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RAND, JUDITH FURBER. Investigation of the Source of Stimulus Control as a Function of the Number of Negative Training Stimuli. (1972)
Directed by: Dr. Ernest A. Lumsden. Pp. 60

Two experiments investigated the source of stimulus control of pigeons' responding in a discrimination learning task as a function of the number of negative stimuli (S-'s) presented during differential training. The stimuli employed in both studies were complex, three-dimensional objects.

The first experiment was performed to determine whether or not rates to a novel stimulus was a function of the number of different S-'s. Results showed that subjects trained with only one S- (Group I) responded to the novel object at a rate equal to or greater than the rate to the S+. Those subjects trained with five S-'s (Group III) responded to the novel stimulus at a rate similar to the rate emitted to the S-'s. Response rates to the novel stimulus of subjects trained with three S-'s (Group II) were intermediate to the rates to the S+ and S-'s. The high rate of response to the novel stimulus of subjects in Group I was taken as behavioral evidence that the novel stimulus was not discriminated from the S+ but was discriminated from the S-, supporting an hypothesis that their responding was under control of the S- (i.e., do not respond if S-; otherwise respond). The low rate of response to the novel object by Group III birds was considered to indicate S+ control (i.e., respond if S+; otherwise do not respond). It was concluded that

rates of response to a novel stimulus might be considered as an indicant of the source and degree of stimulus control.

The second experiment attempted to evaluate this measure by comparing rates of response to the novel stimulus with post-discrimination generalization gradients, the traditional measure of stimulus control. As in Experiment I, three groups of pigeons were trained with either one (Group I), three (Group II), or five (Group III) S-'s. Rates to the novel stimulus as a function of the number of S-'s were generally consistent with those of Experiment I. Results of the generalization test did not, however, show any systematic relationship with the rates to the novel stimulus.

It was concluded that the multidimensionality of the stimuli, as well as the criterial and procedural aspects of the generalization test procedure contributed to the failure to demonstrate any possible relationship between the two measures. Until such difficulties are overcome, the hypothesis that rates of response to a novel stimulus is an indicant of the source of stimulus control will remain untested.


INVESTIGATION OF THE SOURCE OF STIMULUS CONTROL,
AS A FUNCTION OF THE NUMBER OF
NEGATIVE TRAINING STIMULI

by
Judith P. Reed

A Thesis Submitted to
the Faculty of the Graduate School at
The University of North Carolina at Greensboro
in Partial Fulfillment
of the Requirements for the Degree
Doctor of Arts

Greensboro
1974

Approved by


Thesis Advisor

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TABLE OF CONTENTS

ACKNOWLEDGMENTS

INTRODUCTION.....	1
EXPERIMENT I.....	21
EXPERIMENT II.....	30
EXPERIMENT III.....	34
EXPERIMENT IV.....	44
EXPERIMENT V.....	50
EXPERIMENT VI.....	58
EXPERIMENT VII.....	64
EXPERIMENT VIII.....	70
EXPERIMENT IX.....	76
EXPERIMENT X.....	82
EXPERIMENT XI.....	88
EXPERIMENT XII.....	94
EXPERIMENT XIII.....	100
EXPERIMENT XIV.....	106
EXPERIMENT XV.....	112
EXPERIMENT XVI.....	118
EXPERIMENT XVII.....	124
EXPERIMENT XVIII.....	130
EXPERIMENT XIX.....	136
EXPERIMENT XX.....	142
EXPERIMENT XXI.....	148
EXPERIMENT XXII.....	154
EXPERIMENT XXIII.....	160
EXPERIMENT XXIV.....	166
EXPERIMENT XXV.....	172
EXPERIMENT XXVI.....	178
EXPERIMENT XXVII.....	184
EXPERIMENT XXVIII.....	190
EXPERIMENT XXIX.....	196
EXPERIMENT XXX.....	202
EXPERIMENT XXXI.....	208
EXPERIMENT XXXII.....	214
EXPERIMENT XXXIII.....	220
EXPERIMENT XXXIV.....	226
EXPERIMENT XXXV.....	232
EXPERIMENT XXXVI.....	238
EXPERIMENT XXXVII.....	244
EXPERIMENT XXXVIII.....	250
EXPERIMENT XXXIX.....	256
EXPERIMENT XL.....	262
EXPERIMENT XLI.....	268
EXPERIMENT XLII.....	274
EXPERIMENT XLIII.....	280
EXPERIMENT XLIV.....	286
EXPERIMENT XLV.....	292
EXPERIMENT XLVI.....	298
EXPERIMENT XLVII.....	304
EXPERIMENT XLVIII.....	310
EXPERIMENT XLIX.....	316
EXPERIMENT L.....	322
EXPERIMENT LI.....	328
EXPERIMENT LII.....	334
EXPERIMENT LIII.....	340
EXPERIMENT LIV.....	346
EXPERIMENT LV.....	352
EXPERIMENT LVI.....	358
EXPERIMENT LVII.....	364
EXPERIMENT LVIII.....	370
EXPERIMENT LVIX.....	376
EXPERIMENT LX.....	382
EXPERIMENT LXI.....	388
EXPERIMENT LXII.....	394
EXPERIMENT LXIII.....	400
EXPERIMENT LXIV.....	406
EXPERIMENT LXV.....	412
EXPERIMENT LXVI.....	418
EXPERIMENT LXVII.....	424
EXPERIMENT LXVIII.....	430
EXPERIMENT LXIX.....	436
EXPERIMENT LXX.....	442
EXPERIMENT LXXI.....	448
EXPERIMENT LXXII.....	454
EXPERIMENT LXXIII.....	460
EXPERIMENT LXXIV.....	466
EXPERIMENT LXXV.....	472
EXPERIMENT LXXVI.....	478
EXPERIMENT LXXVII.....	484
EXPERIMENT LXXVIII.....	490
EXPERIMENT LXXIX.....	496
EXPERIMENT LXXX.....	502
EXPERIMENT LXXXI.....	508
EXPERIMENT LXXXII.....	514
EXPERIMENT LXXXIII.....	520
EXPERIMENT LXXXIV.....	526
EXPERIMENT LXXXV.....	532
EXPERIMENT LXXXVI.....	538
EXPERIMENT LXXXVII.....	544
EXPERIMENT LXXXVIII.....	550
EXPERIMENT LXXXIX.....	556
EXPERIMENT LXXXX.....	562
EXPERIMENT LXXXXI.....	568
EXPERIMENT LXXXXII.....	574
EXPERIMENT LXXXXIII.....	580
EXPERIMENT LXXXXIV.....	586
EXPERIMENT LXXXXV.....	592
EXPERIMENT LXXXXVI.....	598
EXPERIMENT LXXXXVII.....	604
EXPERIMENT LXXXXVIII.....	610
EXPERIMENT LXXXXIX.....	616
EXPERIMENT LXXXXX.....	622
EXPERIMENT LXXXXXI.....	628
EXPERIMENT LXXXXXII.....	634
EXPERIMENT LXXXXXIII.....	640
EXPERIMENT LXXXXXIV.....	646
EXPERIMENT LXXXXXV.....	652
EXPERIMENT LXXXXXVI.....	658
EXPERIMENT LXXXXXVII.....	664
EXPERIMENT LXXXXXVIII.....	670
EXPERIMENT LXXXXXIX.....	676
EXPERIMENT LXXXXXX.....	682
EXPERIMENT LXXXXXXI.....	688
EXPERIMENT LXXXXXXII.....	694
EXPERIMENT LXXXXXXIII.....	700
EXPERIMENT LXXXXXXIV.....	706
EXPERIMENT LXXXXXXV.....	712
EXPERIMENT LXXXXXXVI.....	718
EXPERIMENT LXXXXXXVII.....	724
EXPERIMENT LXXXXXXVIII.....	730
EXPERIMENT LXXXXXXIX.....	736
EXPERIMENT LXXXXXXX.....	742
EXPERIMENT LXXXXXXXI.....	748
EXPERIMENT LXXXXXXXII.....	754
EXPERIMENT LXXXXXXXIII.....	760
EXPERIMENT LXXXXXXXIV.....	766
EXPERIMENT LXXXXXXXV.....	772
EXPERIMENT LXXXXXXXVI.....	778
EXPERIMENT LXXXXXXXVII.....	784
EXPERIMENT LXXXXXXXVIII.....	790
EXPERIMENT LXXXXXXXIX.....	796
EXPERIMENT LXXXXXXXI.....	802
EXPERIMENT LXXXXXXXII.....	808
EXPERIMENT LXXXXXXXIII.....	814
EXPERIMENT LXXXXXXXIV.....	820
EXPERIMENT LXXXXXXXV.....	826
EXPERIMENT LXXXXXXXVI.....	832
EXPERIMENT LXXXXXXXVII.....	838
EXPERIMENT LXXXXXXXVIII.....	844
EXPERIMENT LXXXXXXXIX.....	850
EXPERIMENT LXXXXXXXI.....	856
EXPERIMENT LXXXXXXXII.....	862
EXPERIMENT LXXXXXXXIII.....	868
EXPERIMENT LXXXXXXXIV.....	874
EXPERIMENT LXXXXXXXV.....	880
EXPERIMENT LXXXXXXXVI.....	886
EXPERIMENT LXXXXXXXVII.....	892
EXPERIMENT LXXXXXXXVIII.....	898
EXPERIMENT LXXXXXXXIX.....	904
EXPERIMENT LXXXXXXXI.....	910
EXPERIMENT LXXXXXXXII.....	916
EXPERIMENT LXXXXXXXIII.....	922
EXPERIMENT LXXXXXXXIV.....	928
EXPERIMENT LXXXXXXXV.....	934
EXPERIMENT LXXXXXXXVI.....	940
EXPERIMENT LXXXXXXXVII.....	946
EXPERIMENT LXXXXXXXVIII.....	952
EXPERIMENT LXXXXXXXIX.....	958
EXPERIMENT LXXXXXXXI.....	964
EXPERIMENT LXXXXXXXII.....	970
EXPERIMENT LXXXXXXXIII.....	976
EXPERIMENT LXXXXXXXIV.....	982
EXPERIMENT LXXXXXXXV.....	988
EXPERIMENT LXXXXXXXVI.....	994
EXPERIMENT LXXXXXXXVII.....	1000

