

Chapter 2

Stimulus Control and Generalization

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2.1 Introduction

The three-term contingency, or operant discrimination, describes a uniquely fundamental unit in the analysis of behavior, as most operant responses (especially outside of a carefully controlled laboratory) are emitted in changing environments, and few are reinforced equally often in the presence of all environmental conditions (e.g., Skinner 1931, 1935a, 1935b; Sidman 1986). The stage is set then for the development of stimulus control over virtually all of our everyday behavior. Accordingly, the laboratory study of stimulus control has a long and venerable history, both outside of behavior analysis (e.g., in comparative psychology, animal psychophysics, animal and human cognition) and within. This chapter focuses on the latter, of course, where principles of stimulus control are studied explicitly as the questions of experimental interest, but even the basic behavior-analytic stimulus control database is voluminous. Many chapters and books could be (and have been) written to summarize this far-ranging literature. Thus, this chapter necessarily provides but an overview of some major areas of stimulus control research, with particular attention paid to topics of potential relevance in the application of stimulus control procedures. For readers interested in more detail concerning a particular topic, the references provided herein should provide an adequate beginning for further exploration.

Familiarity with the fundamentals of stimulus control should hold special significance for applied behavior analysts involved in autism service delivery. Indeed, issues related to too much (as in cases of stimulus overselectivity, e.g., Lovaas et al. 1979; Schreibman 1997) or too little stimulus control are among the most common targets for intervention in working with individuals with autism. It might be argued that, with the exception of dangerous problem behavior (which would optimally not occur under any circumstances), stimulus control plays a necessary role in all

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effective behavior plans (and probably ineffective ones as well), whether explicitly targeted or not. Even in the case of problem behavior, stimulus control procedures can be useful as part of a successful intervention (e.g., Derrickson et al. 1993) and will necessarily be involved in maintaining behavior change. Stimulus control provides the basis for therapeutic efforts ranging from everyday teaching techniques (e.g., prompting; see Cooper et al. 2007, for review), to pivotal forms of assessment and training (e.g., verbal behavior interventions; Sundberg and Partington 1998), to the ultimate goal of programming for treatment generalization (Stokes and Baer 1977). In short, learning to identify possible sources of stimulus control, and to increase or decrease them as needed, is essential to autism service delivery. It follows that the experimental behavior-analytic literature has much to offer practitioners who wish to understand more about the principles and findings that can improve intervention effectiveness.

2.2 The Three-Term Contingency

The *three-term contingency* specifies an environmental arrangement in which an antecedent stimulus varies across at least two states (e.g., a tone may be on or off, a traffic light may be red or green), and reinforcers follow responses in the presence of one antecedent condition but not the other. In a classic example (e.g., Skinner 1938; Herrick et al. 1959), a rat's lever presses produce food when a chamber lamp is turned on, while presses in the absence of the light produce nothing. The standard finding in such arrangements is that the rat comes to press more often in the presence of the light and less often or not at all in its absence. At this point, the rat's performance could be described as being under *stimulus control*. We might say further that a *simple discrimination* had been established, or that lever pressing had become a *discriminated operant*. We could refer to the light-on condition as a *discriminative stimulus* (S^d or S^+), and refer to the light-off condition as an *S -delta* or S^- . It is important to note that full delineation of the three-term contingency requires specification of the consequences in each of the stimulus conditions (e.g., the presence as well as the absence of the light), and that an appropriate determination of discrimination acquisition likewise requires observation of differential responding across the stimulus conditions. Thus, the so-called $A: B \rightarrow C$ depiction of behavior (i.e., for antecedent, behavior, consequence) is technically incomplete if description of "not $A: B \rightarrow C$ " is omitted. The two statements are equally necessary to capture the dependency (of the two-term response \rightarrow consequence unit on the antecedent stimulus) that defines the contingency (e.g., Catania 1998; Sidman 1986, 2000). Also with respect to the terminology of stimulus control, it bears repeating that the term, "discrimination," is a description or abstraction on the part of the experimenter, and not a response on the part of the subject/participant (e.g., Skinner 1953). The observed performance is simply that of differential responding under the control of antecedent stimuli. We call this relation "discrimination," but doing so should not imply unobserved activity (i.e., "discriminating") by the subject or participant. As

a final note on related terminology, the control exerted by a discriminative stimulus is based on its correlation with the reinforcers made available in its presence. Thus, the discriminative stimulus “sets the occasion for reinforcement,” and is said to “occasion” the response (e.g., Catania 1998). The relation between a discriminative stimulus and a response is not one of elicitation (e.g., Skinner 1935b; Catania 1998).

