the reversed occasion setter must be able to augment responding to the reversed target beyond the level of responding elicited by the reversed target alone. Secondarily, the response rate obtained during presentations of the reversed target preceded by the reversed occasion setter should be approximately that obtained during presentations of the trained target preceded by the trained occasion setter, with the expectation again that there may be some generalization decrement.

Reversal tests were conducted, in extinction, following every training condition in the present experiment. As with the transfer test, there was an increasing expectation of reversibility across training procedures such that the likelihood of reversal should have been highest in the last training procedures (MS0 and MS1). In these last two procedures, the primary reversal criterion -- higher rates of responding during presentation of the reversed target preceded by the reversed occasion setter compared to rates for the reversed target presented alone -- was met, but not reliably for all subjects. In none of the tests were both reversal criteria met for all subjects. The results of each test are discussed below by training procedure.

Temporal Proximity. The first reversal tests were conducted following training with the three procedures in which the temporal proximity of the occasion setter to food was manipulated. The results of the tests are presented in Figure 4. A reversal of function was obtained for Subject 1 in TP45/0 and provides an appropriate benchmark for additional reversal test comparisons: the response rate during presentation of the reversed target preceded by the reversed occasion setter (121.20 rpm ± 11.40[18]; "Reversed Target" in the Figure) exceeded the rate of responding for the reversed target alone (44.73 rpm ± 10.88; "Reversed Target Alone")[19] and the rate of responding for the reversed target was approximately equivalent to that of the trained target preceded by the trained occasion setter (124.80 rpm ± 17.10; "Trained Target"). Quick inspection of response rates across subjects in the temporal proximity condition, however, reveals that this same pattern of results was not obtained for any other subject or procedure.

Positive Patterning. Figure 5 shows the results of the reversal tests conducted after training in the three positive patterning procedures, which seemed more likely

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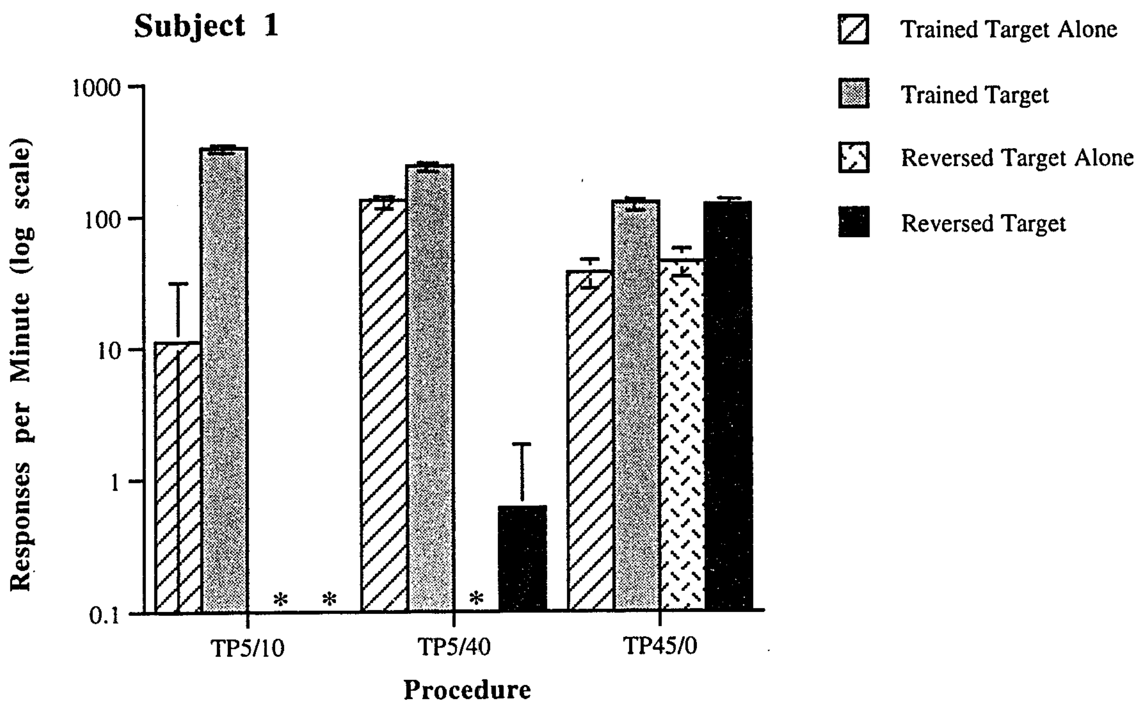
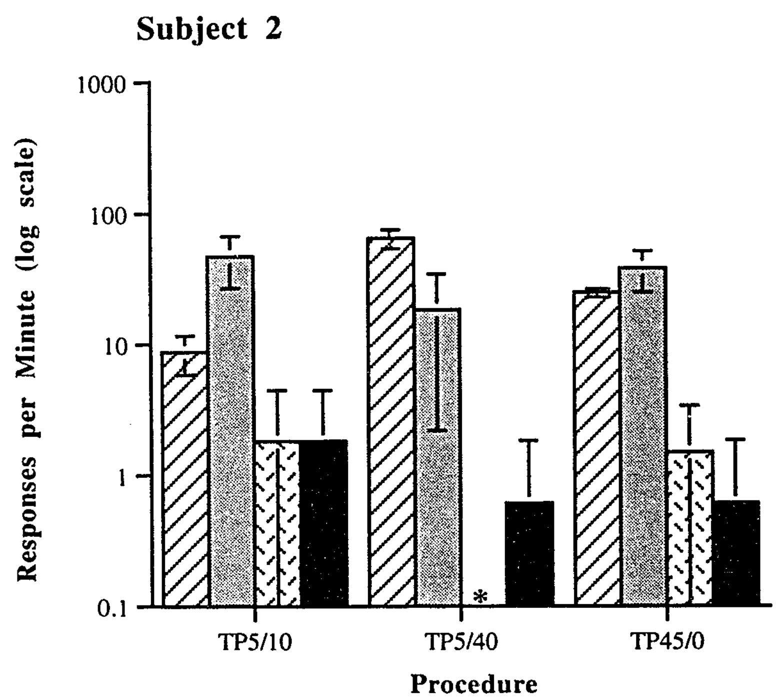
[18]Ninety-five percent confidence intervals are reported.

[19]Explicit five-second presentations of the occasion setter alone, equivalent to presentation of the target alone in training, were not included during testing but have been approximated by the response rate obtained for the occasion setter.

Figure 4. Responding to the Target Stimulus in the Reversal Test Following Manipulation of Temporal Proximity (TP)

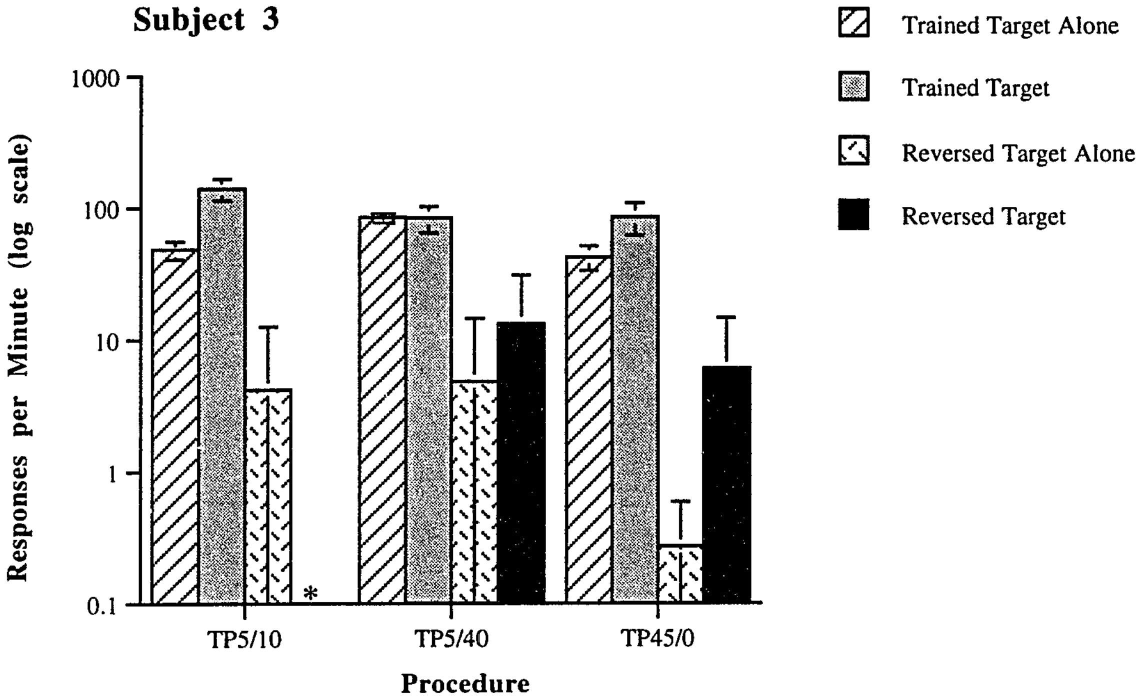




* Value equals zero.

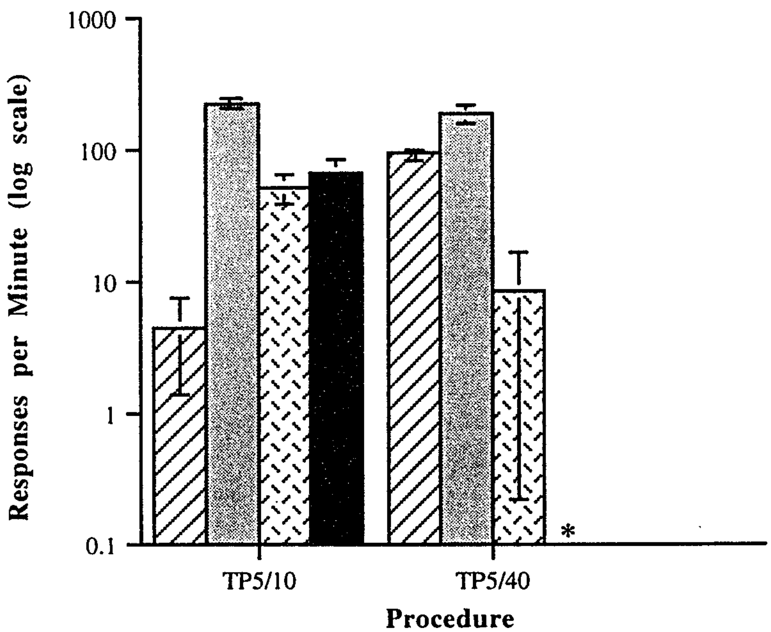
Figure 4. Responding to the Target Stimulus in the Reversal Test Following Manipulation of Temporal Proximity (TP)

Subject 3



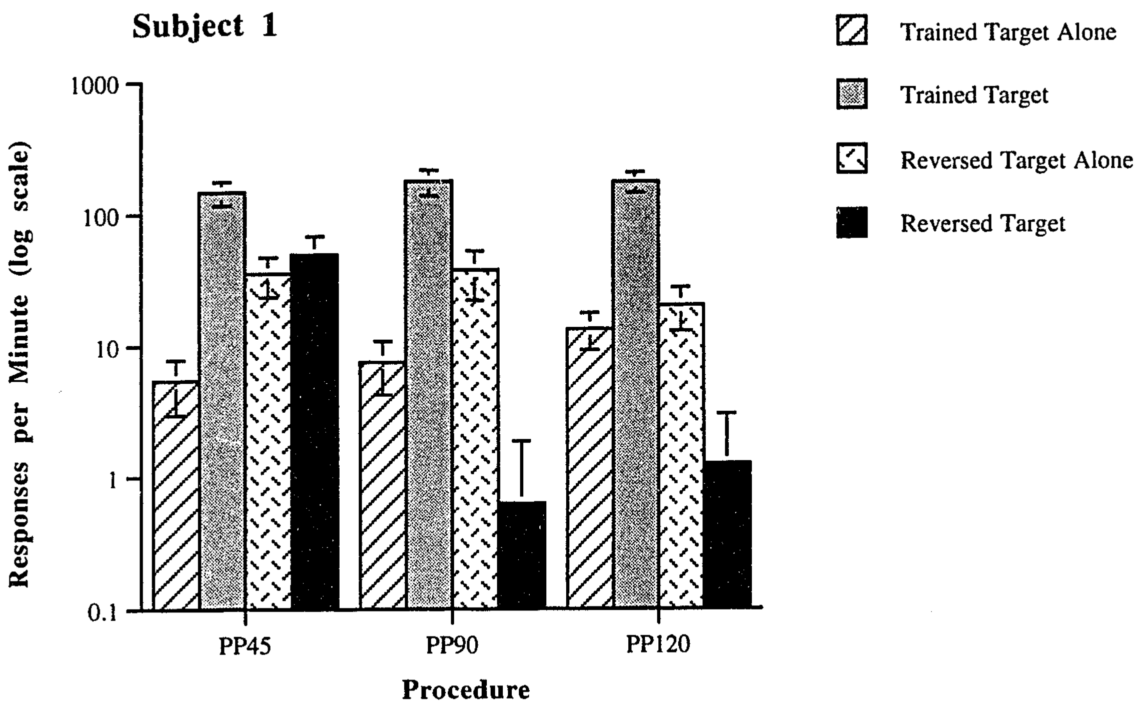
* Value equals zero.