413107

TABLE OF CONTENTS

	Page
INTRODUCTION.....	1
EXPERIMENT I.....	21
Method.....	21
Results: Experiment I.....	26
EXPERIMENT II.....	29
Method.....	30
Results: Experiment II.....	34
DISCUSSION.....	46
BIBLIOGRAPHY.....	56
APPENDIX A.....	59
APPENDIX B.....	60

413107

LIST OF TABLES

	Page
TABLE I. ORDERS OF GENERALIZATION TESTING.....	33
OF STIMULI.....	33
Figure 2. RELATIVE RATE TO NOVEL STIMULUS AS A FUNCTION OF NUMBER OF S- ⁺	27
Figure 3. COMPARISON OF S- AND NOVEL DISCRIMINATION RATIO.....	35
Figure 4. RELATIVE RATE TO NOVEL STIMULUS AND EACH S-.....	37
Figure 5. GROUP I: GENERALIZATION GRADIENTS.....	40
Figure 6. GROUP II: GENERALIZATION GRADIENTS.....	41
Figure 7. GROUP III: GENERALIZATION GRADIENTS.....	42

LIST OF FIGURES

	Page
Figure 1. ILLUSTRATION AND DIMENSION OF STIMULI.....	23
Figure 2. RELATIVE RATE TO NOVEL STIMULUS AS A FUNCTION OF NUMBER OF S-'S.....	27
Figure 3. COMPARISON OF S- AND NOVEL DISCRIMINATION RATIOS.....	35
Figure 4. RELATIVE RATE TO NOVEL STIMULUS AND EACH S-.....	37
Figure 5. GROUP I: GENERALIZATION GRADIENTS.....	40
Figure 6. GROUP II: GENERALIZATION GRADIENTS.....	41
Figure 7. GROUP III: GENERALIZATION GRADIENTS.....	42

INTRODUCTION

Jenkins (1965) has suggested three alternative rules by which the subject may be operating in learning a simple discrimination task:

Rule 1: Respond if S+; otherwise do not respond.

Rule 2: Do not respond if S-; otherwise respond.

Rule 3: Respond if S+, and do not respond if S-.

(Jenkins, 1965, p. 56)

There are many methods by which the controlling stimulus may be identified. Some of these include post-discrimination generalization gradients, a reduction or elevation in response rate when the S+ and S- are presented simultaneously, ease of reversal learning, and the effects of varying the number of positive and/or negative stimuli. The following review of the studies utilizing these various methods indicate that the rule by which the subject is operating may not be transituational, i.e., the different training procedures might affect which of the three rules best describes what is learned.

Stimulus control along a particular continuum is indicated when an aspect of that stimulus is systematically varied away from the training value, resulting in decreasing rates of response (in the case of S+ control) or in

increasing rates of response (in the case of S- control). In addition, a steeper slope indicates greater stimulus control. (Terrace, 1966a). Thus to the extent that an S+ gradient results from variation along a dimension of the positive stimulus, it might be concluded that responding had come under control of that stimulus. Similarly, an S- gradient resulting from variation along some dimension of the negative stimulus may be interpreted as indicating the extent of control by the S-.

To carry the point a step further, however, in order to conclude that the subject learns only the occasion for responding and learns nothing about the negative stimulus (as Rule 1 would dictate), only S+ gradients accompanied by a flat or zero-sloped S- gradient should result. Conversely, if one were to conclude that the subject learns only the stimulus occasion for not responding (Rule 2), the results would exhibit only S- gradients while responding to the variations of the S+ should remain essentially constant. Support for Rule 3 would be evidenced by results which yielded both S+ and S- gradients.

The presence of an S+ post-discrimination generalization gradient is not a sufficient demonstration of the validity of Rule 1. While such gradients, following differential training, have been found by a number of investigators (see Terrace, 1966a), S- control was not tested in many of the

studies. When S- control has been investigated, the training methods or the selected learning criterion were not always such as to permit variation in S- responding during testing (e.g., Vetter and Hearst, 1968; Terrace, 1966b). Such studies will be discussed below in greater detail.

It also appears that Rule 2 may be rejected. If this were the correct alternative, the subject learns not to respond and, therefore, variations of the particular value of the S+ should produce a flat gradient. At the present time, there are no reported studies using this method of assessing stimulus control which have yielded S- gradients in the absence of S+ gradients.

There are several experimental results which support Jenkins' Rule 3 by yielding evidence contrary to Rules 1 and 2. Portions of Terrace's (1966b) study demonstrated both S+ and S- control within the same animal when tested following differential training procedures. Both S+ and S- gradients (obtained from separate groups of subjects) were found by Jenkins and Harrison (1960), (1962). They found, in addition to typical S+ gradients, broad shallow S- gradients which exhibited some degree of specific S- control. In a study by Honig, Boneau, Burstein and Pennypacker (1963), a comparison of positive and negative gradients on the discrimination of angular orientation (line tilt) was made following discrimination training in which the vertical line was the S+ and

its absence the S- for one group of pigeons and the reverse for another group. Both the S+ and S- gradients were obtained although unlike the S+ gradients, the S- gradients appeared to be flatter and shallower toward the latter stages of testing. This result was contrary to the findings of Farthing and Hearst (1968) whose data showed no reliable change in the shape of S- gradients as generalization testing progressed.

Using human subjects, Thomas and Lanier (1962) found generalization gradients of what they termed "Tendencies to respond" and "tendencies not to respond" such tendencies being inferred from obtained gradients of responding. Two groups of subjects were exposed to a light of 525 nm. and then were tested with nine wavelengths including the training value. The "respond" group was instructed to respond only to the training value while the "do not respond" group was instructed to respond to all colors other than the original color. A finger lift from a telegraph key was employed as the response. The shapes of the gradients were symmetrical and they concluded that (using such training procedures) the gradients of "tendencies to respond" were the inverse of the gradients of "tendencies not to respond", a conclusion which is contrary to the findings of Jenkins and Harrison (1962) and Honig, et. al. (1963). Hearst, Besley, and Farthing (1970) have criticized the response

measures used by Thomas and Lanier as "probably not appropriate analogs for the opposing tendencies usually thought to be invoked in comparisons of excitatory and inhibitory control...if subjects are literally forced to make a specific response in S-...is it legitimate to label the outcome an 'inhibitory gradient'. It would be more appropriate to call it an 'excitatory gradient' for a different response".

These studies which resulted in both types of gradients (whether or not they are symmetrical) when values of orthogonal stimuli are varied along a dimension would appear to support Jenkins' Rule 3 which states that the subject learns to respond to the S+ as well as not to respond to the S-. Before proceeding to other methods of identifying the sources of stimulus control, it is necessary to acknowledge considerable confusion regarding the underlying processes, excitation and inhibition.

Jenkins proposed that if the subject is operating according to Rule 1, then responding is due to only excitatory control (i.e., control by the S+ of responding). If Rule 2 is correct, the resultant gradients are due to inhibitory control (i.e., control by the S- of not responding). Rule 3, on the other hand, would entail a combination of both excitatory and inhibitory control.

There are many difficulties related to interpreting generalization gradients as behavioral evidence of excitation

and inhibition. The most obvious problem is in distinguishing inhibition from a lack of or a reduction in excitation. Skinner (1939) argued that the term "inhibition" was an unnecessary term and that any reduction in responding could be adequately described as a reduction in excitation. However, it now appears that the issue is not simply a matter of logic or semantics in that new methods and procedures are yielding evidence that an S- can indeed act as an inhibitor even in the absence of any generalized effect from the S+ (e.g., Brown and Jenkins, 1967; Jenkins and Harrison, 1962).

Brown and Jenkins (1967) have developed another procedure which intended to separate inhibitory effects (decrement in responding) from excitatory effects (increment in responding). Applying Pavlov's method of contrasts procedure for demonstrating conditioned inhibition to operant discrimination learning, they established a tone as a cue for not responding when paired with a previously established excitatory stimulus (green key). When the tone was paired another excitatory stimulus (red key) similar suppression of responding occurred. Similarity of the two excitatory stimuli was ruled out as a possible explanation of these data as discriminative performance in the presence of each of the two stimuli (topographically different responses with respect to spatial location) was maintained throughout the experiment. Despite Skinner's (1938) criticism of the term "inhibition", it was concluded that inhibitory

effects can be separated from any reduction-in-excitation effects.

Another method of attempting to separate excitatory effects from inhibitory effects was developed by Jenkins and Harrison (1962). The critical feature of their method was to use a dimension of the S+ which is independent of the dimension of the S-. For example, when the S- is tested by presenting values along that dimension, those values are assumed to be equidistant from the S+. Any resultant gradient would then be attributed to specific inhibitory control by the S- and not attributed to the reduction of excitatory control by the S+. Recently Hearst, Besley, and Farthing (1970) have examined some of the difficulties inherent in the issue of orthogonality of stimulus dimensions, the most important one being whether or not two stimuli are in fact independent, especially when they are perceived via the same sensory modality. Nevertheless, the method can offer an advantage over the previous intradimensional methods of testing, with regard to separating the effects of generalization from the S- and S+. It may not be the case, however, that generalization test procedures are equally effective in measuring S- and S+ control.