2.2.1 *Simple Discrimination Basics*

The early years of basic experimental analyses of stimulus control witnessed a broad exploration of the conditions under which discriminated operants could be established. Discrimination learning proved such a ubiquitous outcome that it came quickly to be treated as a fundamental behavioral process (e.g., Skinner 1931, 1935a, b, 1938, 1953). Important demonstrations of stimulus control represented a wide range of species and stimulus modalities. Not surprisingly, the optimal modality for rapid discrimination acquisition depended largely on the species, with sensory capabilities obviously determining the likelihood of strong stimulus control in some cases, but not all (see Harrison 1991, for review). This literature also made clear that the pattern of development of discriminative control could differ for the S+ and S− stimulus conditions (see, e.g., Skinner 1938, where control by the S+ was established within a few presentations but strong control by S− required repeated sessions), and that the pattern was a function of any number of procedural training and testing variables. Examples of these variables include: The nature of training prior to the implementation of the three-term contingency (e.g., Terrace 1970), the schedule or probability of reinforcement during the S+ and S− conditions (e.g., Nevin 1967; Eckerman 1969), the nature of the S+ and S− stimuli (Carter and Eckerman 1975; Dinsmoor 1995a; Iwai et al. 1986; Jenkins and Sainsbury 1970), and the duration of the intertrial interval (Marcucella 1974), to name but a few.

The range of conditions that could give rise to discriminative performances was further emphasized by the development of important variations in analytic approaches to stimulus control. In studies of *simultaneous discrimination*, two or more stimuli are presented together. Responses to the stimulus designated as the S+ produce reinforcers according to some schedule, while responses to the S− stimulus (or stimuli) do not. In studies of *successive discrimination*, only one stimulus is present at any given time, but the two (or more) stimuli alternate (either regularly or irregularly) over time. Again, one of the stimuli is designated as the S+, and responses in its presence are reinforced according to some schedule. Responses made in the presence of the other stimulus condition(s) do not produce reinforcers.

Both simultaneous and successive discrimination approaches can be arranged as either a trial-by-trial procedure (sometimes called a discrete-trial or forced-choice procedure) or a combination of free-operant reinforcement schedules. In trial procedures, one stimulus (for successive approaches) or more (for simultaneous approaches) is presented on each trial, and either the subject's response or a time limit ends the trial. Consequences are delivered as per the three-term contingency

in effect, the stimulus presentation is removed, and an intertrial interval ensues, prior to presentation of the next programmed trial. With respect to issues of stimulus control, primary interest is in the probability of a particular response in the presence and absence of a particular stimulus condition, so accuracy is the typical dependent variable in trial procedures, although signal detection analysis (e.g., McCarthy and Davison 1979) and latency to respond are sometimes of interest as well. Successive discrimination trial procedures are sometimes referred to as “go/no-go” procedures, as evidence of discrimination requires a high probability of responding when the S+ is presented, and a relatively lower probability of responding given S-. Other things being equal, discrimination acquisition is likely to develop more slowly with successive than with simultaneous trial procedures (e.g., Carter and Eckerman 1975). Both simultaneous and successive discrimination trial procedures have been used extensively in basic experimental analyses of stimulus control. While the particular arrangement selected will necessarily depend on the experimental question of interest, a trial procedure is a particularly likely candidate when the primary experimental question concerns establishing discriminative responding in and of itself. Other topic areas in basic behavior analysis in which these trial procedures are well represented include studies of perception and psychophysics (e.g., Green and Swets 1966; Irwin and McCarthy 1998), vigilance (e.g., Holland 1958), and behavioral drug effects (e.g., Williams and Saunders 1997).