Subject 5



* Value equals zero.

Figure 5. Responding to the Target Stimulus in the Reversal Test Following Positive Patterning (PP) Training



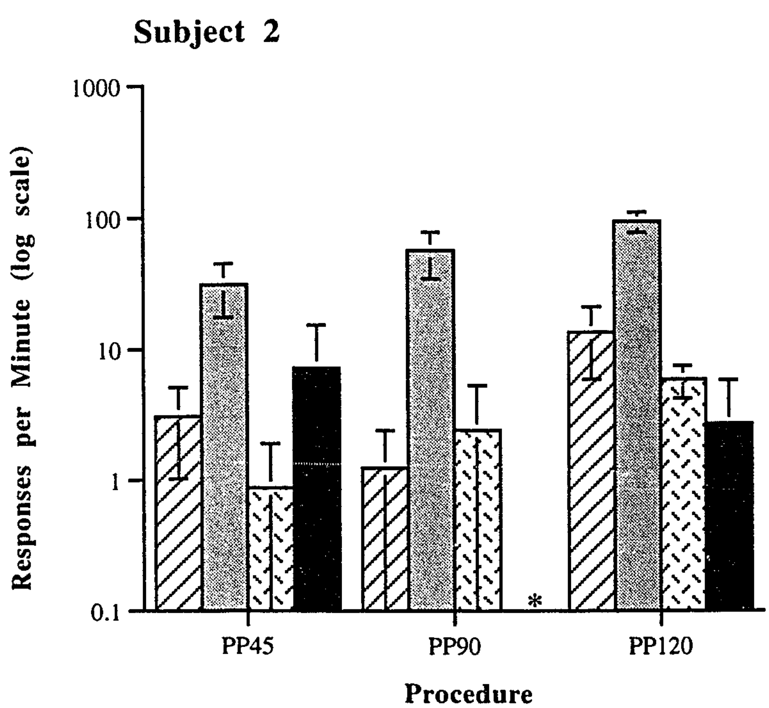


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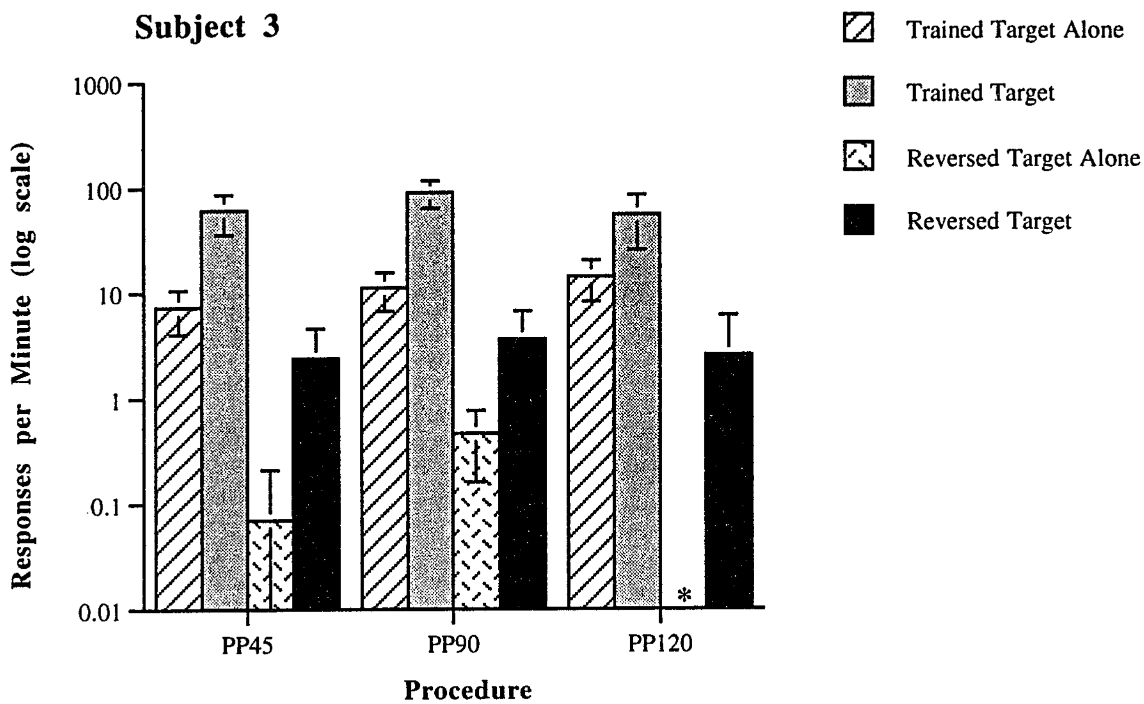
Figure 5. Responding to the Target Stimulus in the Reversal Test Following Positive Patterning (PP) Training



* Value equals zero.

than the temporal proximity procedures to produce an occasion setting effect under the reversal. In some tests, the reversal criteria were met. For example, response rates during presentation of the reversed target for Subject 3 were somewhat higher than rates obtained during presentation of the reversed target alone. Subject 2 in PP45 showed a pattern of results similar to Subject 3 in that the rate of responding during the reversed target in compound exceeded the rate obtained for the reversed target alone. No other test results, however, were indicative of reversal in the positive patterning condition.

Multiple Stimuli. Training with multiple occasion setting compounds and with multiple compounds that included a one-second "transition" had the greatest expectation of successful reversal. The increased number of positive occasion setting compounds should have reduced control by the specific colors of the stimuli in the compound relative to other compound features. Inclusion of the one-second transition should have made the transition a more salient event thereby further increasing the likelihood of reversal, as the transition, rather than the keylight colors, should have come to control responding. The same criteria for reversal were applied in these tests, despite the multiple compounds.[20]

The results of the multiple stimuli reversal tests are shown in Figure 6 for both multiple stimuli procedures (without the transition, MS0, and with the transition, MS1). Only Subject 3 met both criteria for successful reversal. However, the primary reversal criterion was met in both MS0 and MS1. The rates of responding obtained

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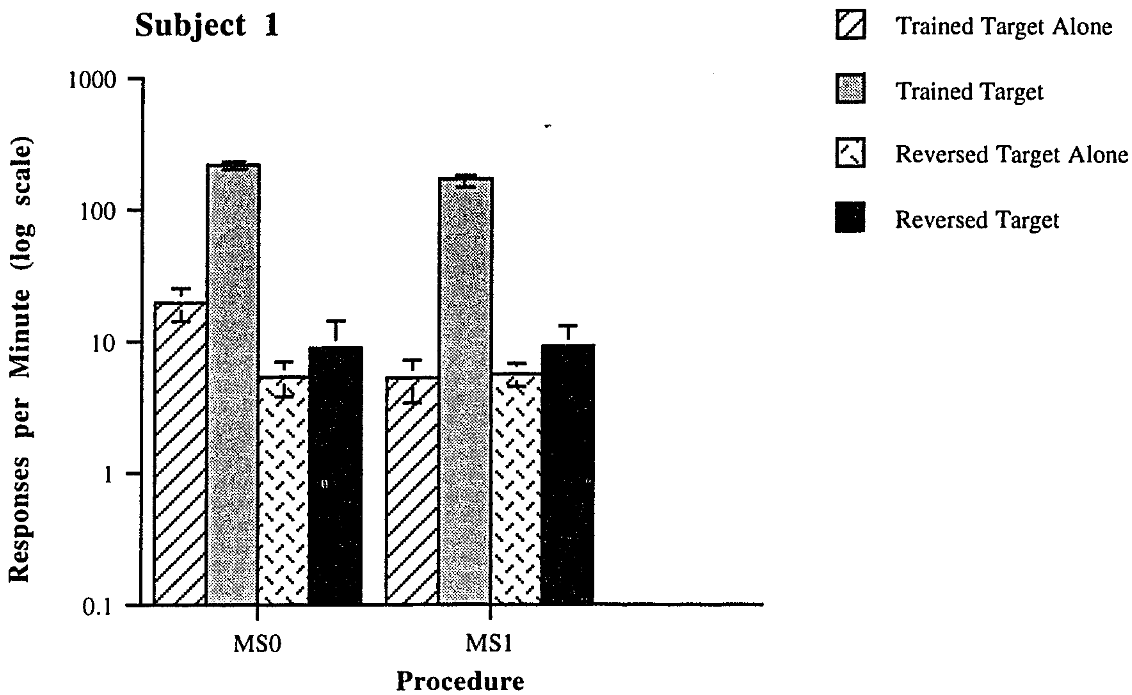
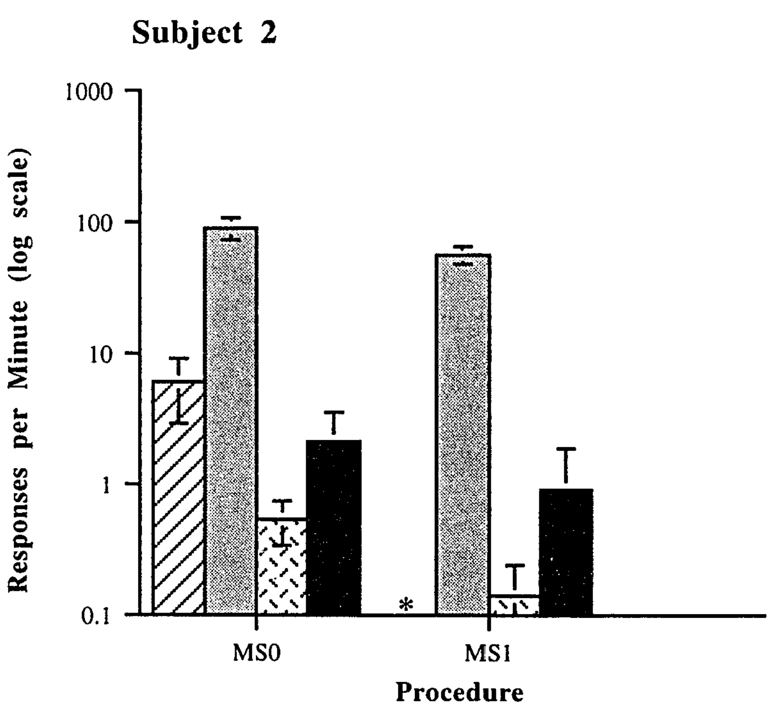
[20]Response rates were calculated across keylight colors to produce a single value for each stimulus type.