Studying generalization and discrimination of shape orientation in the pigeon, Vetter and Hearst (1968) found sharp excitatory gradients following discrimination training in which the S+ was a parallelogram on a green key and the

S- was a blank green key. However, for another group of subjects receiving the reversed stimulus conditions, they found no inhibitory gradients as responding across the orientation dimension was essentially zero (a result which, on the surface, would lend support for Jenkins' Rule 1).

Terrace (1966b) assessed the effects of errorless discrimination training on inhibitory stimulus control. Pigeons learned to discriminate between two orthogonal stimuli either with or without errors. While excitatory gradients were found for both groups, gradients of inhibition were obtained only for those subjects who had been trained with errors. Terrace concluded that following discrimination training with errors, the animal learned to respond to the S+ and not to respond to the S- (Jenkins' Rule 3) whereas following errorless training, the animal only learned to respond to the S+ (Rule 1). He interpreted these data as indicating that "the occurrence of errors is a necessary condition for the S- to function as an inhibitory stimulus." Such a statement basically proposes that if a stimulus exhibits any inhibitory control, upon subsequent testing, an inhibitory gradient must occur. Conversely, a flat inhibitory gradient indicates the absence of inhibitory control.

This conclusion has been questioned by several investigators. For example, Deutsch (1967) suggested that since the pigeons in Terrace's study did not respond to the S- and since the animal cannot make fewer than zero responses,

it is not possible to evaluate any differential inhibitory control between the S- and the extremes of the S- test values. When one considers the possibility of an hypothetical inhibitory gradient below zero, an empirical zero rate to the test stimuli provides an ambiguous basis for judging the extent of inhibitory dimensional control. If the subjects had responded to the test stimuli and at an equal rate, there would perhaps be less ambiguity.

The major problem appears to be that of elevating the rate of responding to the S- in order to permit any differential responding to the test values, e.g., testing dimensional control before responding to the S- has completely extinguished (Terrace's error birds) superimposing the S- test values upon the S+ stimulus (Lyons, 1969) Lyons compared generalization gradients following non-differential (S+ only) training, errorless, and error discrimination training. S- (line tilt) gradients were similarly flat for the errorless and non-differential groups whereas those obtained from the error group were typically U-shaped gradients obtained from all three groups were above zero level of responding. While these data might be interpreted as revealing "neutrality" of the S- for both the non-differential and errorless birds, Lyons applied another technique which showed this not to be the case. Superimposing the line-tilt test values on the S+ (green) resulted in differential responding as a function of line-tilt for the errorless and error groups while

the gradient remained flat for the non-differential control group. Lyons concluded that "the negative stimulus is not a neutral stimulus after errorless discrimination learning", there is some specific stimulus control by the line-tilt which was seen only by the superimposition test.

The second commonly used measure of inhibition is a reduction in behavior. In commenting upon Terrace's (1966b) conclusion that the occurrence of errors was necessary for the S- to function as an inhibitory rather than a neutral stimulus, Deutsch (1967) proposed the rate of responding as a measure of inhibition. Comparing the rates to the extreme test values of the S- for both groups (error and errorless), the rates for the birds trained with errors are greater than those for the birds trained without errors. Deutsch concluded that those data demonstrated that as the stimuli increasingly differ from the S-, there is greater inhibition when the subjects are trained without errors, a conclusion that is clearly contrary to that of Terrace. In the previously mentioned study, Brown and Jenkins (1967) also emphasized a definition of inhibition which is based on a reduction of behavior.

Investigating generalization gradients of inhibition using a line-tilt S-, Farthing and Hearst (1968) also found inhibitory gradients that became sharper with extended training. In discussing the implications of their results, they stated that the exclusive use of either definition of

"inhibition" (either reduction in responding or the presence of a generalization gradient around the S-) has resulted in controversial interpretations, e.g., Terrace (1966b) and Deutsch (1967). Suggesting that both a reduction in responding and specific dimensional control be included in the definition of "inhibitory control", Farthing and Hearst stated that "the words 'inhibition' and 'inhibitory control' should be used, if at all, in comparable fashion to the words 'excitation' and 'excitatory stimulus control'. Just as there can be excitation without the experimental evidence of specific excitatory stimulus control (...for example, the flat auditory frequency gradients of Jenkins and Harrison (1960) following nondifferential (excitatory) training to peck in the presence of one tonal frequency), it seems reasonable that inhibition may occur without experimental evidence of specific inhibitory stimulus control". Therefore, "inhibitory control" should include a reduction in behavior as well as specific stimulus control as indicated by the presence of a gradient. In order to permit a situation in which both measures could be utilized, the establishment of a baseline of responding to the S- above zero would appear to be essential.

Recently Wilton and Godbout (1970) have cautioned against interpreting generalization gradients as indicating the nature of the controlling stimulus-response relation, i.e., excitatory vs. inhibitory. They stated that the typical gradients obtained from a generalization test around

either the S+ or the S- may result from excitation ("factor which encourages responding") or inhibition ("a hypothetical response suppression factor"). The presence of a U-shaped gradient around the S- on a dimension orthogonal to the S+ will permit identification of the controlling stimulus (S-) but will not permit a distinction to be made between the two underlying sources of control, excitation or inhibition. "If excitation reduction occurs at S-, the gradient will reflect increasing excitation as we move from S-; if inhibition occurs at S-, the gradient will reflect decreasing inhibition (overlying a constant level of excitation as we move from S-." Applying this ambiguity to a discussion of Jenkins' three rules, they stated that control over the response may be the result of inhibition, excitation or a combination of both.

In addition, Wilton and Godbout warned against interpreting a flat gradient as indicating the absence of stimulus control. Modifying Jenkins' three rules, they proposed separate rules which apply not only to the S+ and S- but also to specific attributes of these stimuli varied during the generalization tests ($S+_t$ and $S-_t$), and to other characteristics not being varied ($S+_o$ and $S-_o$). The additional versions of Jenkins' three rules are formed by using all possible combinations of the tested (S_t) and non-tested (S_o) characteristics of the original stimuli. In discussion of the question of which stimulus is controlling responding, they stated that while the presence of an S+ gradient would eliminate

Rule 2 and the presence of a S- gradient would eliminate Rule 1, "no set of results allows the elimination of Rule 3". The failure to obtain a gradient around one characteristic of a stimulus does not indicate that there is no control by that stimulus as there may be some untested aspect which does exert control. While the presence of a gradient may say that a particular attribute controls responding, the absence of that gradient does not say that no attribute of the stimulus possible controls responding.

Two positions regarding the existence of "inhibition" have been presented. (1) Skinner (1938) proposed that the concept is an unnecessary term used to designate a change in behavior which would be better described as a reduction in excitation. (2) Brown and Jenkins (1967) suggested that inhibition is separable from excitation and is, therefore, a necessary term. Wilton and Godbout (1970) also argued that both 'excitation' and 'inhibition' should be acknowledged as factors controlling responding but added that identification of which factor underlies performance in any given situation cannot be made on the basis of generalization gradients. With the issue of inhibition being far from settled (Schoenfeld and Farmer, 1970), Wilton and Godbout's warning regarding the interpretation of generalization gradients seems well founded.

In order to remain theoretically neutral with regard to the underlying processes, discussion of related studies use a modified terminology, based only on an operational definition. The terms, "S+ gradient" and "S- gradient" are

used to indicate a controlling stimulus as Wilton and Godbout have suggested rather than indicate an underlying process.

The experimental evidence (based on post-discrimination generalization gradients) reported thus far have tended to support Jenkins' Rule 3, control by both the S+ and S- in a simple discrimination learning task. If, however, a decision is to be made as to the rule by which the subject is operating, other behavioral measures should support that decision. In other words, other behavioral measures obtained under different experimental situations should be of diagnostic service.

Rate of learning a discrimination task as a function of the number of negative and/or positive stimuli has been investigated in an attempt to discover the source of stimulus control. Mandler (1970) performed an experiment (Y maze) with rats in which the number of negative stimuli were not only varied in number but also were heterogeneous in order to avoid the possible effects of oddity learning. Mandler predicted that if the S- plays a greater role in learning a discrimination problem than does the S+, the constant S-, multiple S+'s (S-M+) problem would be relatively easier to learn than the constant S+, multiple S-'s (S+M-) problem. Results showed that the S-M+ groups learned the discrimination faster than the S+M- groups although both were slower than the controls with one S+ and one S-.

Meyer (1964) also found that rats learned a simultaneous discrimination problem with one S+ and one S- significantly faster than rats presented with one S+ and two different S-'s.

Reversal and transfer learning tasks have frequently been used to study the relative importance of positive and negative information in a simultaneous discrimination learning problem (e.g., D'amato and Jagoda, 1960, 1961; Mandler, 1968; and Schaeffer and Shandro, 1969). In Mandler's study, the following conditions were used: (a) reversal of S+ and S-; (b) reversal of S+ to S- with new S-; (c) reversal of S- to S+ with new S-; (d) new S+ and new S-; (e) new S+ with old S-; (f) old S+ with new S-. Results of the mean number of days to criterion in the new task showed the following descending order: (a), (c), (b), (d), (f), and (e). The easiest task was that in which the old S- was retained and the most difficult was the one in which the stimuli were reversed, demonstrating that avoidance of the S- was most important in controlling choice behavior at the end of acquisition than was approach to the S+. This conclusion was reached since disruption caused by changing the S- was greater than that caused by changing the S+. However, the differences were relatively small, and the rate of transfer learning was faster when either the S+ or the S- was retained in the new task. Mandler concluded that the subjects had learned something about both the negative and positive stimuli.