Simultaneous and successive discrimination procedures are also implemented in free-operant arrangements, in the form of multiple and concurrent reinforcement schedules. These procedures differ from the trial arrangements just described, in that each stimulus condition is presented for an extended period of time (rather than for an individual trial), and responding can occur or not throughout the period of each stimulus presentation. Responses are typically reinforced according to an intermittent schedule of reinforcement in the presence of one stimulus, and they are either on extinction (EXT) or reinforced according to a different intermittent schedule in the presence of one or more other stimuli. There is no intertrial interval separating schedule components or responses. The multiple schedule arranges for successive presentations of at least two schedule components; these alternate, usually on a temporal basis and often irregularly, and a different stimulus is correlated with each component (e.g., Ferster and Skinner 1957; Catania 1998). For example, a red light may be illuminated when the reinforcement schedule is in effect, and a green light illuminated when EXT conditions are arranged. Stimulus control is demonstrated when typical schedule performance tracks the stimulus presented at any given point in time. For example, Ferster and Skinner (1957) arranged a multiple variable interval EXT schedule (mult VI EXT). They found that rats lever pressed at steady rates in the presence of the VI stimulus, while near-zero rates were obtained when the EXT stimulus was presented. Alternatively, on a multiple variable ratio fixed interval schedule (mult VR FI), stimulus control would be indicated by high steady rates in the presence of the VR stimulus and scalloped patterns in the presence of the FI stimulus.

In a concurrent reinforcement schedule, at least two different reinforcement schedules are available simultaneously, each programmed for a different response

operanda (e.g., two different levers or two different keys) and each with a different stimulus (e.g., Catania 1998). Typically, the schedules and their correlated stimuli are alternated across operanda on an irregular temporal basis. As was the case for multiple schedules, stimulus control is demonstrated when schedule-typical performances track the stimulus alternations. For example, on a concurrent VI EXT schedule, a pigeon might peck at steady rates on the VI key, illuminated with a green light, and at near-zero rates on the EXT key, illuminated with a red light, regardless of the location of the illuminated keys. Alternatively, on a concurrent VI 1-min, VI 5-min schedule, the pigeon might peck at relatively higher steady rates on the green key correlated with the VI 1-min schedule and at relatively lower steady rates on the red key correlated with the VI 5-min schedule, regardless of key location. With respect to issues of stimulus control, and as indicated by these examples, relative response rates and patterns are the dependent indices of greatest interest in these arrangements. Also with respect to studying stimulus control, the multiple and concurrent schedules are particularly useful when repeated responding (rather than a single response) in the presence of a stimulus is important for addressing experimental questions. Relatedly, because multiple and concurrent schedules often involve intermittent reinforcement even in the presence of S^+ , they can be useful in experiments focused on the outcomes of testing phases to be conducted subsequent to discrimination training, where EXT conditions are in effect (as in tests for controlling-stimulus dimensions or generalization tests, e.g., Reynolds 1961; Guttman 1959). Other topic areas in basic behavior analysis in which the stimulus control aspects of multiple and concurrent schedules have proved relevant include behavioral pharmacology, where these schedules provide important baselines for investigating drug effects (e.g., Dews 1970; Weiss and Laties 1969), and the study of observing responses, in which access to the schedule's discriminative stimuli serves to maintain responding—that is, serves a conditioned-reinforcing function (e.g., Wyckoff 1969; Dinsmoor 1995b; Dinsmoor et al. 1982; Dinsmoor 1983; Kelleher et al. 1962).

2.2.2 *Issues in Establishing Simple Discriminations*

One complicating truth about discrimination training is that every stimulus, including a laboratory stimulus explicitly designed to be as simple as possible, comprises multiple dimensions or properties (e.g., Ray and Sidman 1970). A colored stimulus light in an operant chamber has properties of brightness, intensity, hue, saturation, size, shape, and position, for example. Stimuli in the everyday environment would typically have many more. Even though the experimenter carefully programs stimulus presentations, a given three-term contingency cannot ensure the specific properties of the S^+ that will come to control the subject's responding (more complex additional training would be needed to ensure control by a particular dimension; see discussion of *abstraction* later in this chapter), and an abundant literature suggests that not all stimulus properties are equally likely to become controlling dimensions. In one classic analysis, Reynolds (1961) first established strong stimulus control with

two pigeons by conducting discrimination training in which the S+ stimulus was a white triangle presented on a red background, and the S− stimulus was a white circle presented on a green background. Tests were then conducted in which each of the four stimulus components (i.e., red, triangle, green, and circle) was presented independently, in extinction. For one bird, responding occurred almost exclusively in the presence of the triangle; for the other, steady rates of responding were observed only in the presence of the red stimulus. Although equally correlated with reinforcement, only one of the two stimulus properties assessed in this study actually controlled responding, and the controlling property varied across subjects despite identical training. This finding in no way implies that control by multiple properties cannot develop (e.g., Wilkie and Mason 1976; Kendall and Mills 1979). It does emphasize, however, the importance of recognizing that control by the stimulus compound or by any given stimulus dimension cannot be assumed, and it underscores the need for careful analysis of responding over repeated and varied stimulus presentations to correctly determine controlling dimensions (e.g., Skinner 1935a; Sidman 1979).