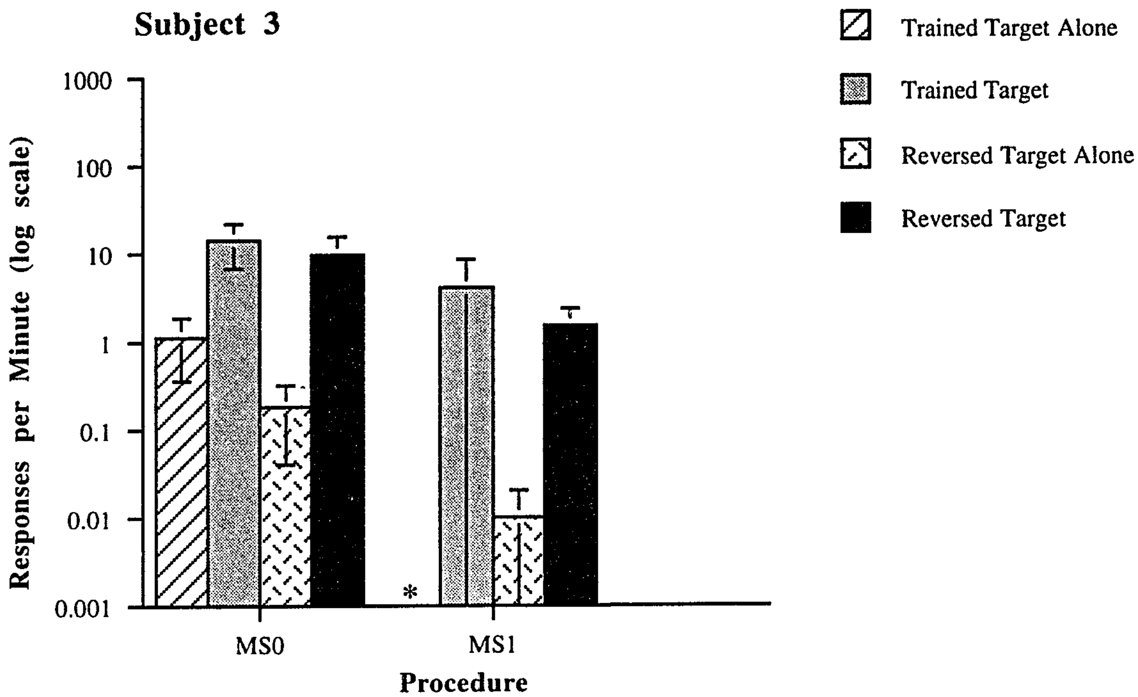
Figure 6. Responding to the Target Stimulus in the Reversal Test Following Training with Multiple Stimuli (MS0 and MS1)





* Value equals zero.

Figure 6. Responding to the Target Stimulus in the Reversal Test Following Training with Multiple Stimuli (MS0 and MS1)



* Value equals zero.

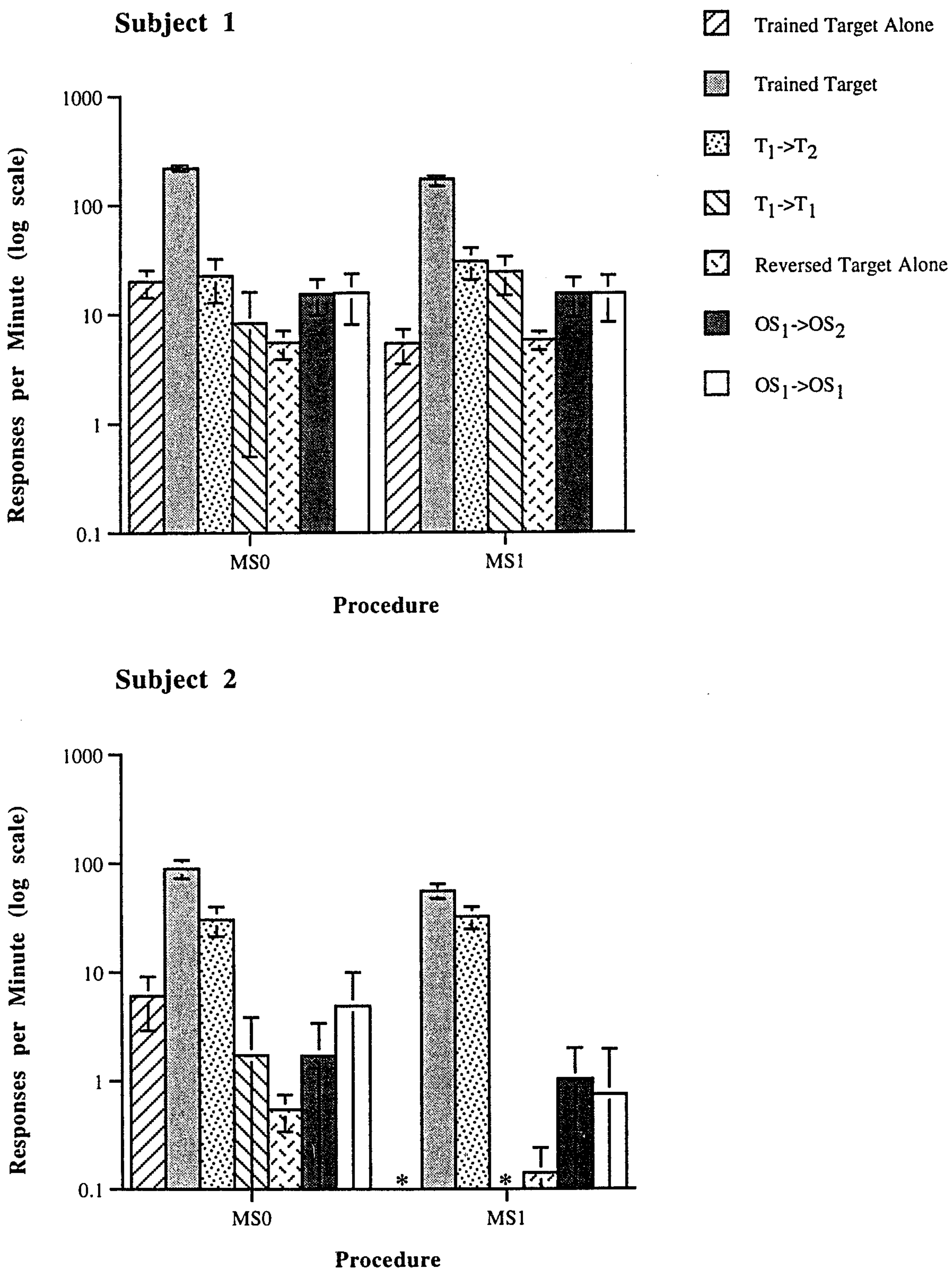
during presentations of the reversed target exceeded rates obtained during presentations of the reversed target alone. Although these differences were not judged significant for all subjects, there is a hint or suggestion that the reversed occasion setter may have been facilitating responding to the reversed target, if only to a limited extent.

Variations on the Reversal Test. In addition to the usual reversal test, the four occasion setting compounds trained in the multiple stimuli procedures enabled additional testing of various combinations of the occasion setting and target stimuli. These variations were included to determine (1) whether an occasion setter can function as a target stimulus when a trained occasion setter is presented first (e.g., $OS_1 \rightarrow OS_2$; $OS_1 \rightarrow OS_1$) and (2) whether a target stimulus can function as an occasion setter when a trained target stimulus is presented second (e.g., $T_2 \rightarrow T_1$; $T_2 \rightarrow T_2$).

The results of the additional tests are presented in Figure 7. The comparison of interest is between response rates for each of the target stimuli alone and their respective targets, which could be either target stimuli ($T_1 \rightarrow T_2$ and $T_1 \rightarrow T_1$) or occasion setters ($OS_1 \rightarrow OS_2$ and $OS_1 \rightarrow OS_1$) depending upon the particular compound being tested. If a particular "occasion setter" were having a facilitative effect on its associated "target stimulus" in the test compound, the rate of responding observed for that target stimulus should exceed that obtained for its target alone. Secondarily, the rate should be at an approximately equivalent level to the trained target stimulus preceded by the trained occasion setter.

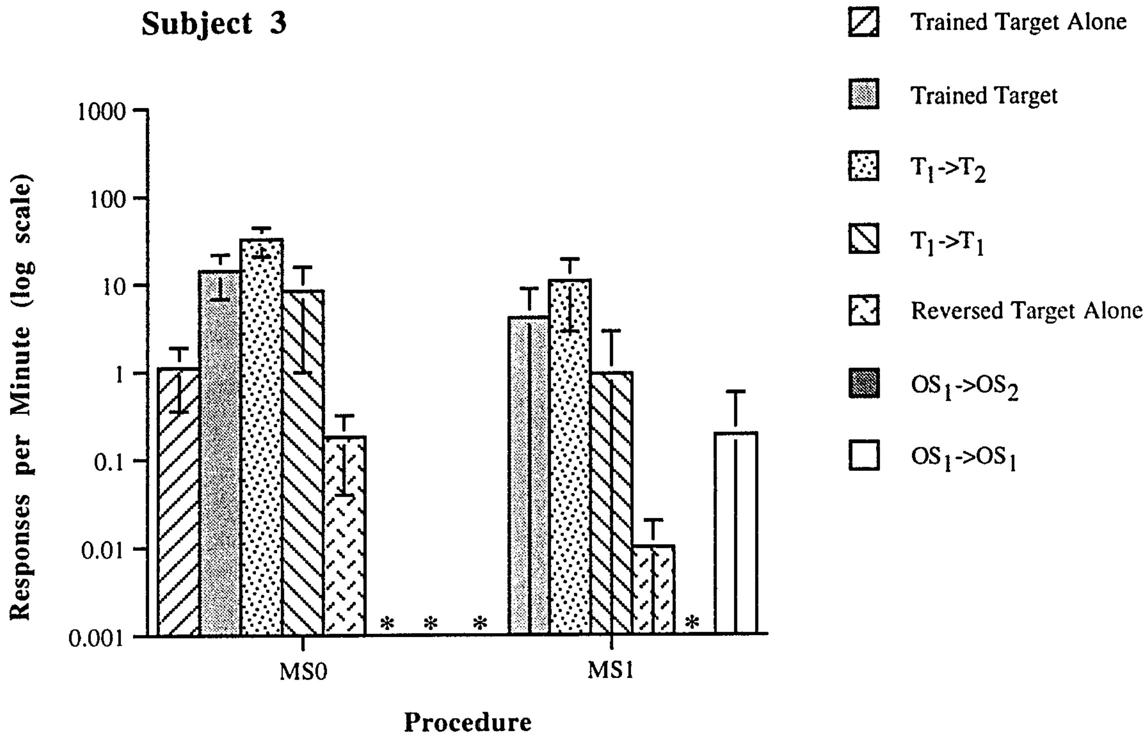
During these variations of the reversal test, rates of responding obtained when the occasion setting compound was comprised of two different training targets were

Figure 7. Responding to the Target Stimulus in Variations of the Reversal Test Following Training With Multiple Stimuli (MS0 and MS1)



* Value equals zero.

Figure 7. Responding to the Target Stimulus in Variations of the Reversal Test Following Training With Multiple Stimuli (MS0 and MS1)



* Value equals zero.

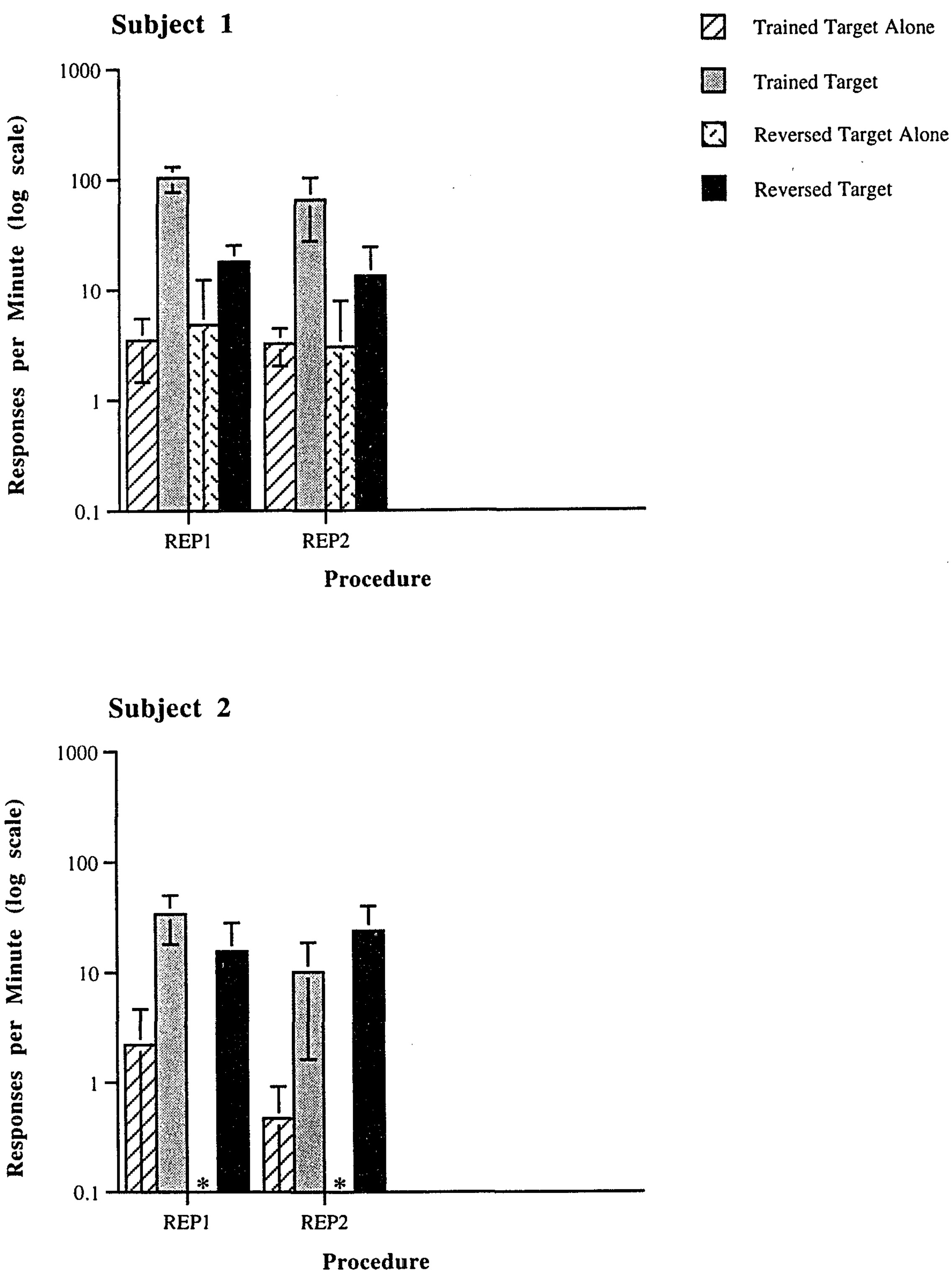
consistently higher than response rates for the trained target alone, with a reliable difference obtained in MS1 for all subjects. (For Subject 3, response rates obtained during presentation of target stimuli preceded by target occasion setters actually exceeded those obtained for the trained target stimuli preceded by trained occasion setters.) Although some rate differences were also found in the other tests, none were consistent across subjects. However, the consistency of the results of the target-target variation test, together with the finding of somewhat higher response rates for the reversed compound in MS0 and MS1, may indicate the beginning of a breakdown of color as the controlling feature of the occasion setting compound.