The results of these studies on acquisition, transfer and reversal learning problems using multiples of varying stimulus conditions would seem to indicate that the negative stimulus is playing the greater role in animal discrimination learning. While such results are supportive of the uniprocess(inhibition) discrimination theory of Harlow and Hicks (1957) which contends that there is greater learning of the non-rewarded stimulus, they are clearly contrary to those results found in studies using post-discrimination generalization gradients. It is not presently obvious why such difference should occur.

Another method, rate of response to a novel stimulus, has been suggested as a possible indicant of the source of stimulus control (Lumsden and Rand, 1971). Investigating object constancy, pigeons were differentially trained to respond to a three-dimensional object (S+) which differed from the S- object with respect to form. The birds were then presented with several orientations of the S+ under extinction conditions which yielded flat generalization gradients. In addition, a high equivalent rate of responding occurred in the presence of "almost any object" presented to the pigeon except the S- object itself. It was inferred that all orientations of a number of objects were perceptually equivalent, the only exception being the S- object. Pursuing the problem of object constancy, the training procedures were modified by the sequential addition of several S- objects

until responding to the introduction of the novel object was eliminated. Although originally an unexpected result of this study on object constancy, these findings suggested that rate of response to a novel object was a function of the number of training stimuli.

Terrace (1966a) noted that just as differential reinforcement seems to be an important procedure in establishing stimulus control along a particular dimension, it is also important with regard to complex stimuli. "Specific differential reinforcement with respect to one of the numerous dimensions along which a stimulus may be specified, makes that dimension more distinctive than a dimension which does not enter into the differential procedure" (Terrace, 1966a). Reynolds (1961) demonstrated that for different subjects different aspects of a complex stimulus may acquire control over responding. Thus it would seem that control by a specific characteristic of a complex stimulus (e.g. form) would occur only if all other characteristics were rendered irrelevant. A procedure which could bring about such specific control by one characteristic of, for example, the S+, would be utilizing several S- stimuli, each differing from each other and from the S+ with respect to only one of the multiple S+ characteristics. The maximum number of S- stimuli necessary to bring about control by the S+ characteristic would equal $n-1$, where n = the number of characteristics of the S+.

Differentially training subjects with many S-'s, therefore, could result in conditioning to respond only in the presence of the S+ by specific differential reinforcement with respect to many characteristics. Perhaps only by extinguishing to a multiple set of characteristics will the subject respond only in the presence of the S+ (exclusive S+ control).

Under what conditions could the S- acquire control of "not responding"? A parallel approach might be to use multiple S+ stimuli during training in order that a specified characteristic of the S- could control not responding. On the other hand, a logical analysis of the operations comprising the response shaping and other features of the pre-discrimination training procedures suggest that the source of stimulus control in a simple discrimination task could well be from the S-, i.e., Jenkins' Rule 2 is not without some analytical support. In training pigeons by the method of successive approximations in the presence of the S+, the subject learns to respond not only in the presence of the S+ but also in the presence of the many other stimuli (e.g., house lights, white noise, key light, etc.,) which are constantly present during training. The animal's only task is to respond. At this point, prior to differential training, generalization testing has resulted in flat gradients (Jenkins and Harrison, 1960; Peterson, 1962), which are taken to indicate no control by the S+.

Upon initiation of training with differential reinforcement procedures (Mult VI EXT) i.e., introduction of the S-, the subject might now learn the stimulus conditions during which responding is not reinforced in order to reach the criterion set by the experimenter. If this is the full extent to which stimulus control is involved in attaining criterion, subsequent presentation of a probe stimulus would result in a high rate of responding to that stimulus insofar as it does not constitute the stimulus conditions which have come to control not responding. This might be regarded as training the subject to stop responding to a stimulus attribute while still conditioned to respond to all other attributes which are within the universal set, or the complementary set.

Rate of response to a novel stimulus as a function of the number of negative stimuli is an empirical question. If the hypothesis that such a rate of response is an indicator of the source of stimulus control is supported by the data, the next step would be to see if the novel rate of response are related to the traditional measure of stimulus control: generalization gradients. Inconsistent with such an hypothesis is the fact that S+ gradients have frequently been obtained when one S- was used in training. This result has occurred using three-dimensional stimulus objects (Lumsden and Pullen, 1970). Nevertheless, it is of interest to determine if there is any relationship between the two measures within the same animal.

Experiment I was performed to determine whether or not rates of response to a novel stimulus was a function of the number of different negative stimuli. Experiment II was performed in order to explore the possibility that such a response rate is an indicant of the source of stimulus control as traditionally measured by post-discrimination generalization tests.

EXPERIMENT I

The purpose of this study was to investigate whether or not the rate of response to a novel stimulus presented following discrimination learning is a function of the number of different negative stimuli utilized in the preceding operant discrimination learning task.

METHOD

Subjects: The subjects were six experimentally naive Silver King pigeons obtained from the Palmetto Pigeon Plant, Sumter, South Carolina. They were maintained at approximately 80% of their free-feeding weight throughout the experiment. Water was available at all times in their home cages.

Apparatus: The experimental chamber was a 14 x 8 x 12 inch box made of 1/2 inch plywood and painted uniformly black. Extraneous sounds were masked by a speaker delivering white noise within the chamber. Responses were recorded and reinforcement programmed automatically by a Grason-Stadler relay circuitry. A transparent Plexiglass key was mounted behind a 1 1/2 inch diameter opening which was located in the center of the front panel of the chamber 8 3/4 inches above the base of the box. A minimum force of approximately

12 grams was required to operate the key. Reinforcement consisted of grain made available automatically by a Lehigh Valley Electronics Grain Dispenser (Model 1347) for 3.0 second duration, through a 2 x 2 1/2 inch rectangular opening 3 inches directly below the key. A standard 24-volt light illuminated the magazine opening during reinforcement presentation.

Stimuli: All of the objects used in this study were three-dimensional objects of approximately equal height and volume, differing only in form (see Fig. 1). The stimulus object was located at a distance of 3 1/2 inches directly behind the response key in an enclosed box. The box was of translucent plastic measuring 5 x 5 inches with a black cardboard floor for mounting the objects and a black cardboard backing to maximize the contrast of the white objects and background. The stimulus object was illuminated by a 15 watt lamp located approximately 1 1/2 inches above the stimulus box.

Procedure: Upon arrival, Ss were weighed, individually caged, and given free access to both food and water. Beginning on the fifth day, free-feeding was discontinued and Ss were allowed only approximately 3 grams each day thereafter until each bird was reduced to 80% of his free-feeding weight. At that time, Ss were magazine trained and were key-peck trained by the method of successive approximations. Initial training occurred in the presence of the S+ oriented in the frontal-parallel position. Throughout the entire