The terminology of “attention” or “attending” is often occasioned by findings like those just described, and stimulus properties that come easily to control responding are commonly described as “salient.” While these terms can serve well as descriptions of observed stimulus control patterns, care is needed to avoid the implication that the terms provide explanation of the stimulus control (e.g., a stimulus property does not control behavior *because* it is salient; we describe it as salient *because* it controls responding). Still, it is useful and appropriate to consider attending as operant behavior (e.g., Catania 1998). Certainly, attending to, or observing, stimuli is amenable to control by consequences (e.g., Dube et al. 2010). Indeed, attending or observing could properly be viewed as a necessary prerequisite skill for discrimination learning of any type (e.g., Sidman 1977; Sidman and Stoddard 1966; Stoddard and McIlvane 1989), and it has been argued that a better understanding of stimulus control will necessarily hinge on increased analytic focus for attending and observing (e.g., Mackintosh 1977; Dinsmoor 1995; Shahan 2013).

Another analytic approach based on the understanding that controlling properties of stimuli can vary is *stimulus control topography (SCT) coherence theory* (e.g., Dube and McIlvane 1996; McIlvane and Dube 2003). An SCT describes the particular stimulus property controlling a response at any given point in time (e.g., control by the triangle shape or the red color for Reynolds’ pigeons), while SCT coherence describes the correlation (or lack thereof) between the SCT intended by the experimenter and the dimension actually controlling the subject’s response. By this view, any pattern of discriminative performance (especially patterns indicative of poor coherence; i.e., low to moderate accuracy levels) may include multiple SCTs, the relative frequencies of which are determined by the reinforcement patterns, past and present, for each. That is, differing SCTs are viewed as concurrent (discriminated) operants, with their distribution seen as likely to conform to the matching law (e.g., Herrnstein 1970; Davison and McCarthy 1988).

SCT coherence theory has also been integrated at a conceptual level (McIlvane and Dube 2003) with Davison and Nevin’s (1999) contingency discriminability analysis. This important synthesis emphasizes that for optimal discrimination

learning, coherence must hold with respect to relevant dimensions of all elements of the three-term contingency. Establishing intended stimulus control patterns will be enhanced to the extent that the antecedent stimulus dimensions of S+ and S−, the individual response requirements for those stimuli, and the reinforcement schedules correlated with each, are all as distinct for the participant/subject as they are for the experimenter. For example, in two-choice simultaneous discrimination training, where position of the S+ and S− stimuli is determined according to a randomized sequence, selection of the S+ will produce reinforcers on a continuous reinforcement schedule, but selection of the left stimulus will produce reinforcers approximately every other time (i.e., on a variable ratio (VR)2 schedule). This schedule discrepancy may seem more significant to the experimenter than to the subject, especially if the relevant SCT—selection of S+—has not yet been established and the richer schedule not contacted sufficiently. SCT coherence theory offers important implications for isolating sources of stimulus control, or SCTs, for modifying them, and for establishing discriminations in ways that facilitate both coherence and optimal discrimination acquisition. (See discussion of other implications of the SCT analysis later in this chapter.)

A significant body of work in basic stimulus control research has focused on variables that might enhance discrimination acquisition. This research direction was important both for practical reasons (i.e., discriminative control sometimes proves difficult to establish) and theoretical ones. Regardless of the inspiration, the results from much of this work are consistent with analyses of discrimination in terms of attention and SCT coherence. Studies of *fading*, *stimulus-control shaping*, and *errorless discrimination learning* stand as one important research theme that illustrates the point. These approaches to discrimination training have in common a starting point at which stimulus control already exists or is easily produced, but involving S+ and S− stimuli that differ, often dramatically, from those of the target discrimination. Once the initial discriminative control is documented, one or more of the stimuli is changed gradually, across a series of steps, to more and more closely approximate the targets, while maintaining discriminative responding across the steps. Thus, this collection of procedures takes advantage of the fact that a (discriminated) response must occur before it can be reinforced. In addition, when implemented optimally, these procedures explicitly program for control by the relevant stimulus dimensions (or experimenter-intended SCTs).