Replication of Conditions. The results of the first two replication tests conducted are shown in Figure 8. Based on previous reversal results with similar procedures, there was no expectation that the reversal would be successful for either REP1 or REP2. As shown in the Figure, differences in response rates obtained for presentations of the reversed target and reversed target alone were determined to be significant for Subject 1 in REP2 and Subject 2 in both REP1 and REP2. However, both criteria for successful reversal -- a higher rate of responding for the reversed target compared to the reversed target alone and equivalent rates of responding for the trained and reversed target stimuli -- were not met by any of the subjects.[21]

The results of the reversal test variation conducted in REP3, presented in Figure 9, replicated previous findings for all subjects. Response rates for the target stimulus, when the occasion setting compound was made up of the two different target stimuli,

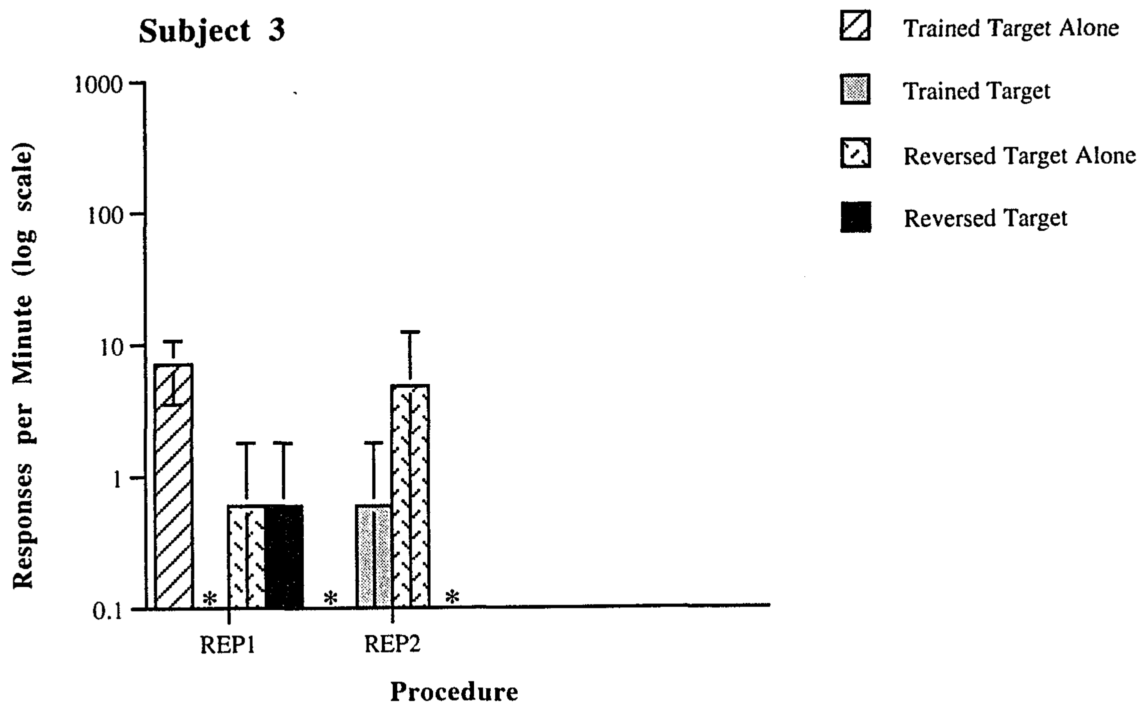
[21]Subject 3's behavior throughout the replication training and test procedures was unstable, perhaps due to the change in housing required by construction of a new laboratory space in the building.

Figure 8. Responding to the Target Stimulus During Replication of the Reversal Test



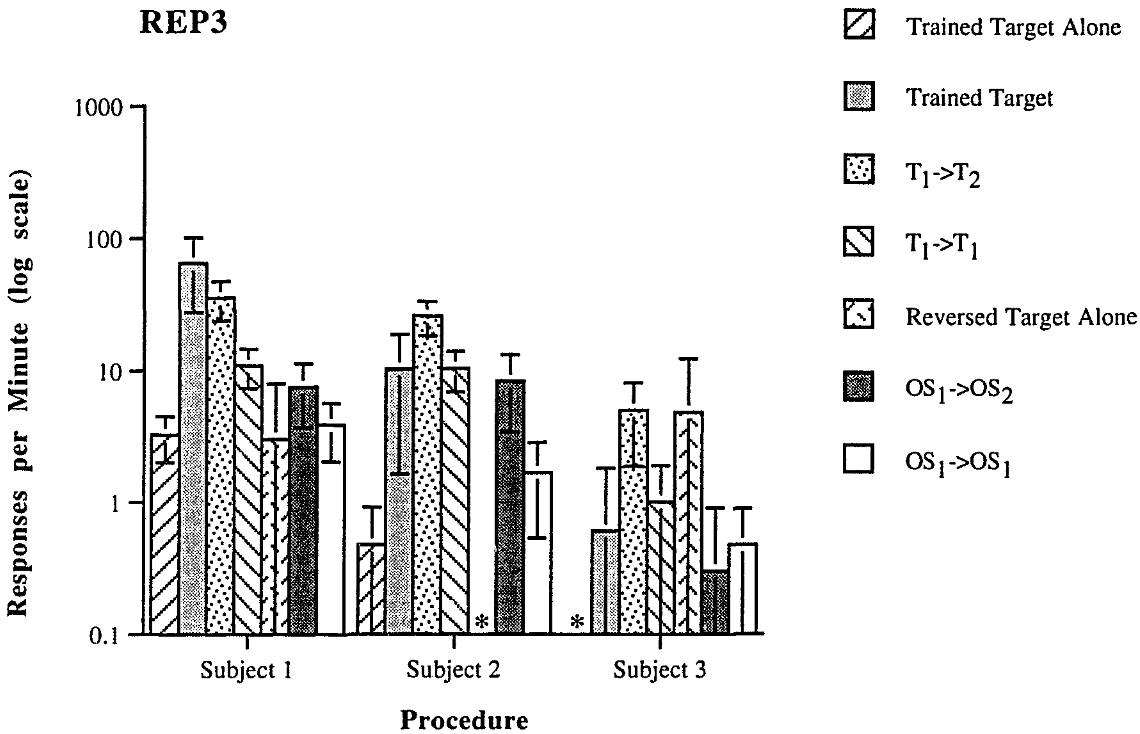
* Value equals zero.

Figure 8. Responding to the Target Stimulus During Replication of the Reversal Test



* Value equals zero.

Figure 9. Responding to the Target Stimulus During Replication of the Reversal Test Variation



* Value equals zero.

reliably exceeded the trained target alone rate for all subjects. Although the occasion setter compounds evoked some behavior for all subjects, the results were not reliable (in fact, response rates for Subject 3 during presentation of the reversed target alone exceeded rates for either occasion setter compound). Unlike the initial test, the rates obtained when the compound was comprised of the same target stimuli also exceeded those obtained for the trained target alone. In addition to confirming the initial findings, these results help to dispel the possibility that the target-target facilitation demonstrated in the main experiment was due to chance, that is, due to an order effect or to the increased likelihood of a significant result with repeated testing.

Procedural Considerations

While the results of the occasion setting training and associated testing procedures were the primary concern of the present experiment, there were certain tangential results that may be of interest. Specifically, these are the results of the initial pretraining procedure and an analysis of response rates during the intertrial and interstimulus intervals.

Pretraining - Autoshaping. The autoshaping procedure elicits keypecking by exposing pigeons to repeated presentations of an illuminated keylight followed by food. It is used frequently, as an alternative to hand shaping, to quickly develop responding on a particular response key. Subjects in the present experiment were first pretrained to peck on the operative response key using an autoshaping procedure that, on each of 40 trials, presented a white illuminated response key for five seconds, followed by four seconds of food. An intertrial interval (ITI) of 30 seconds' duration separated each trial.

The number of trials in which keypecking occurred was the dependent measure. Within 5 days, all five subjects were pecking the operative response key. By 28 days, the criterion of responding to the illuminated key on 90 percent of the trials was met and occasion setting training begun.

Responding During Intertrial and Interstimulus Intervals. In the present experiment, an intertrial interval (ITI), during which the chamber was dark, separated every trial. The duration of any single ITI was selected at random from among seven preset values to yield a mean ITI of 160 seconds (60 seconds for TP5/10). Interstimulus intervals (ISIs), during which the chamber was also dark, separated presentations of the occasion setter and target stimulus of the occasion setting compound in TP5/10 and TP5/40. Responding during both the intertrial and interstimulus intervals of occasion setting training and testing was recorded for each condition of the experiment.

Response rates during all ITIs and ISIs were negligible for Subjects 1, 2, and 3. Subjects 4 and 5 exhibited higher rates of responding when the keylight was not illuminated than did the other subjects, but only during the ISI, not the ITI. Moreover, response rates for both subjects during the ISIs were still quite low: responding for Subject 4 was 1.23 and 0.38 rpm for TP5/10 and TP5/40 respectively; for Subject 5, rates were at 1.38 for TP5/10 and 3.56 rpm for TP5/40.

CHAPTER IV

DISCUSSION

The training and test procedures of the experiment presented here were designed with one principal purpose -- to demonstrate that those data, which have both supported the existence of an occasion setting stimulus function and defied explication from any compound-stimulus model, are predictable and interpretable in terms of at least one version of a compound-stimulus account, the complex features model. A basic assumption of the complex features model is that all stimuli contain obvious and nonobvious features which become conditioned exciters or inhibitors according to the same set of principles which describes all Pavlovian stimulus control. Moreover, when stimuli are presented in compound, as in the occasion setting compound, additional features exclusive to the compound itself, such as the transition between stimuli, are conditioned as well, and their effects are accounted for by the same set of principles.

As has been discussed, the findings of transferability of the facilitative power of the occasion setter to novel stimuli and irreversibility of function of the occasion setter and target stimulus have been detrimental to other compound-stimulus accounts of occasion setting. According to the complex features account, successful transfer and reversibility will be possible to the extent that the controlling features of the trained occasion setting compound are present in the tested compound as well. Arranging contingencies favorable for transfer or reversibility requires only that the training procedure itself be arranged in such a way that features common to the training and test compounds are made more excitatory than any features exclusive to the training compound, without also disrupting the characteristic occasion setting effect.