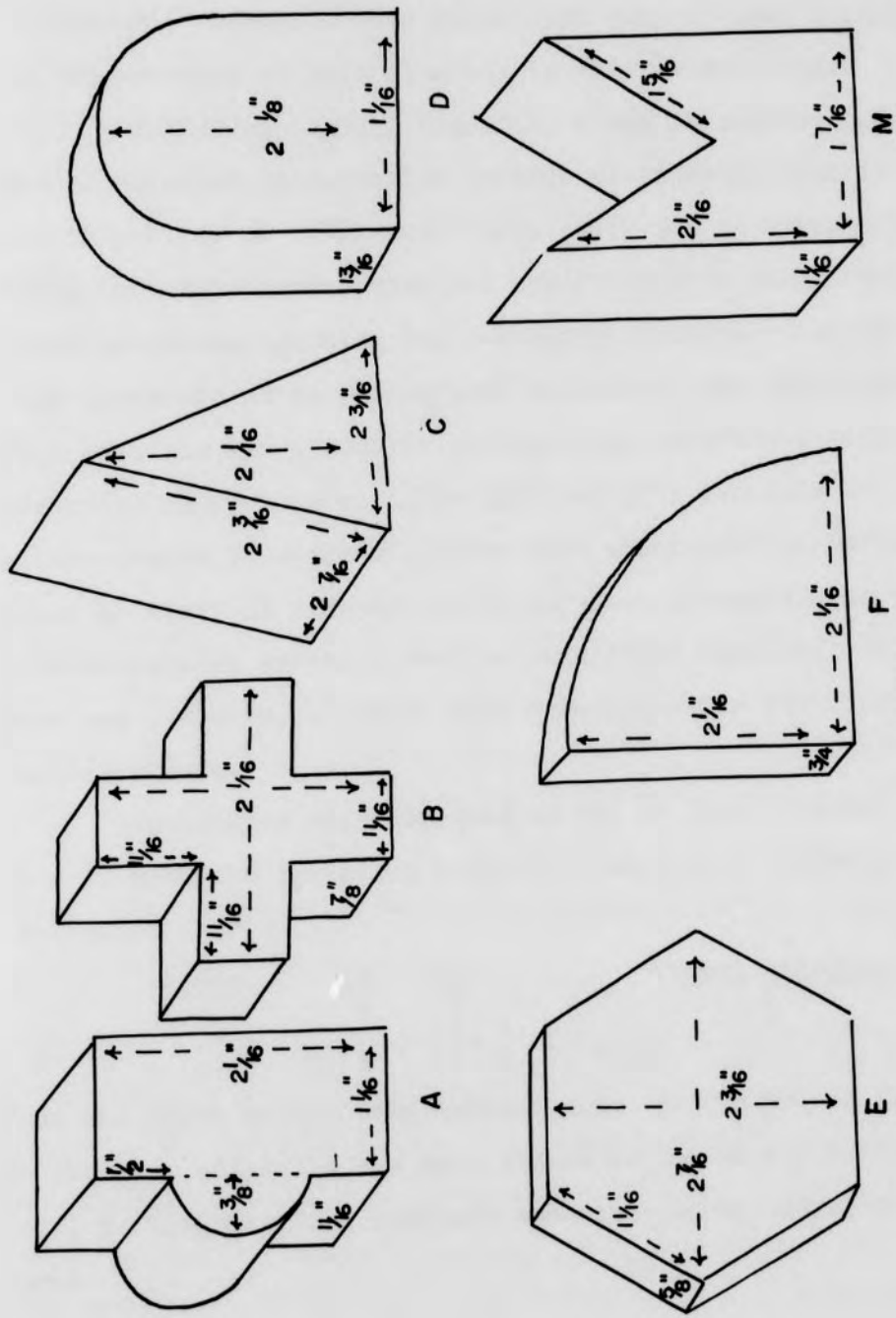


FIGURE 1
ILLUSTRATION AND DIMENSIONS OF STIMULI

experiment, responses were reinforced only if they occurred in the presence of this stimulus in this orientation.

Following initial training, S was introduced to 30 second stimulus-presentation periods alternating with 12 second periods of black-out. This black-out interval provided the experimenter with the opportunity to change the stimulus during training and subsequent testing. During this black-out no responses were recorded. The reinforcement schedule was gradually reduced from continuous reinforcement (CRF) to a variable interval (VI) schedule of reinforcement in which responses were reinforced on the average of every 20 seconds (VI 20"). Each S remained on the intermediate VI schedule until a relatively high and stable rate was obtained, at which time discrimination training was introduced.

The six Ss were assigned to one of three groups (n = 2) with the following stimulus conditions: (objects are identified in Fig. 1)

<u>Group</u>	<u>S+</u>	<u>S-</u>	<u>Novel</u>	<u>Stimulus</u>
I	A	B		M
II	A	B, C, D		M
III	A	B, C, D, E, F		M

Thus the three groups were trained with one, three, or five S- objects, utilizing the same object as the S+ and holding total S- training time constant and equal to S+ training time.

Phase I: Discrimination training for all groups involved reinforcement of responses made in the presence of the S+ and involved no reinforcement (EXT) of those responses made in the presence of the S- or S-'s. During discrimination training all objects were oriented in the frontal-parallel position. Total S+ and S- times were equivalent, i.e., each S was presented with 30 S+ periods and 30 S- periods. The total S- time consisted of 30 presentations of object B for Group I; for Group II the total S- time consisted of 10 presentations each of the three objects: B, C, and D; whereas for Group III it consisted of 6 presentations each of the five objects: B, C, D, E, and F. All stimuli were presented in random order with the stipulation that neither the S+ nor the S- (or S-'s) appear for more than three consecutive presentations. Discrimination training continued for fifteen days for all Ss regardless of discrimination ratio ($DR = \frac{S+ \text{ responses per minute}}{S+ \text{ responses per minute} + S- \text{ responses per minute}}$.) The number of exposures per stimulus during training for each S is presented in the Appendix B.

Phase II: Following discrimination training, each S was presented with a stimulus object of the same height, volume and color as the training objects. The particular object utilized in this capacity as "novel" object is identified as "M" in Fig. 1. Five presentations of this novel stimulus were randomly interspersed among the regular presentations

of the S+ and S- objects of the discrimination training schedule. Thus the total session consisted of 65 stimulus periods for this day.

RESULTS: EXPERIMENT I

The response rate to the novel stimulus relative to the rate to the S+ for each S is given in Fig. 2. A summary of these results is as follows: (1) For those Ss trained with one S-, the response rate to the novel stimulus is equal to or greater than the rate to the S+. (2) For those Ss trained with three S-'s, the response rate to the novel stimulus was intermediate to the rate to the S+ and the rate to the S-'s. (3) For those Ss trained with five S-'s, the rate to the novel stimulus was similar to the rate emitted to the S-'s. It should be noted that while the S- rate in Fig. 2 is an individual S's average relative rate to the three stimuli in the case of Group II and to the five stimuli in the case of Group III, there was little variability among the rates to these stimuli for each individual S. The relative rate to the individual S-'s are graphed in Fig. 4, a composite figure, which appears in the context of the result section of the second experiment. Absolute rates of response for each subject are presented in Appendix A.

The high rate of response to the novel object for Group I was taken as behavioral evidence that the novel

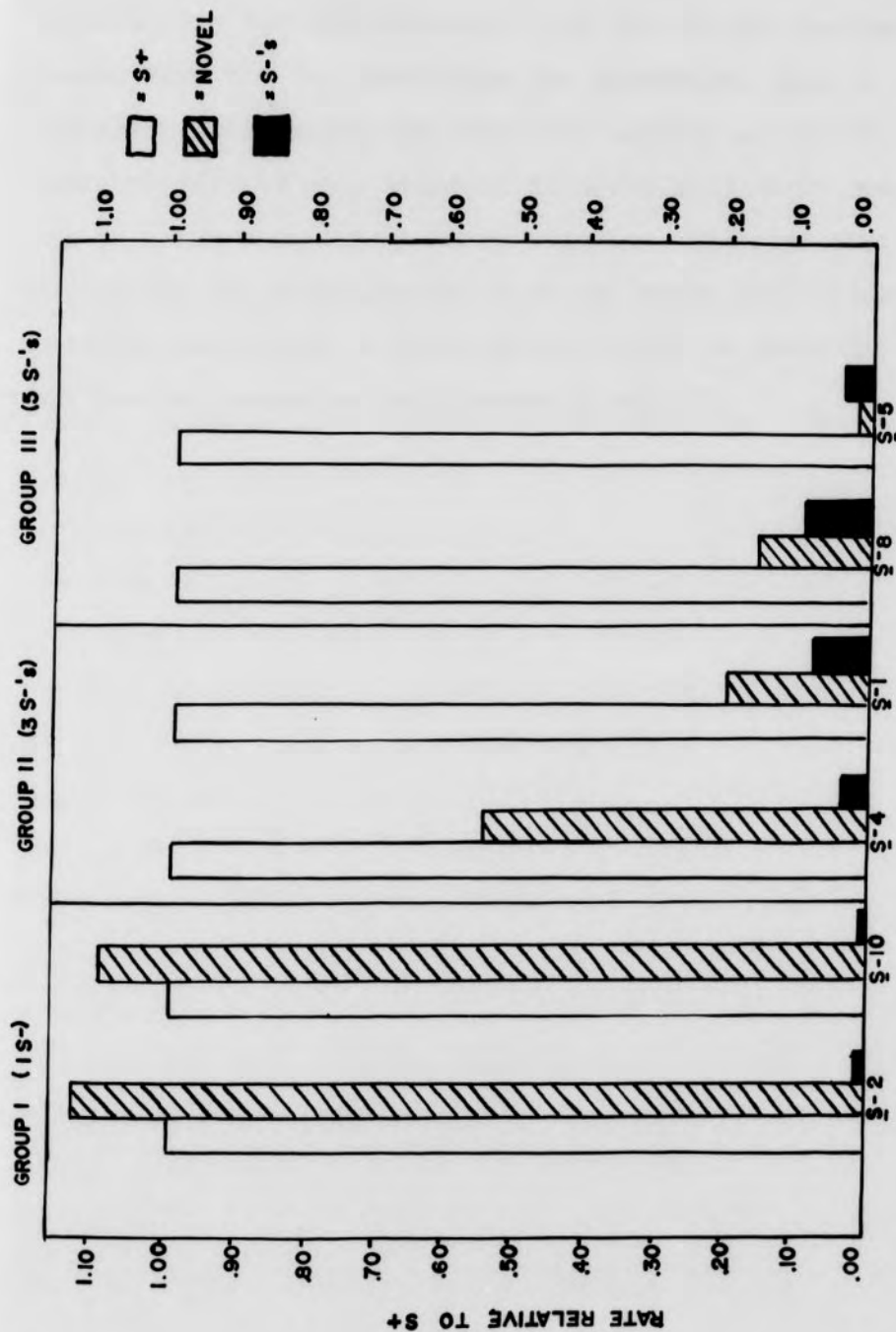


FIGURE 2: RELATIVE RATE TO NOVEL STIMULUS AS A FUNCTION OF NUMBER OF S-'s

stimulus was not discriminated from the S+ but was discriminated from the S-, supporting the hypothesis that in this situation, responding was under the control of the S-. The opposite results were obtained in Group III, where responding at a low rate to the novel stimulus indicated that this object was not discriminated from the S- in this situation. (Further discussion of these results will be presented in the section comparing Experiments I and II).

EXPERIMENT II

In interpreting the results of Experiment I, it was suggested that stimulus control is primarily from the S- in a simple operant discrimination learning task utilizing complex three-dimensional stimuli whereas when multiple S-'s are used in training, stimulus control is primarily from the S+. This interpretation is not consistent with the results of studies using as a measure of the stimulus control, post-discrimination generalization gradients following similar discrimination training with unidimensional stimuli. The present experiment, therefore, was performed to replicate Experiment I with the added procedure of generalization testing of various orientations of the S+ object and the S- object, both of which were common to all groups of pigeons. The primary concern was to determine the degree to which the two behavioral measures (relative response rate to a novel stimulus and post-discrimination generalization gradients) are related. Specifically, the hypothesis tested here is that relative rates of responding to a novel stimulus may indeed be an indicant of the source of stimulus control by examining the relationship between such a response rate and the traditional indicant, generalization gradients.