In an early example, Terrace (1963a) found that pigeons trained with standard differential reinforcement procedures made many hundreds of responses to S− before a strong red/green color discrimination was established. With other birds, he began training with a multiple VI EXT schedule, where pecks to a red key light were reinforced in 3-min VI components that alternated with 5 s of an EXT condition for which the key was dark. Responses were rarely emitted in the presence of the briefly presented dark key. Next, across three phases that each included alternation with the 3-min red VI component, the duration of the dark key was gradually increased to 3 min, the color of the 5-s key was changed to dim and then progressively brighter green, and, finally, the duration of the bright green light was gradually changed from 5 s to 3 min. In short, the 3-min green light (or S−) was

gradually “faded in.” The birds trained in this way made fewer than 10 responses total to S[−]. When particularly effective, as in this case, fading approaches have sometimes been described as “errorless,” although the label is more relative (to standard differential reinforcement arrangements) than absolute. In a related study, Terrace (1963b) demonstrated similar results by “fading out” a controlling-stimulus dimension. A difficult line-orientation discrimination (i.e., vertical versus horizontal lines presented on white keys) was targeted in pigeons by starting with an established color discrimination (i.e., between red and green keys). The lines were then presented on the red and green keys and, over a series of steps, the color was gradually “faded out,” until line orientation alone maintained discriminative control. Sidman and Stoddard (1966, 1967) reported equally effective fading outcomes with young boys with developmental delays. The target discrimination required selection of a circle stimulus rather than any of the seven S[−] ellipses presented as a 3 × 3 matrix (with a blank center). Of the nine participants exposed to standard discrimination training, only one acquired the circle/ellipse discrimination. In contrast, stimulus control was effectively established in seven of ten participants taught with a fading sequence. First, only the circle key was illuminated, with all other keys dark. In successive steps, the other seven keys were gradually brightened, dim ellipses were superimposed on the keys, and ellipse intensity was gradually increased. Thus, control by the relevant stimulus dimension was gradually shaped across the training steps, and irrelevant or incompatible SCTs had little opportunity to acquire control over responding.

Other arrangements involving presentation of the antecedent stimuli have also been successful in enhancing discrimination acquisition. In one such approach, the antecedent stimuli are withheld on each trial until the subject/participant makes a *trial-initiation response* (Harrison and Beecher 1969; Dube et al. 1993). The strategy can help ensure that the subject is optimally positioned and prepared to attend to the stimulus display when it is presented. Another example has been described as the *delayed S⁺ procedure* (Dube and McIlvane 1996; McIlvane et al. 2002). In seeking to establish discrimination between a flashing stimulus (S⁺) and an identical but nonflashing stimulus (S[−]), each trial began with presentation of two identical S[−] stimuli only. One stimulus (now S⁺) began to flash only after some period of time with no response to either S[−]. This procedure resulted in rapid acquisition of the discrimination for many participants who had failed to reach mastery with standard differential reinforcement arrangements. By preventing adventitious reinforcement of control by stimulus onset alone, a competing SCT was extinguished and the discrimination established.

Other laboratory approaches to establishing discriminative control have targeted just the consequences for S[−] responding, with no change to presentation of the discriminative stimuli. These approaches are designed to prevent adventitious reinforcement for S[−] responding, and they serve to increase the disparity in reinforcement contacted for responses in S⁺ and S[−] stimulus conditions. Their effectiveness is thus consistent with the SCT coherence and contingency discriminability analyses described above. *Correction procedures* involve repeating a trial presentation until either a response to S⁺ is made and reinforced (in simultaneous discrimination

training) or until no response to S[−] is made and the next scheduled trial is presented (in successive discrimination training). In *timeout procedures*, a response to S[−] produces a signaled period (often a darkened chamber or response apparatus) in which no reinforcers are available. A related alternative involves adding a requirement that some period of time must pass without a response to S[−] before the next trial (or schedule component) is presented. Each of these approaches can be useful in cases of position or stimulus preferences.

2.2.3 *Stimulus Classes, Generalization, and Generalized Discriminated Operants*

Just as basic operant classes are characterized by both the direct effects of reinforcement (i.e., response differentiation) and the spread of those reinforcement effects (i.e., response induction), so are discriminated operant classes characterized by a direct impact of reinforcement (i.e., stimulus discrimination) and a spread of that reinforcement impact to other stimuli not explicitly correlated with reinforcement during training (i.e., stimulus generalization). This valuable comparison (e.g., Catania 1998) helps to emphasize the fundamental point that classes of events—whether responses or stimuli—lie always at the heart of an operant analysis (e.g., Skinner 1935a). Study of the nature and determinants of stimulus classes created by three-term contingencies has thus been the focus of tremendous interest in experimental behavior analysis. A complete description of this literature is beyond the scope of the present chapter, but illustrative highlights are outlined here.