The Occasion Setting Effect

The present training procedures generated reliable occasion setting effects. Response rates during presentations of the target stimulus preceded by its occasion setter were found consistently to exceed those obtained when the target stimulus was presented alone. More importantly, the occasion setting effect was a reliable outcome across most subjects despite changes in the temporal proximity of the occasion setter to food, the inclusion of inhibitory, occasion setter alone trials, and training with four rather than one occasion setting compound. At issue is whether this observed occasion setting effect supports the existence of a new type of stimulus function or whether it can be interpreted as the result of excitatory control by stimulus features of the training and testing events. If the latter, the likelihood of successful transferability and reversibility following occasion setting training should be alterable by systematically manipulating the excitatory strength of key features of the occasion setting compound.

The three conditions of the present experiment -- temporal proximity, positive patterning, and multiple stimuli -- were implemented in an attempt to produce transfer and reversibility by decreasing the excitatory strength of the keylight colors of the occasion setter relative to other features in the occasion setting compound, specifically, the transition to the target stimulus. Transfer was achieved following training in the positive patterning procedure with a 45-second occasion setter; reversal was obtained, and replicated, for occasion setting compounds containing two different target stimuli (the reversal test variation). Although not providing definitive support, these results are consistent with predictions made by the complex features model.

The limited demonstration of transfer and reversal in the present experiment is also consistent with previous experimental results from the occasion setting literature. Holland (1989), for example, postulated that the addition of occasion setter alone trials in positive patterning training enhances the likelihood of successful transfer compared to the basic serial, feature-positive procedure since the additional negative occasion setter trials reduce the specific occasion setter-target associations that would otherwise interfere with transfer. Following tests for reversibility in a serial, feature-positive procedure, Rescorla (1985) determined that occasion setters and target stimuli have separate and irreversible roles in the occasion setting compound.

In elaborating the quality of irreversibility, Rescorla added that an occasion setter may not be able to facilitate responding to another occasion setter and that a target stimulus may not be able to facilitate responding to other targets. His tests of occasion setters preceded by other occasion setters and target stimuli preceded by other target stimuli (equivalent to the variations of the reversal test conducted in the present experiment) showed that responding could only be augmented by an occasion setter preceding a target stimulus. Consequently, the present results challenge the idea that the stimuli are irreversible since there was some evidence that rates of responding obtained when a target stimulus was preceded by another target stimulus were equivalent to and sometimes higher than those obtained when a trained target was preceded by a trained occasion setter. This finding of increased response rates during presentations of target-target compounds was reproduced during the replication tests as well.

The fact that the results of the reversal test variation were consistent with predictions of the complex features model, and not with those of occasion setting theory, is really a nontrivial finding. According to Rescorla (1985), that occasion setting stimuli are able to augment responding while excitatory stimuli are not is a fundamental difference between the two types of stimuli. For occasion setting theory, the present results imply a violation of this property. According to the complex features model, however, that an excitatory stimulus was able to augment responding to another excitatory stimulus is consistent with the expectation that any keylight color will augment responding to a target stimulus once control by the keylight color of the trained occasion setter is sufficiently degraded to enhance control by the transition.

In fact, Rescorla's (1985) own results are consistent with this expectation. Prior to testing for the target-target reversal, Rescorla's subjects (pigeons) were trained with two occasion setting compounds in a serial, feature-positive procedure which presented the occasion setter for five seconds, followed by a five-second ISI, and then a five-second target stimulus. The predictiveness of the occasion setter, therefore, was at 1.00 since there were no presentations of the occasion setter alone. Moreover, the temporal relationship between the occasion setter and food was better than that of the first procedure of the present experiment (TP5/10) since the ISI was only five seconds in duration. A target-target reversal would not be expected in his preparation, despite the multiple stimuli, since features of the occasion setter should still be at great excitatory strength in the compound.

The results of the reversal tests in the multiple stimuli condition, although not providing a reliable result, lend some additional support to the possibility of a breakdown of control by the color feature of the occasion setter anticipated by the complex features model. Rates of responding obtained for the reversed target preceded by the reversed occasion setter were higher overall than rates obtained during presentations of the reversed target alone. A similar difference was obtained during replication.

In summary, according to the complex features model, the procedural manipulations of the present experiment should have provided an increasing likelihood of transfer and reversal, such that the probability of a successful test result was maximized in the last training procedure for each test type. The manipulations were successful in demonstrating the basic occasion setting effect, producing transfer in one preparation, and producing a target-target facilitation following several preparations, including the replication; the manipulations were unsuccessful in producing convincing evidence of reversal, but there were hints in the data that reversal might be possible. The present results, therefore, confirm and extend the generality of some significant facts about occasion setting that have been reported previously -- for example, that transfer of occasion setting control to new target stimuli is possible under some conditions and that reversal is at least difficult to obtain. The present results help further to clarify the conditions under which transfer and reversal will or will not occur. At the very least, the consistency of the results with occasion setting theory validates the procedural manipulations imposed to reduce control by the color feature of the occasion setter.

Contributions of the Complex Features Model

The results of the present experiment thus provide modest support that the complex features model could be a plausible account of the occasion setting effect, leaving open the possibility that a compound-stimulus interpretation of occasion setting is still viable. Procedural manipulations imposed during training were successful in producing transfer of stimulus function and, to a limited extent, the reversal effect. Further research, therefore, seems warranted, following the same empirical method prescribed by the complex features model: systematically manipulating the excitatory strength of features in common between training and test compounds while decreasing the strength of exclusive features. Issues to be addressed include examination of the effect of additional occasion setter and target stimulus color combinations (beyond those used here) on the likelihood of obtaining a reliable reversal result, and the introduction of occasion setters and target stimuli of different modalities to demonstrate that outcomes are not restricted to a specific experimental preparation. Of course, manipulation of features conditioned during occasion setting training will first have to be evaluated for what it does to the occasion setting effect. The robustness of this effect, demonstrated in the present experiment, provides a useful benchmark for evaluating the impact of any procedural manipulations made.

The results of the present experiment, however, do not preclude explanation from the perspective of occasion setting theory. An imaginable interpretation is that other features of the occasion setter, such as the duration of the stimulus, acquired facilitative properties when the procedural manipulations imposed affected the strength of the color feature. In the reversal tests, that facilitative feature continued to augment behavior to the target stimulus regardless of the order of presentation of the keylight colors, making it appear as though the reversals were successful. Such an interpretation would at least support the basic assumptions of the complex features model -- that all stimuli are multifeatured and that conditioning occurs at the level of those stimulus features.

With both theories able to account for the same data, however, appropriateness of occasion setting theory over the complex features model will not be resolved with a single experiment. For advocates of a compound-stimulus approach, the complex features model represents the first successful attempt to reconcile the occasion setting data with a compound-stimulus theory. To its credit, although the complex features model treats the occasion setting compound as a complex, multifeatured stimulus, it does not require postulation of an additional facilitative function to account for the occasion setting effect. More generally, because it accounts for that effect by applying what is already known about evocative stimuli in Pavlovian preparations, the model offers the more parsimonious account of stimulus control.

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APPENDIX A

DATA SUMMARY

Table A-1. Responding to Target Stimuli during Training

Subject 1

Procedure	Trial Type	Trial Count	Mean RPM	Std Dev	Std Error	95% Confidence Interval	
						Lower Bound	Upper Bound
TP5/10	TTA	204	11.00	50.45	3.53	3.94	18.06
	TT	200	237.18	144.08	10.19	216.80	257.56
TP5/40	TTA	66	131.46	76.11	9.37	112.72	150.20
	TT	88	282.41	80.05	8.53	265.35	299.47
TP45/0	TTA	126	36.67	50.42	4.49	27.69	45.65
	TT	125	130.85	48.54	4.34	122.17	139.53
PP45	TTA	119	5.45	13.51	1.24	2.97	7.93
	TT	125	118.27	47.38	4.24	109.81	126.73
PP90	TTA	125	7.56	17.18	1.65	4.26	10.86
	TT	108	118.27	85.52	7.65	102.97	133.57
PP120	TTA	130	13.39	23.84	2.09	9.21	17.57
	TT	125	133.63	76.95	6.88	119.87	147.39
MS0	TTA	164	19.83	35.36	2.76	14.31	25.35
	TT	182	130.55	94.39	7.00	116.55	144.55
MS1	TTA	140	5.31	11.08	0.94	3.43	7.19
	TT	163	153.57	131.53	10.30	132.97	174.17

TTA=Trained Target Alone TT=Trained Target

Subject 2 - Training

Procedure	Trial Type	Trial Count	Mean RPM	Std Dev	Std Error	95% Confidence Interval	
						Lower Bound	Upper Bound
TP5/10	TTA	206	8.68	20.38	1.42	5.84	11.52
	TT	201	40.30	35.21	2.48	35.34	45.26
TP5/40	TTA	96	63.38	49.58	5.06	53.26	73.50
	TT	89	107.87	32.64	3.46	100.95	114.79
TP45/0	TTA	176	24.34	37.56	2.83	21.51	27.17
	TT	125	56.54	38.13	3.41	49.72	63.36
PP45	TTA	117	3.08	11.16	1.03	1.02	5.14
	TT	125	35.71	35.59	3.18	29.35	42.07
PP90	TTA	127	1.23	6.56	0.58	0.07	2.39
	TT	125	66.43	49.72	4.45	57.53	75.33
PP120	TTA	123	13.27	41.34	3.73	5.81	20.73
	TT	125	55.39	42.31	3.78	47.83	62.95
MS0	TTA	160	6.00	19.73	1.56	2.88	9.12
	TT	184	100.44	63.22	4.66	91.12	109.76
MS1	TTA	141	0.00	0.00	0.00	0.00	0.00
	TT	163	8.61	23.23	1.82	4.97	12.25

TTA=Trained Target Alone

TT=Trained Target

Subject 3 - Training

Procedure	Trial Type	Trial Count	Mean RPM	Std Dev	Std Error	95% Confidence Interval	
						Lower Bound	Upper Bound
TP5/10	TTA	197	48.55	52.62	3.75	41.05	56.05
	TT	200	113.94	58.42	4.13	105.68	122.20
TP5/40	TTA	84	83.86	51.20	5.59	72.80	95.12
	TT	87	87.17	27.72	2.97	81.23	93.11
TP45/0	TTA	131	41.86	49.71	4.34	33.18	50.54
	TT	125	67.68	39.61	3.54	60.60	74.76
PP45	TTA	126	7.33	18.40	1.64	4.05	10.61
	TT	125	94.56	51.61	4.62	85.32	103.80
PP90	TTA	100	11.05	20.52	2.19	6.67	15.43
	TT	88	81.12	49.53	4.95	71.22	91.02
PP120	TTA	132	14.00	34.04	2.96	8.08	19.92
	TT	125	50.40	57.39	5.13	40.14	60.66
MS0	TTA	161	1.12	4.80	0.38	0.36	1.88
	TT	161	18.19	33.03	2.60	12.99	23.39
MS1	TTA	137	0.00	0.00	0.00	0.00	0.00
	TT	159	3.55	21.54	1.71	0.13	6.97

TTA=Trained Target Alone TT=Trained Target

Subject 4 - Training

Procedure	Trial Type	Trial Count	Mean RPM	Std Dev	Std Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
TP5/10	TTA	194	4.33	11.42	0.82	2.69	5.97
	TT	200	47.88	34.15	2.42	43.04	52.72
TP5/40	TTA	101	9.51	35.53	3.54	2.43	16.59
	TT	100	3.84	20.46	2.05	0.00	7.94
TP45/0	TTA	109	18.39	32.89	3.15	12.09	24.69
	TT	125	0.10	1.07	0.10	0.00	0.20
PP45	TTA	96	3.00	10.15	1.04	0.92	5.08
	TT	110	0.00	0.00	0.00	0.00	0.00
PP90	TTA	100	0.24	2.40	0.24	0.00	0.72
	TT	125	0.00	0.00	0.00	0.00	0.00
PP120	TTA	114	0.53	3.35	0.31	0.00	1.15
	TT	125	0.00	0.00	0.00	0.00	0.00
MS0	TTA	155	32.21	57.06	4.58	23.05	41.37
	TT	176	0.00	0.00	0.00	0.00	0.00
MS1	TTA	144	2.08	9.45	0.79	0.50	3.66
	TT	156	1.46	5.16	0.41	0.64	2.28