METHOD

Subjects: Eleven experimentally naive White Careaux pigeons and one experimentally naive Silver King pigeon were obtained from the Palmetto Pigeon Plant. The same deprivation schedules were maintained as for the subjects in Experiment I.

Apparatus: The same apparatus was used as is described for Experiment I.

Stimuli: The stimulus object was located at a distance of approximately 3 1/2 inches directly behind the key, illuminated and enclosed in the previously described manner. Each object could be rotated around its vertical axis to any desired orientation. The orientations utilized included 30, 50, 70, 90, 110, 130, and 150 degrees orientation corresponding to the frontal-parallel position.

Procedure: The same procedure for the preliminary training was followed as for Experiment I with the exception that the terminal reinforcement schedule was VI 45 seconds. The twelve subjects were assigned to one of three groups (n = 4) with the following stimulus conditions: (for identification of the objects see Fig. 1)

<u>Group</u>	<u>S+</u>	<u>S-</u>	<u>Novel Stimulus</u>
I	D	B	M
II	D	B, C, A	M
III	D	B, C, A, E, F	M

The particular object serving as the S+ was altered from that used in Experiment I (object A) because that object was asymmetrical and would have posed problems for the generalization test along the dimension of orientation. "Thus, although object A was utilized as an S- in both multiple S- conditions, only the symmetrical objects (B, C, D, and E) were ever utilized as test stimuli in the determination of generalization gradients along the orientation dimension.

Phase I: This phase was the same as in Experiment I except that discrimination training continued until the subject responded to a criterion of a discrimination ratio (DR) of .80, i.e., 80% of all responses during the total session were S+ responses. In addition, the S must have responded during every S+ period of the session. The purpose of the .80 DR criterion (as opposed to a more stringent DR) was to insure some responses to the S- during subsequent testing.

Phase II: As in Experiment I, five presentations of the novel stimulus were interspersed among the regular presentations of the S+ and S- objects of the discrimination training schedule. Unlike Experiment I, however, the novel stimulus was presented on the day following attainment of a DR of .80.

Phase III: In the session after the presentation of the novel stimulus, each bird was given four warm-up periods of S+ (reinforced on a VI 45 second schedule) after which a generalization test under extinction conditions was conducted. This test included orientations of either S+ or S-. In subsequent test sessions more than one S- was tested for birds in Group II and III. For specific orders of testing see Table 1.

The first two tests utilized the common S+ object (D) and the common S- object (B). The order in which these two common stimuli were tested were counterbalanced within groups. Following the first generalization test, each subsequent test was preceded by a sufficient amount of training to re-establish criterion performance ($DR = .80$). After the completion of testing of the common stimuli, generalization gradients were obtained with the other symmetrical stimuli as well. No effort was made to counterbalance the order in which these gradients were obtained as there were no across-group comparisons to be made with them.

A testing session consisted of the presentation of seven randomized blocks of test orientations (30, 50, 70, 90, 110, 130, and 150 degrees) and the 90 degree orientation of those stimuli for which generalization gradients were not obtained during that testing session. As in the training sessions, the total test session (including warm-up periods) consisted of 60 stimulus presentations.

TABLE 1

ORDERS OF GENERALIZATION TESTING

<u>Group</u>	<u>Subject</u>	<u>Order of Testing</u>
I	52	D, B
	71	B, D
	78	D, B
	74	B, D
II	73	B, D, C
	75	D, B, C
	77	B, D, C
	72	D, B, C
III	76	D, B, C, E
	79	B, D, C
	80	B, D, C, E
	81	D, B, C, E

RESULTS: EXPERIMENT II

The assumption was that to the extent that a novel stimulus is responded to at a rate comparable to the S- rate, stimulus control is from the S+ and conversely, to the extent that the novel stimulus is responded to at a rate comparable to the S+, control is from the S-. In order to provide a less variable basis for comparison across subjects, the rate of response to the novel stimulus and the rate to the S- (or S-'s) were compared in the context of the rate of S+ responding for each subject. The DR measure provided a readily available measure for the S- rate in the context of S+ responding. A comparable contextual measure for novel stimulus rate was provided by modifying the DR measure specifically by replacing the S- rate in that formula with the novel stimulus rate: $S+ \text{ responses per minute} / S+ \text{ responses per minute plus novel stimulus responses per minute}$. Comparison of these data is found in Fig. 3 along with similar data from those Ss in Experiment I. To the extent that the slope of the line approximates zero, the novel stimulus was being responded to at a rate comparable to the S-, a condition which was interpreted as indicating stimulus control from the S+. To the extent that the slope differed from zero in a negative direction, the novel stimulus was being responded to at a rate similar to the rate in the presence of the S+, a condition interpreted as indicating control from

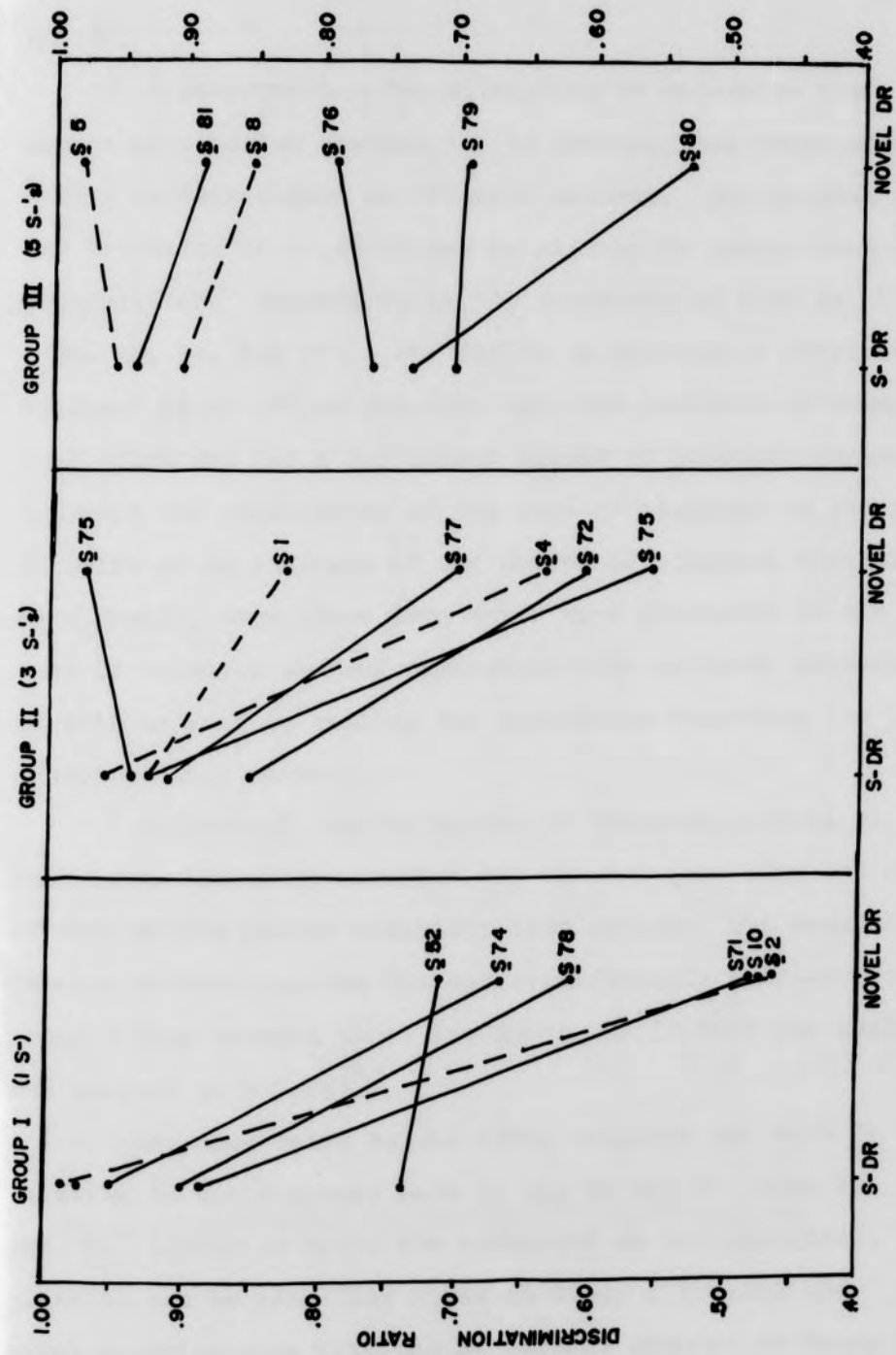


FIGURE 3: COMPARISON OF S- AND NOVEL DISCRIMINATION RATIOS

the S-.

A precondition for attempting to determine the source of stimulus control is, of course, that there exists a certain degree of stimulus control. The purpose of the criterion of a .80 DR was an attempt to insure such a precondition. Therefore, in the instances of four Ss (#52, 76, 79, and 80), who failed to maintain a previously acquired DR of .80 on the test day, the position is taken that there was not a sufficient degree of stimulus control to merit the utilization of the rate of response to the novel stimulus as an indicant of the source of stimulus control. As a result, only those data which were generated in the context of stimulus control consistent with at least criterion DR will be used in testing the hypothesis regarding the source of that control.