In one classic category of work in this area, the nature of stimulus classes is analyzed in the form of *generalization gradients*. Studies in this category typically involve at least two phases—training, in which (at minimum) responding is reinforced in the presence of some stimulus, and testing, in which that stimulus and many variations of it are presented in EXT. In standard procedures, the stimulus variations can be ordered along some physical dimension (e.g., wavelength of colored lights, frequency of tones, degree of line tilts), and the particular variations chosen will fall on either side of the S⁺ stimulus along that dimension (e.g., both shorter and longer wavelengths). The outcome of greatest interest is the extent of control over responding exerted by each of the stimulus variations, and these results are presented as plots of some response measure (e.g., rate, total number, percentage of total number across all stimuli) in the presence of each of the stimulus variations, ordered along the physical dimension employed. Responding in the presence of stimulus variations not included during training is termed *generalization*, and the classic (though not inevitable) function revealed in this manner shows a peak of responding in the presence of the stimulus that was correlated with reinforcement during training. For the other stimulus variations, the degree of control over responding decreases systematically as the stimulus becomes more different from the S⁺ in each direction along the stimulus dimension (e.g., for both shorter and longer wavelengths, compared to S⁺). Thus, a symmetrical gradient of responding is often

revealed, with an inverted V shape that reaches its highest point over S+ (e.g., Guttman and Kalish 1956; Blough 1959; Hanson 1959).

Across studies involving a wide range of species and stimulus dimensions, and training and testing arrangements, generalization gradients provided a prominent tool for analysis of stimulus control. While the classic peaked gradient was common, the shape of the gradient was found to vary from almost flat (indicating no control by, or attention to, the stimulus dimension) to extremely peaked (indicating very little generalization). A voluminous literature now addresses the many variables that impact the shape of the generalization gradient, as well as theoretical interpretations of those effects (see, e.g., reviews by: Harrison 1991; Honig and Urcuioli 1981; Rilling 1977).

By way of example, consider the nature of the training procedures arranged prior to generalization testing. Jenkins and Harrison (1960) reported dramatically different generalization gradients with tones of varying frequencies for two groups of pigeons. For one group, training involved only VI reinforcement in the presence of a single-tone stimulus. For the second group, a multiple VI Ext schedule was arranged, with the tone on during the VI schedule component and the tone off during EXT (sometimes referred to as “presence/absence training”). Gradients for the birds in the first group were virtually flat, while the subjects exposed to presence/absence training showed classic symmetrical gradients, peaked exactly at the S+ stimulus. Even after presence/absence training, however, the shape of the gradient can vary depending on many factors (e.g., the specific reinforcement schedule arranged during training, e.g., Hearst et al. 1964), and peaked gradients are often obtained even without including an EXT training component (e.g., Guttman and Kalish 1956).

Training can also be conducted with two different stimuli as S+ and S− (e.g., a white key light and a white key with a black vertical line, or two tones at different frequencies), rather than with a single stimulus either present or not. A general finding has been that discrimination training with two stimuli tends to produce steeper generalization gradients than training procedures involving only a single stimulus (e.g., Hanson 1959; Thomas 1969, Harrison 1991). Further, the gradients obtained after discrimination training with two stimuli from the same stimulus dimension (e.g., two colors, or two tone frequencies; sometimes described as *postdiscrimination gradients*) are frequently characterized by a different shape, with the peak of responding shifted away from the S+ stimulus, in the direction opposite the S− (sometimes described as *peak shift*). For example, Hanson (1959) measured generalization gradients in two groups of pigeons provided with different training arrangements. For birds in the first group, pecks were reinforced in the presence of a green stimulus light; no other stimulus conditions were presented. Training in the second group involved a multiple schedule in which the same reinforcement condition (a VI schedule operated in the presence of the green key light) alternated with an EXT condition, correlated with a yellow key light. Standard symmetrical gradients were obtained with the first group, with a peak of responding in the presence of the green S+. For the second group, however, the peak of responding was much higher (that is, the greatest number of responses occasioned by a particular stimulus increased from

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