TTA=Trained Target Alone TT=Trained Target

Subject 5 - Training

Procedure	Trial Type	Trial Count	Mean RPM	Std Dev	Std Error	95% Confidence Interval	
						Lower Bound	Upper Bound
TP5/10	TTA	195	4.43	21.20	1.52	1.39	7.47
	TT	200	199.02	43.41	3.07	192.88	205.16
TP5/40	TTA	114	94.60	67.73	6.37	81.86	107.34
	TT	125	211.20	57.39	5.13	200.94	221.468

TTA=Trained Target Alone

TT=Trained Target

Table A-2. Responding to the Target Stimulus in the Transfer Test

Subject 1

Procedure	Trial Type	Trial Count	Mean RPM	Std Dev	Std Error	95% Confidence Interval	
						Lower Bound	Upper Bound
TP5/10	TTA	200	11.00	50.45	10.19	3.94	18.06
	TT	20	291.60	70.84	15.84	259.92	323.28
	NT	20	7.20	17.15	3.84	0.00	14.88
TP5/40	TTA	66	131.46	76.11	9.37	112.72	150.20
	TT	16	134.25	60.59	15.15	103.95	164.55
	NT	20	7.20	18.01	4.03	0.00	15.26
TP45/0	TTA	126	36.67	50.42	4.49	27.69	45.65
	TT	16	165.00	65.65	16.41	132.18	197.82
	NT	16	76.50	39.89	9.97	56.56	96.44
PP45	TTA	119	5.45	13.51	1.24	2.97	7.93
	TT	16	142.50	61.17	15.29	111.92	173.08
	NT	16	59.25	31.74	7.94	43.37	75.13

TTA=Trained Target Alone
NT=Novel Target

TT=Trained Target

Subject 2 - Transfer Testing

Procedure	Trial Type	Trial Count	Mean RPM	Std Dev	Std Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
TP5/10	TTA	206	8.68	20.38	1.42	5.84	11.52
	TT	20	30.60	32.45	7.26	16.08	45.12
	NT	20	24.60	33.82	7.56	9.48	39.72
TP5/40	TTA	96	63.38	49.58	5.06	53.26	73.50
	TT	20	30.00	41.48	9.28	11.44	48.56
	NT	20	6.60	15.80	3.53	0.00	13.66
TP45/0	TTA	176	24.34	37.56	2.83	21.51	27.17
	TT	18	63.33	26.61	6.27	50.79	75.87
	NT	20	4.20	11.20	2.50	0.00	9.20
PP45	TTA	117	3.08	11.16	1.03	1.02	5.14
	TT	16	69.00	35.19	8.80	51.40	86.60
	NT	16	34.50	32.46	8.12	18.26	50.74

TTA=Trained Target Alone
NT=Novel Target

TT=Trained Target

Subject 3 - Transfer Testing

Procedure	Trial Type	Trial Count	Mean RPM	Std Dev	Std Error	95% Confidence Interval	
						Lower Bound	Upper Bound
TP5/10	TTA	197	48.55	52.62	3.75	41.05	56.05
	TT	20	137.40	27.11	6.06	125.28	149.52
	NT	20	30.60	38.04	8.51	13.58	47.62
TP5/40	TTA	84	83.86	51.20	5.59	72.80	95.12
	TT	20	46.20	54.82	12.26	21.68	70.72
	NT	20	3.00	9.44	2.11	0.00	7.22
TP45/0	TTA	131	41.86	49.71	4.34	33.18	50.54
	TT	16	95.25	38.57	9.64	75.97	114.53
	NT	16	2.25	9.00	2.25	0.00	6.75
PP45	TTA	126	7.33	18.40	1.64	4.05	10.61
	TT	16	108.75	20.30	5.08	98.59	118.91
	NT	16	34.50	46.76	11.69	11.12	57.88

TTA=Trained Target Alone
TT=Trained Target
NT=Novel Target

Subject 4 - Transfer Testing

Procedure	Trial Type	Trial Count	Mean RPM	Std Dev	Std Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
TP5/10	TTA	194	4.33	11.42	0.82	2.69	5.97
	TT	20	58.20	32.87	7.35	43.50	72.90
	NT	20	12.60	23.19	5.19	2.22	22.98
TP5/40	TTA	101	9.51	35.53	3.54	2.43	16.59
	TT	16	0.00	0.00	0.00	0.00	0.00
	NT	20	72.00	77.08	17.24	37.52	106.48
TP45/0	TTA	109	18.39	32.89	3.15	12.09	24.69
	TT	15	0.00	0.00	0.00	0.00	0.00
	NT	16	12.75	41.91	10.48	0.00	33.71
PP45	TTA	96	3.00	10.15	1.04	0.92	5.08
	TT	12	0.00	0.00	0.00	0.00	0.00
	NT	12	28.00	32.09	9.26	9.46	46.54

TTA=Trained Target Alone
TT=Trained Target
NT=Novel Target

Subject 5 - Transfer Testing

Procedure	Trial Type	Trial Count	Mean RPM	Std Dev	Std Error	Lower Bound	Upper Bound
TP5/10	TTA	195	4.43	21.20	1.52	1.39	7.47
	TT	20	203.40	41.84	9.36	184.68	222.12
	NT	20	123.60	69.87	15.62	92.36	154.84
TP5/40	TTA	114	94.60	67.73	6.37	81.86	107.34
	TT	20	222.60	61.12	13.67	195.26	249.94
	NT	20	39.60	34.85	7.79	24.02	55.18

TTA=Trained Target Alone
TT=Trained Target
NT=Novel Target

Table A-3. Responding to the Target Stimulus in the Reversal Test

Subject 1

Procedure	Trial Type	Trial Count	Mean RPM	Std Dev	Std Error	95% Confidence Interval	
						Lower Bound	Upper Bound
TP5/10	TTA	200	11.00	50.45	10.19	0.00	31.38
	TT	20	326.40	42.40	9.48	307.44	345.36
	RTA	20	0.00	0.00	0.00	0.00	0.00
	RT	20	0.00	0.00	0.00	0.00	0.00
TP5/40	TTA	66	131.46	76.11	9.37	112.72	150.20
	TT	20	238.8	61.30	13.71	211.38	266.22
	RTA	20	0.00	0.00	0.00	0.00	0.00
	RT	20	0.60	2.68	0.60	0.00	1.80
TP45/0	TTA	126	36.67	50.42	4.49	27.69	45.65
	TT	20	124.80	38.23	8.55	107.70	141.90
	RTA	20	44.73	24.32	5.44	33.85	55.61
	RT	20	121.20	25.50	5.70	109.80	132.60
PP45	TTA	119	5.45	13.51	1.24	2.97	7.93
	TT	20	145.80	66.67	14.91	115.98	175.62
	RTA	20	35.2	26.30	11.76	23.44	46.96
	RT	20	49.20	41.37	9.25	30.70	67.70
PP90	TTA	108	7.56	17.18	1.65	4.26	10.86
	TT	16	175.50	78.37	19.59	136.32	214.68
	RTA	16	37.33	30.25	7.56	22.21	52.45
	RT	19	0.63	2.75	0.63	0.00	1.89

TTA=Trained Target Alone
TT=Trained Target

RTA=Reversed Target Alone
RT=Reversed Target

Subject 1 - Reversal Testing

Procedure	Trial Type	Trial Count	Mean RPM	Std Dev	Std Error	95% Confidence Interval	
						Lower Bound	Upper Bound
PP120	TTA	130	13.39	23.84	2.09	9.21	17.57
	TT	17	174.35	63.37	15.37	143.61	205.09
	RTA	17	20.12	14.98	3.63	12.86	27.38
	RT	19	1.26	3.78	0.87	0.00	3.00
MS0	TTA	164	19.83	35.36	2.76	14.31	25.35
	TT	80	218.85	100.82	11.27	196.31	241.39
	RTA	80	5.44	7.12	0.80	3.84	7.04
	RT	80	9.00	23.89	2.67	3.66	14.34
	T1-T2	79	22.33	42.61	4.79	12.75	31.91
	OS1-OS2	78	15.08	23.88	2.70	9.68	20.48
	T1-T1	41	8.20	24.66	3.85	0.50	15.90
	OS1-OS1	41	15.51	24.33	3.80	7.91	23.11
MS1	TTA	140	5.31	11.08	0.94	3.43	7.19
	TT	80	169.50	103.68	11.59	146.32	192.68
	RTA	80	5.69	4.97	0.56	4.57	6.81
	RT	80	9.15	17.63	1.97	5.21	13.09
	T1-T2	70	29.83	41.00	4.90	20.03	39.63
	OS1-OS2	69	15.13	24.41	2.94	9.25	21.01
	T1-T1	64	23.81	37.13	4.64	14.53	33.09
	OS1-OS1	64	15.19	27.90	3.49	8.21	22.17

TTA=Trained Target Alone
TT=Trained Target

RTA=Reversed Target Alone
RT=Reversed Target

Subject 2 - Reversal Testing

Procedure	Trial Type	Trial Count	Mean RPM	Std Dev	Std Error	95% Confidence Interval	
						Lower Bound	Upper Bound
TP5/10	TTA	206	8.68	20.38	1.42	5.84	11.52
	TT	20	46.80	45.05	10.07	26.66	66.94
	RTA	20	1.80	5.87	1.31	0.00	4.42
	RT	20	1.80	5.87	1.31	0.00	4.42
TP5/40	TTA	96	63.38	49.58	5.06	53.26	73.50
	TT	20	18.00	35.36	7.91	2.18	33.82
	RTA	20	0.00	0.00	0.00	0.00	0.00
	RT	20	0.60	2.68	0.60	0.00	1.20
TP45/0	TTA	176	24.34	37.56	2.83	21.51	27.17
	TT	20	37.20	28.85	6.45	24.30	50.10
	RTA	20	1.47	4.17	0.93	0.00	3.33
	RT	20	0.60	2.68	0.60	0.00	1.20
PP45	TTA	117	3.08	11.16	1.03	1.02	5.14
	TT	20	31.20	30.51	6.82	17.56	44.84
	RTA	20	0.87	2.34	0.52	0.00	1.91
	RT	20	7.20	18.01	4.03	0.00	11.23
PP90	TTA	127	1.23	6.56	0.58	0.07	2.39
	TT	16	55.50	42.68	10.67	34.16	76.84
	RTA	16	2.38	5.74	1.44	0.00	5.24
	RT	20	0.00	0.00	0.00	0.00	0.00

TTA=Trained Target Alone
TT=Trained Target

RTA=Reversed Target Alone
RT=Reversed Target

Subject 2 - Reversal Testing

Procedure	Trial Type	Trial Count	Mean RPM	Std Dev	Std Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
PP120	TTA	123	13.27	41.34	3.73	5.81	20.73
	TT	16	92.25	33.29	8.32	75.61	108.89
	RTA	16	5.81	3.27	0.82	4.17	7.45
	RT	18	2.67	6.58	1.55	0.00	4.22
MS0	TTA	160	6.00	19.73	1.56	2.88	9.12
	TT	80	89.10	76.15	8.51	72.08	106.12
	RTA	80	0.54	0.89	0.10	0.34	0.74
	RT	80	2.10	6.27	0.70	0.70	2.80
	T1-T2	64	30.38	36.91	4.61	21.16	39.60
	OS1-OS2	64	1.69	6.72	0.84	0.01	3.37
	T1-T1	42	1.71	6.79	1.05	0.00	2.76
	OS1-OS1	42	4.86	16.14	2.49	0.00	9.84
MS1	TTA	141	0.00	0.00	0.00	0.00	0.00
	TT	80	55.05	38.12	4.26	46.53	63.57
	RTA	80	0.14	0.41	0.05	0.04	0.24
	RT	80	0.90	4.17	0.47	0.00	1.37
	T1-T2	70	31.89	30.71	3.67	24.55	39.23
	OS1-OS2	70	1.03	3.95	0.47	0.09	1.50
	T1-T1	64	0.00	0.00	0.00	0.00	0.00
	OS1-OS1	64	0.75	4.72	0.59	0.00	1.34