In general, as the number of training stimuli is increased, the novel stimulus was treated more like the S- as seen by the higher discrimination ratios. The mean difference between the two DRs was significantly greater for Group I than between those for Group III (T test for small and unequal n: $p < .05$).

Response rates to the novel stimulus and each S- relative to the response rate to the S+ may be found in Fig. 4. (Absolute rates are presented on the Appendix). Again it can be seen that birds in Group I treated the novel stimulus more like the S+ whereas those Ss in Group III

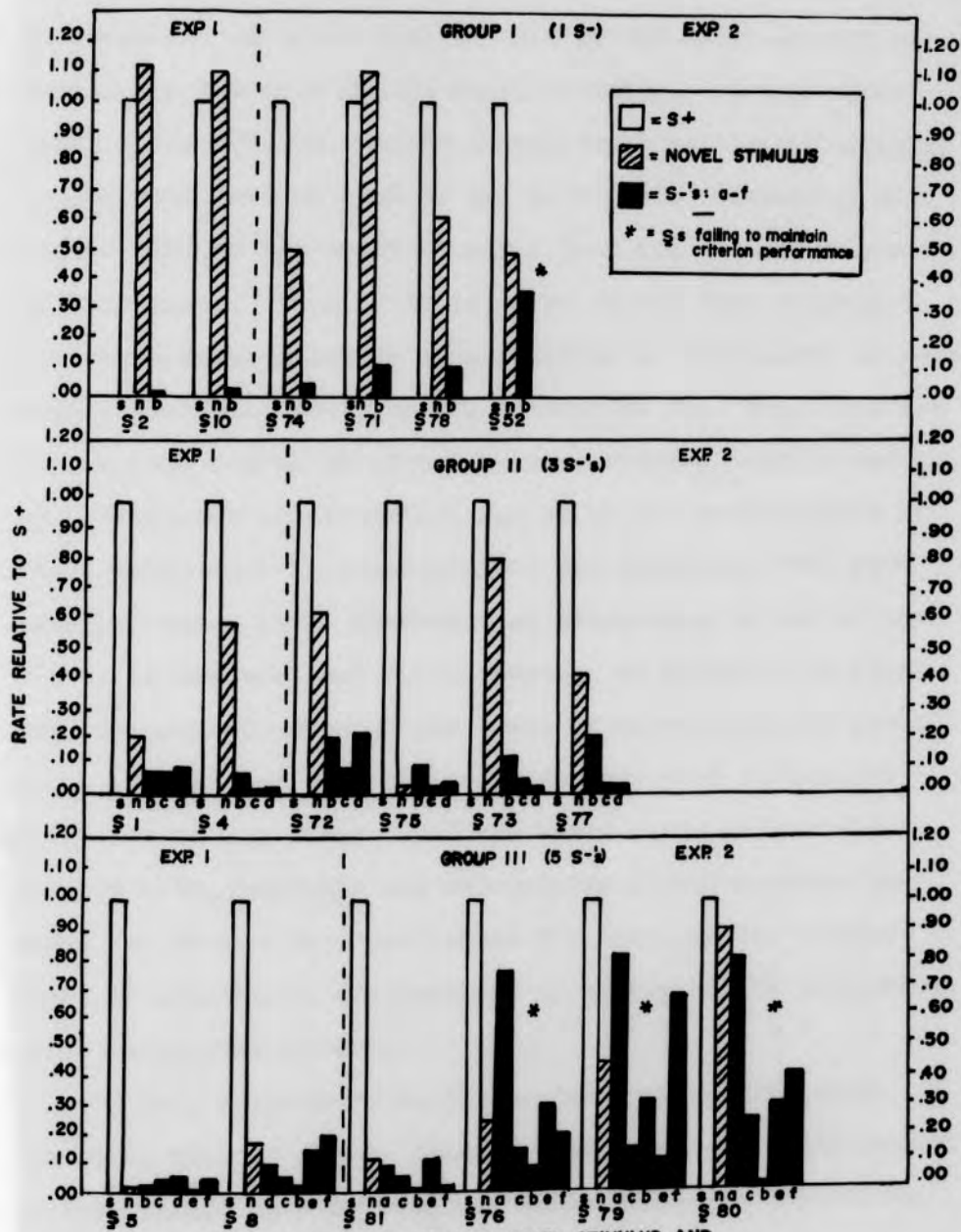


FIGURE 4: RELATIVE RATE TO NOVEL STIMULUS AND EACH S-

treated this stimulus more like the S-'s. Birds #5, 8, and 81 responded at a low rate to each of the S-'s as well as emitting a low rate to the novel stimulus. On the other hand, Birds #76, 79, and 80 showed considerable variability in response rate to each of the S-'s while responding at a higher rate to the novel stimulus than did the other birds of this group. Thus if it is to be stated that response rate to a novel stimulus is a function of the number of S-'s, such a statement rests on the assumption that the S has acquired some degree of discrimination between each S- and the S+. That such an assumption cannot be met on the basis of these data, must be considered in the analysis. If, for example, there is no differential responding to one of the S-'s, as was the case for responding to object A by birds #76, 79, and 80, then on the basis of performance it would be as if they had been trained with four S-'s instead of five. It is not clear why these three birds had such difficulty with acquiring and maintaining discrimination between the S+ and this particular S-, although the reason might be related to the problems of orthogonality discussed below in greater detail.

Only when there is differential responding with regard to each of the S- stimuli (and therefore, with regard to the average rate of response to all S-s) can evaluation be made as to the functional relationship between the rate of response to a novel stimulus and the number of S-'s.

Thus the necessary conjunctive precondition of maintaining the DR of .80 and discriminating between the S+ and each S- were not met in the present experiment. It would appear that both are important in order to merit the use of rate of response to a novel stimulus as a possible indicant of the source of stimulus control.

Fig. 4 permits a closer look at the data than does Fig. 3 and demonstrates that averaging response rates or discrimination ratios may obscure considerable variability. This may be a significant factor in light of the hypotheses that a S will come to respond to the S+ only and not to the novel stimulus if responses to a multiple set of dimensions have been differentially extinguished.

Results of the generalization tests on the orientation dimension for a number of training stimuli are shown in Figs. 5, 6, and 7. The test orientations were ± 20 , ± 40 , and ± 60 degrees deviation from the training orientation, 90 degrees. Each test session followed a training session during which the criterion of .80 DR was re-established thus the earlier remarks concerning the disqualification of the novel stimulus data of birds #52, 76, 79, and 80 do not pertain to these generalization gradients. To counterbalance any possible order effects of testing, half of the Ss in each group was tested on the orientations of the common S+ first while the other half was tested on the common S- first (object B). Points on the graph represent rates of