TTA=Trained Target Alone
TT=Trained Target

RTA=Reversed Target Alone
RT=Reversed Target

Subject 3 - Reversal Testing

Procedure	Trial Type	Trial Count	Mean RPM	Std Dev	Std Error	95% Confidence Interval	
						Lower Bound	Upper Bound
TP5/10	TTA	197	48.55	52.62	3.75	41.05	56.05
	TT	20	139.20	57.93	12.95	113.30	165.10
	RTA	20	4.20	18.78	4.20	0.00	12.60
	RT	20	0.00	0.00	0.00	0.00	0.00
TP5/40	TTA	84	83.86	51.20	5.59	72.80	95.12
	TT	20	82.80	41.73	9.33	64.14	101.46
	RTA	20	4.80	21.47	4.80	0.00	14.40
	RT	20	13.20	39.11	8.75	0.00	30.70
TP45/0	TTA	131	41.86	49.71	4.34	33.18	50.54
	TT	20	84.00	50.91	11.38	61.24	106.76
	RTA	20	0.27	0.70	0.16	0.00	0.59
	RT	20	6.00	19.27	4.31	0.00	14.62
PP45	TTA	126	7.33	18.40	1.64	4.05	10.61
	TT	20	61.20	56.94	12.73	35.74	86.66
	RTA	20	0.07	0.30	0.07	0.00	0.21
	RT	20	2.40	4.93	1.10	0.20	4.60
PP90	TTA	100	11.05	20.52	2.19	6.67	15.43
	TT	16	88.50	50.89	12.72	63.06	113.94
	RTA	16	0.46	0.58	0.15	0.16	0.76
	RT	20	3.60	6.86	1.53	0.54	6.66

TTA=Trained Target Alone
TT=Trained Target

RTA=Reversed Target Alone
RT=Reversed Target

Subject 3 - Reversal Testing

Procedure	Trial Type	Trial Count	Mean RPM	Std Dev	Std Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
PP120	TTA	132	14.00	34.04	2.96	8.08	19.92
	TT	15	54.40	56.81	14.67	25.06	83.74
	RTA	15	0.00	0.00	0.00	0.00	0.00
	RT	19	2.53	7.57	1.74	0.00	6.01
MS0	TTA	161	1.12	4.80	0.38	0.36	1.88
	TT	80	14.25	33.35	3.73	6.79	21.71
	RTA	80	0.18	0.66	0.07	0.04	0.32
	RT	80	9.60	26.28	2.94	3.72	15.48
	T1-T2	64	32.35	45.75	5.72	20.81	43.69
	OS1-OS2	64	0.00	0.00	0.00	0.00	0.00
	T1-T1	42	8.29	23.63	3.65	0.99	15.59
	OS1-OS1	41	0.00	0.00	0.00	0.00	0.00
MS1	TTA	137	0.00	0.00	0.00	0.00	0.00
	TT	80	4.05	20.11	2.25	0.00	8.55
	RTA	80	0.01	0.06	0.01	0.00	0.02
	RT	80	1.51	3.80	0.42	0.67	2.35
	T1-T2	80	10.65	35.15	3.93	2.79	18.51
	OS1-OS2	80	0.00	0.00	0.00	0.00	0.00
	T1-T1	64	0.94	7.50	0.94	0.00	1.88
	OS1-OS1	64	0.19	1.50	0.19	0.00	0.38

TTA=Trained Target Alone
TT=Trained Target

RTA=Reversed Target Alone
RT=Reversed Target

Subject 4 - Reversal Testing

Procedure	Trial Type	Trial Count	Mean RPM	Std Dev	Std Error	95% Confidence Interval	
						Lower Bound	Upper Bound
TP5/10	TTA	194	4.33	11.42	0.82	2.69	5.97
	TT	20	33.00	27.77	6.21	20.58	45.42
	RTA	20	0.00	0.00	0.00	0.00	0.00
	RT	20	0.00	0.00	0.00	0.00	0.00
TP5/40	TTA	101	9.51	35.53	3.54	2.43	16.59
	TT	16	3.00	12.00	3.00	0.00	9.00
	RTA	16	0.75	3.00	0.75	0.00	2.25
	RT	16	0.00	0.00	0.00	0.00	0.00
TP45/0	TTA	109	18.39	32.89	3.15	12.09	24.69
	TT	20	0.00	0.00	0.00	0.00	0.00
	RTA	0.00	0.00	0.00	0.00	0.00	0.00
	RT	20	0.00	0.00	0.00	0.00	0.00
PP45	TTA	96	3.00	10.15	1.04	0.92	5.08
	TT	16	0.00	0.00	0.00	0.00	0.00
	RTA	16	1.42	3.39	0.85	0.00	3.12
	RT	20	0.00	0.00	0.00	0.00	0.00
PP90	TTA	100	0.24	2.40	0.24	0.00	0.72
	TT	18	0.00	0.00	0.00	0.00	0.00
	RTA	18	0.00	0.00	0.00	0.00	0.00
	RT	20	0.00	0.00	0.00	0.00	0.00

TTA=Trained Target Alone
TT=Trained Target

RTA=Reversed Target Alone
RT=Reversed Target

Subject 4 - Reversal Testing

Procedure	Trial Type	Trial Count	Mean RPM	Std Dev	Std Error	95% Confidence Interval	
						Lower Bound	Upper Bound
PP120	TTA	114	0.53	3.35	0.31	0.00	1.15
	TT	13	0.00	0.00	0.00	0.00	0.00
	RTA	13	1.23	4.14	1.15	0.00	3.53
	RT	16	12.00	29.39	7.35	0.00	26.7
MS0	TTA	155	32.21	57.06	4.58	23.05	41.37
	TT	74	0.00	0.00	0.00	0.00	0.00
	RTA	74	0.08	0.50	0.06	0.00	0.20
	RT	74	0.65	4.39	0.51	0.00	1.67
	T1-T2	48	4.25	21.37	3.08	0.00	10.41
	OS1-OS2	48	0.00	0.00	0.00	0.00	0.00
	T1-T1	42	0.57	2.59	0.40	0.00	1.37
	OS1-OS1	42	0.29	1.85	0.29	0.00	0.87
MS1	TTA	144	2.08	9.45	0.79	0.17	0.90
	TT	80	1.20	5.92	0.66	0.00	2.52
	RTA	80	0.17	0.61	0.07	0.03	0.31
	RT	80	0.90	4.17	0.47	0.00	1.84
	T1-T2	80	3.00	12.45	1.39	0.22	5.78
	OS1-OS2	80	0.60	3.25	0.36	0.00	1.32
	T1-T1	64	0.94	4.44	0.56	0.00	2.06
	OS1-OS1	64	0.38	2.10	0.26	0.00	0.90

TTA=Trained Target Alone
TT=Trained Target

RTA=Reversed Target Alone
RT=Reversed Target

Subject 5 -- Reversal Testing

Procedure	Trial Type	Trial Count	Mean RPM	Std Dev	Std Error	95% Confidence Interval	
						Lower Bound	Upper Bound
TP5/10	TTA	195	4.43	21.20	1.52	1.39	7.47
	TT	20	221.40	41.47	9.27	202.86	239.94
	RTA	20	51.60	29.16	6.52	38.56	64.64
	RT	20	66.00	39.99	8.94	48.12	83.88
TP5/40	TTA	114	94.60	67.73	6.37	81.86	107.34
	TT	20	186.00	65.21	14.58	156.84	215.16
	RTA	20	8.40	18.30	4.09	0.22	16.58
	RT	20	0.00	0.00	0.00	0.00	0.00

TTA=Trained Target Alone
TT=Trained Target

RTA=Reversed Target Alone
RT=Reversed Target

Table A-4. Responding to the Target Stimulus during Replication of the Reversal Test

Subject 1

Procedure	Trial Type	Trial Count	Mean RPM	Std Dev	Std Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
REP1	TTA	117	3.49	10.92	1.01	1.47	5.51
	TT	20	103.80	59.46	13.30	77.20	130.40
	RTA	20	4.80	16.70	3.73	0.00	12.26
	RT	20	18.00	16.29	3.64	10.72	25.28
REP2	TTA	156	3.23	7.63	0.61	2.01	4.45
	TT	20	64.80	83.45	18.66	27.48	102.12
	RTA	20	3.00	10.93	2.44	0.00	7.88
	RT	20	13.20	24.59	5.50	2.20	24.20
REP3	TTA	156	3.23	7.63	0.61	2.01	4.45
	TT	20	64.80	83.45	18.66	27.48	102.12
	RTA	20	3.00	10.93	2.44	0.00	7.88
	T1-T2	80	35.40	51.73	5.78	23.84	46.96
	OS1-OS2	40	7.50	12.06	1.91	3.68	11.32
	T1-T1	80	10.88	15.88	1.78	7.32	14.44
	OS1-OS1	40	3.83	5.69	0.90	2.03	5.63

TTA=Trained Target Alone
TT=Trained Target

RTA=Reversed Target Alone
RT=Reversed Target

Subject 2 - Replication Testing

Procedure	Trial Type	Trial Count	Mean RPM	Std Dev	Std Error	95% Confidence Interval	
						Lower Bound	Upper Bound
REP1	TTA	125	2.21	13.75	1.23	0.00	4.67
	TT	20	34.20	35.95	8.04	18.12	50.28
	RTA	20	0.00	0.00	0.00	0.00	0.00
	RT	20	15.60	28.64	6.40	2.80	28.40
REP2	TTA	155	0.47	2.70	0.22	0.03	0.91
	TT	20	10.20	19.18	4.29	1.62	18.78
	RTA	20	0.00	0.00	0.00	0.00	0.00
	RT	20	24.00	36.31	8.12	7.76	40.24
REP3	TTA	155	0.47	2.70	0.22	0.03	0.91
	TT	20	10.20	19.18	4.29	1.62	18.78
	RTA	20	0.00	0.00	0.00	0.00	0.00
	T1-T2	64	25.69	29.77	3.72	18.25	33.13
	OS1-OS2	32	8.25	13.78	2.44	3.37	13.13
	T1-T1	64	10.33	14.15	1.77	6.79	13.87
	OS1-OS1	32	1.67	3.23	0.57	0.53	2.81

TTA=Trained Target Alone
TT=Trained Target

RTA=Reversed Target Alone
RT=Reversed Target

Subject 3 - Replication Testing

Procedure	Trial Type	Trial Count	Mean RPM	Std Dev	Std Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
REP1	TTA	126	7.14	20.26	1.81	3.52	10.76
	TT	20	0.00	0.00	0.00	0.00	0.00
	RTA	20	0.60	2.68	0.60	0.00	1.80
	RT	20	0.60	2.68	0.60	0.00	1.80
REP2	TTA	175	0.00	0.00	0.00	0.00	0.00
	TT	20	0.60	2.68	0.60	0.00	1.80
	RTA	20	4.80	16.70	3.73	0.00	12.26
	RT	20	0.00	0.00	0.00	0.00	0.00
REP3	TTA	175	0.00	0.00	0.00	0.00	0.00
	TT	20	0.60	2.68	0.60	0.00	1.80
	RTA	20	4.80	16.70	3.73	0.00	12.26
	T1-T2	80	4.95	13.73	1.54	1.87	8.03
	OS1-OS2	40	0.30	1.90	0.30	0.00	0.90
	T1-T1	80	1.00	4.01	0.45	0.10	1.90
	OS1-OS1	40	0.47	1.30	0.21	0.05	0.89

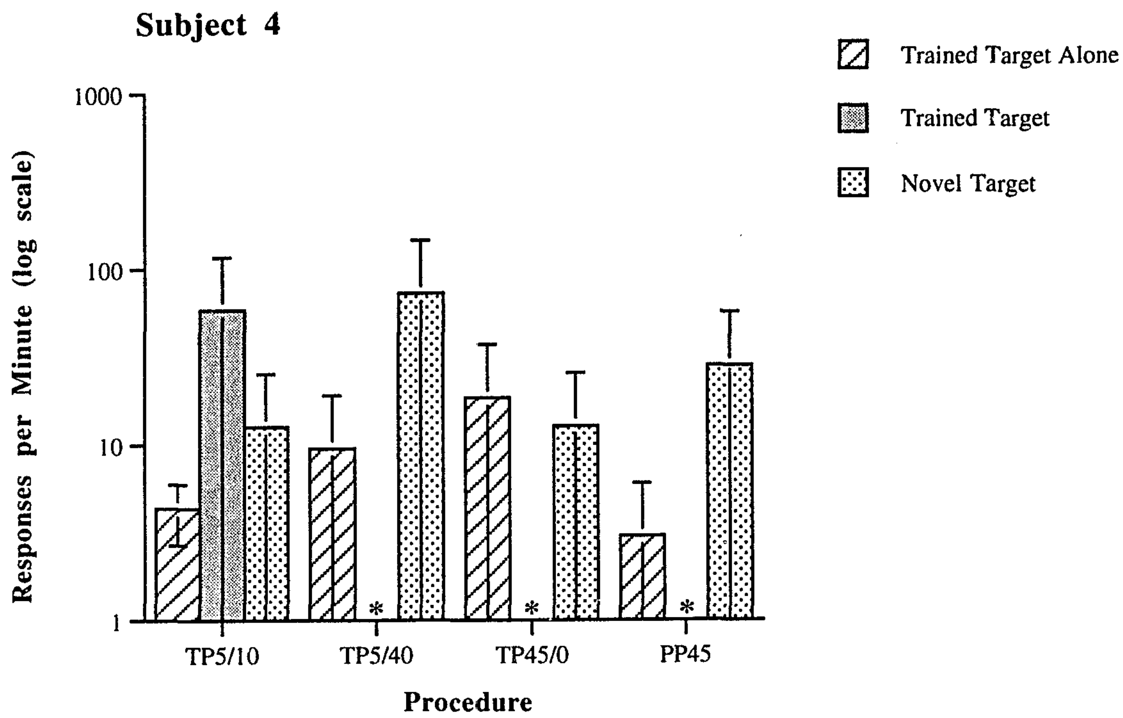
TTA=Trained Target Alone
TT=Trained Target

RTA=Reversed Target Alone
RT=Reversed Target

APPENDIX B

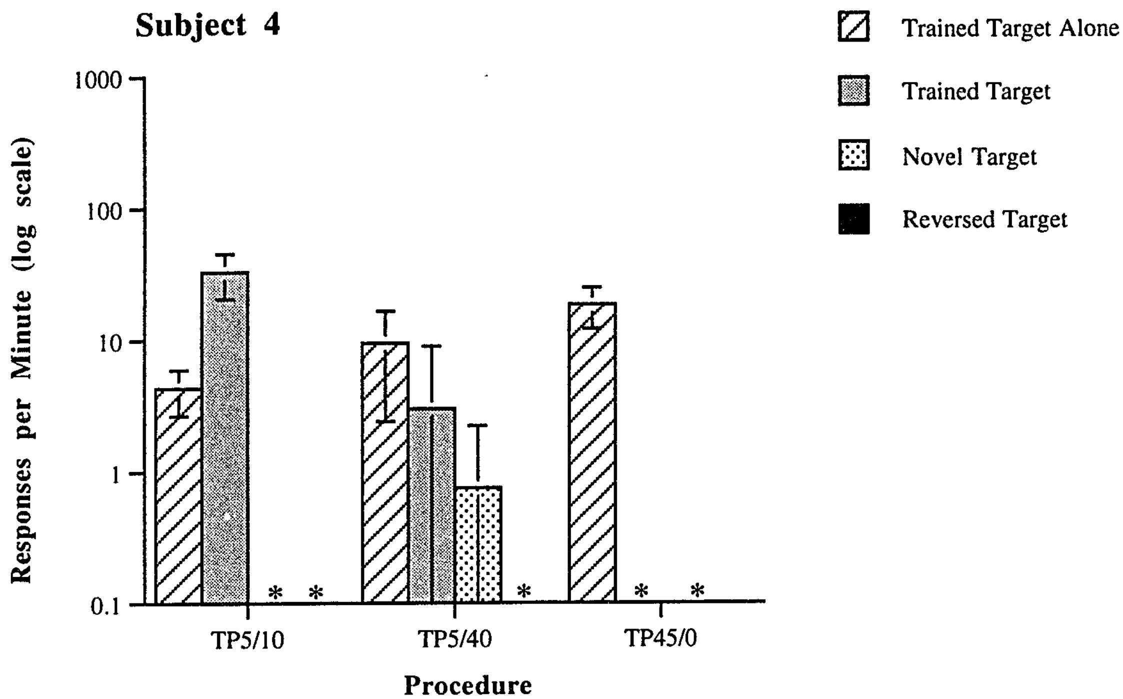
SUBJECT 4 TEST DATA

Figure B1. Responding to the Target Stimulus in the Transfer Test



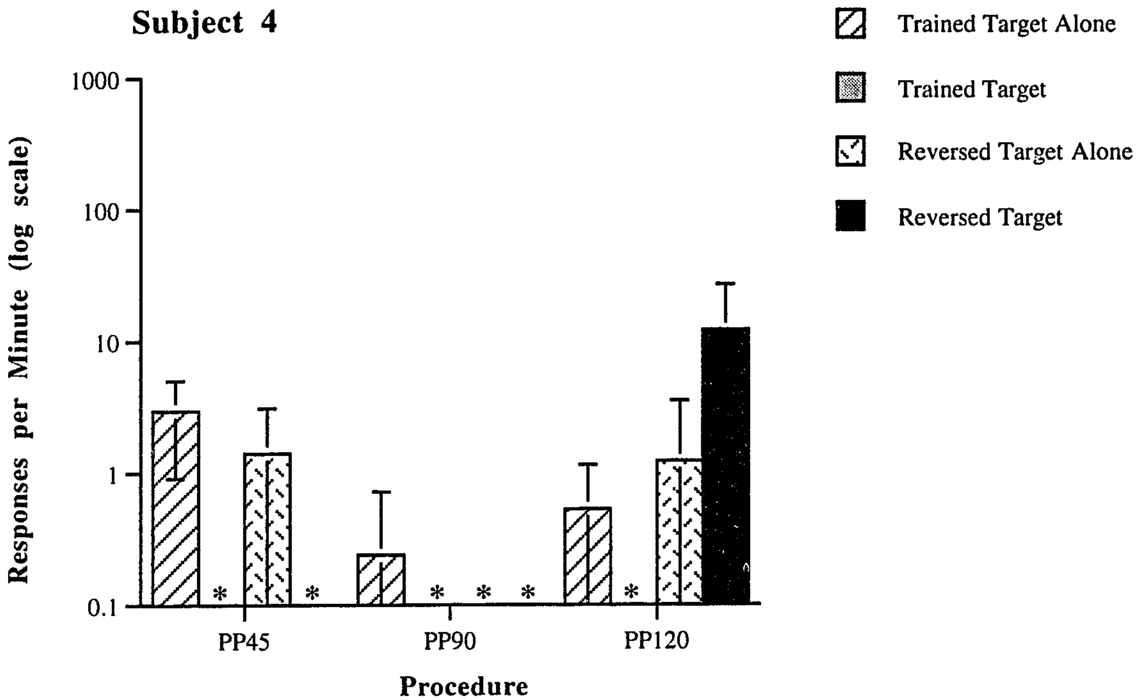
* **Value equals zero.**

Figure B2. Responding to the Target Stimulus in the Reversal Test Following Manipulation of Temporal Proximity (TP)



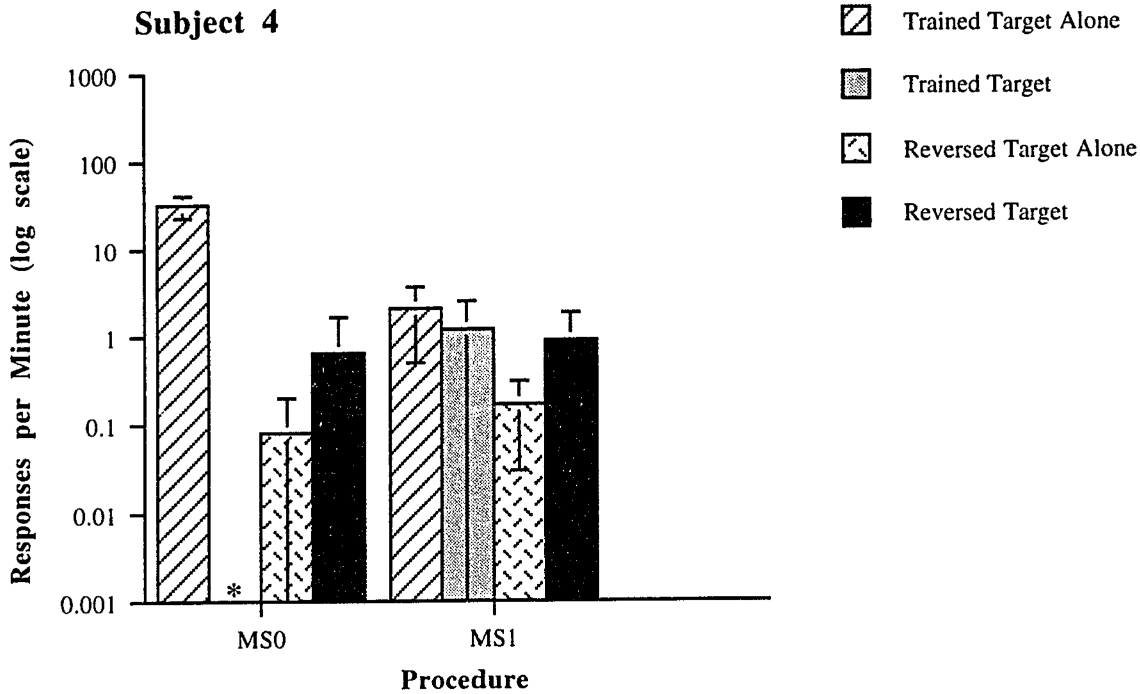
* Value equals zero.

Figure B-3. Responding to the Target Stimulus in the Reversal Test Following Positive Patterning (PP) Training



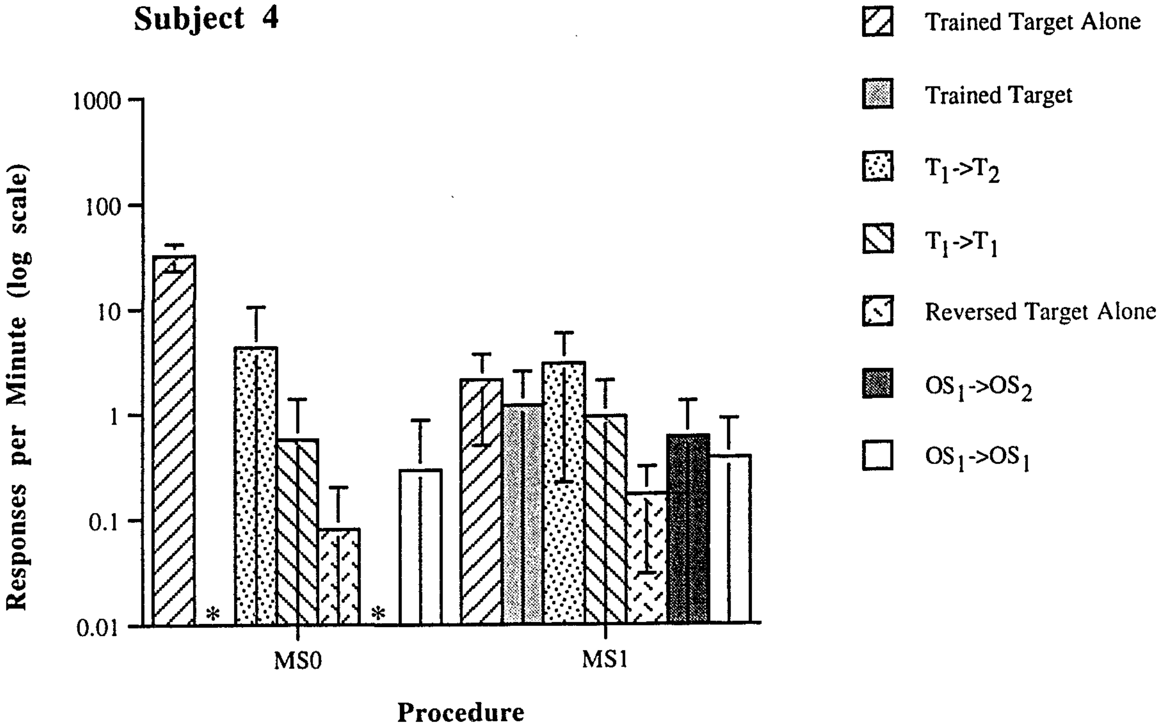
* Value equals zero.

Figure B-4. Responding to the Target Stimulus in the Reversal Test Following Training with Multiple Stimuli (MS0 and MS1)



* Value equals zero.

Figure B-5. Responding to the Target Stimulus in Variations of the Reversal Test Following Training With Multiple Stimuli (MS0 and MS1)



* Value equals zero.