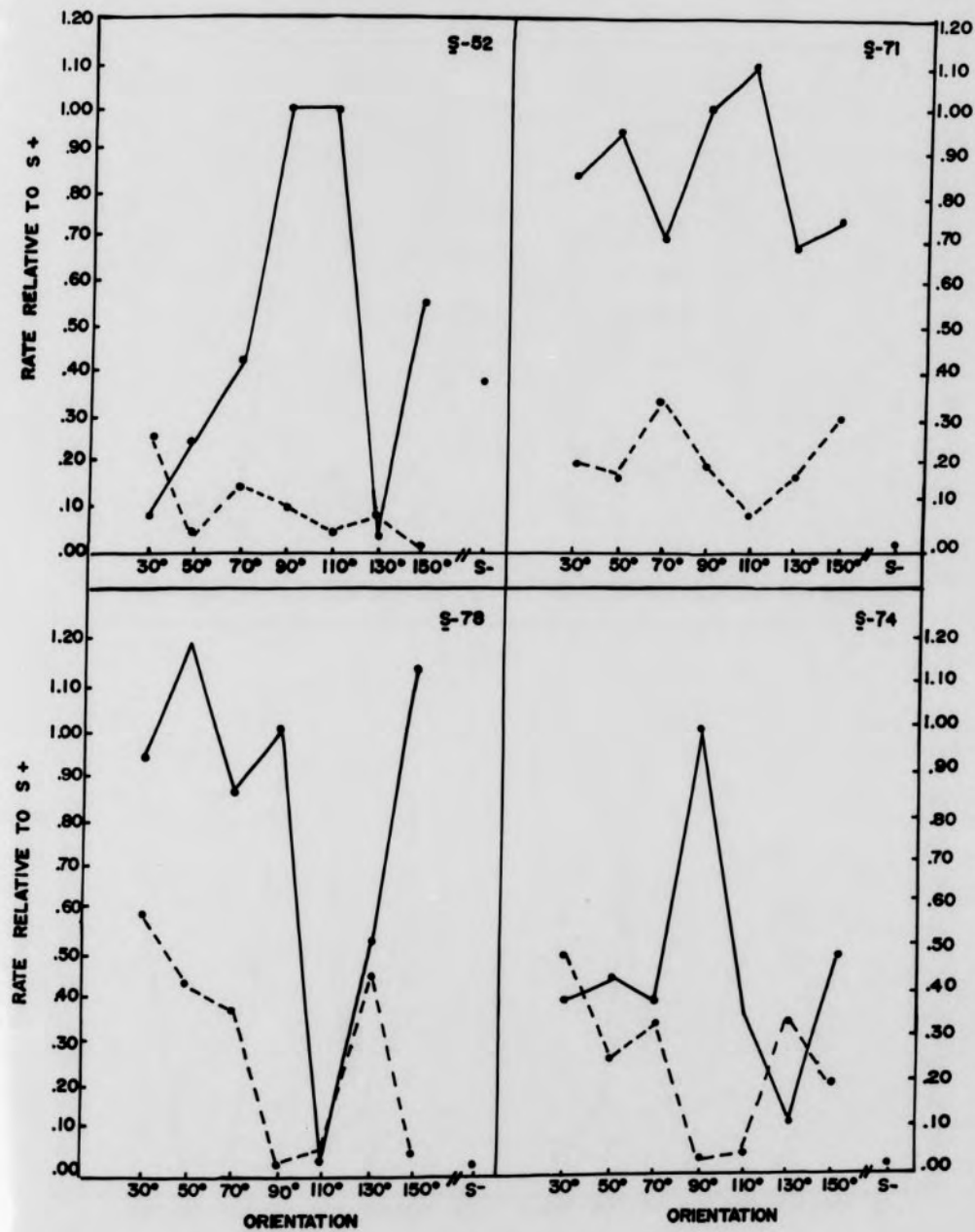
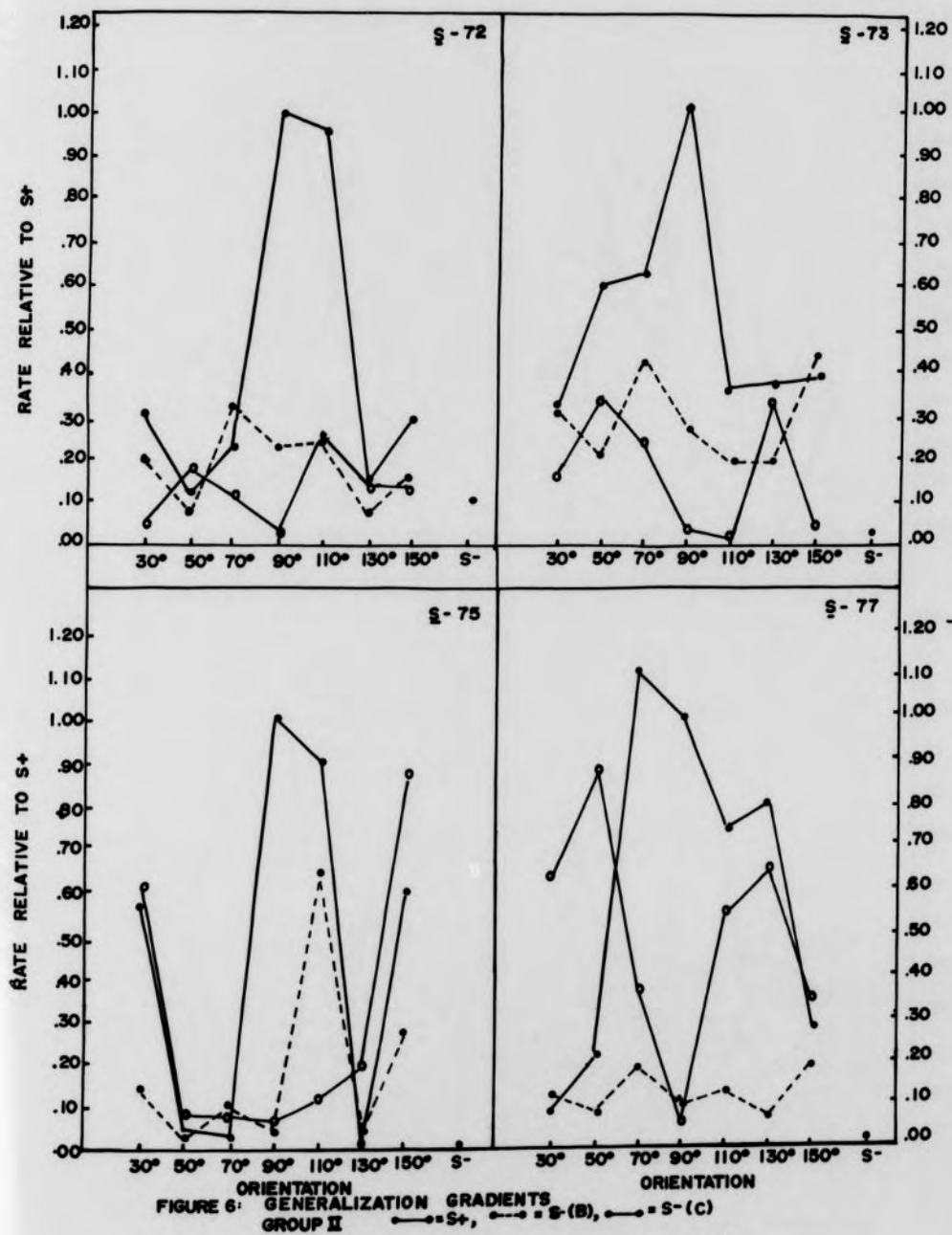


FIGURE 5: GROUP I GENERALIZATION GRADIENTS

—•— = S+, - - -•- = S- (B)



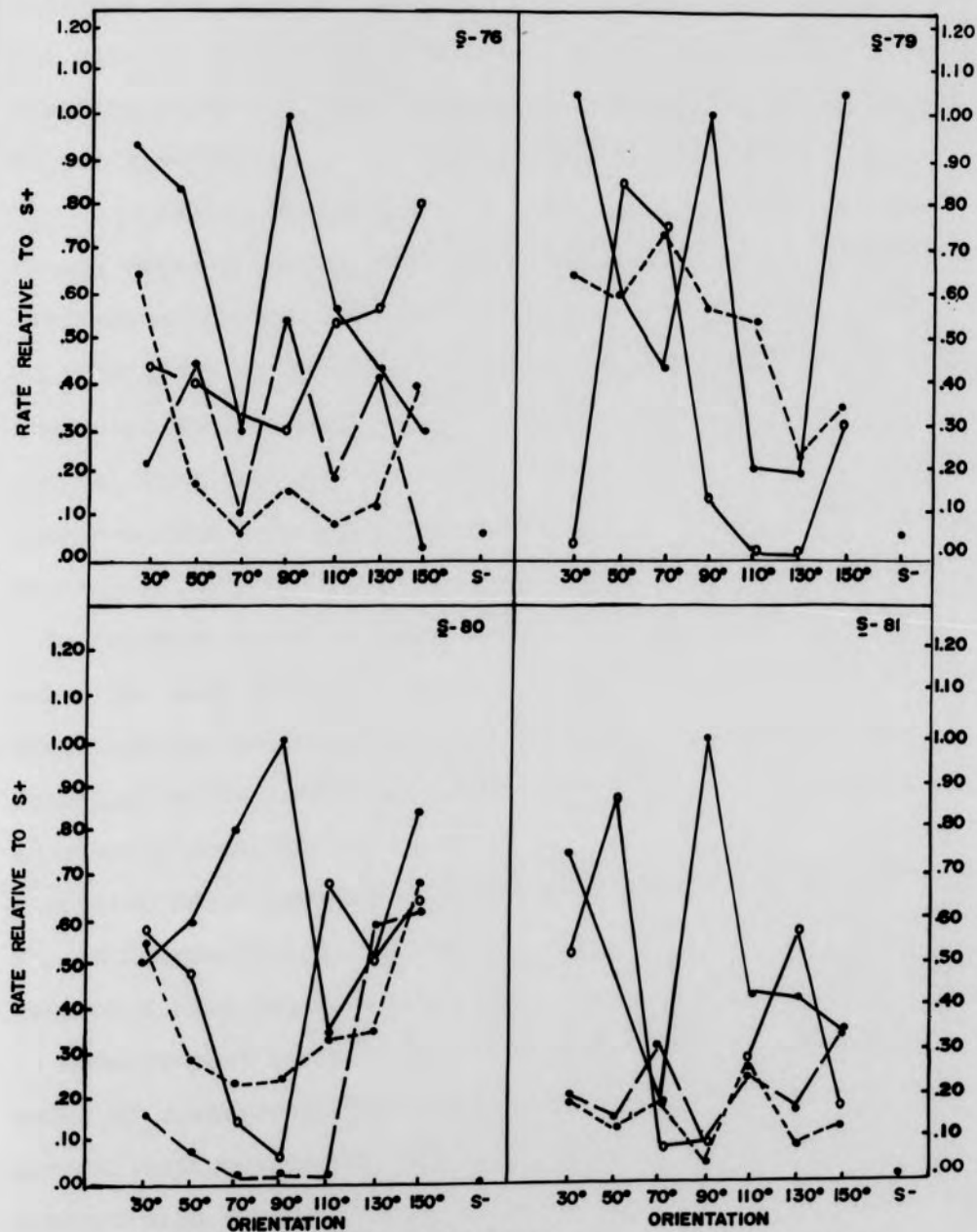


FIGURE 7: GENERALIZATION GRADIENTS
GROUP III —●— = S+, -○- = S-(B), —●— = S-(C), -○- = S-(E)

response per minute to each of the test stimuli relative to the rate of responding to the S+. In addition, rates of responding to the S- are included for the session in which the S+ was tested.

Group I exhibited considerable variability in response rates to the various test stimuli (Fig. 5). Clear evidence of control from either stimulus across all birds in this group is lacking. A typical S+ gradient was obtained from Bird #52 in addition to a flat S- gradient, indicating control from the S+. Fairly typical S+ and S- gradients were obtained from #74, reflecting control by both stimuli. This bird's responding to the novel stimulus was also intermediate to those rates in the presence of the S+ and S-. Despite the high rate of response to the novel stimulus (higher than that to the S+), bird #71 showed no differential responding to the test orientations of the S- object as the hypothesis predicts he should. On the other hand, with the exception of responding to the 150 degree orientation of the S-, an incremental S- gradient was obtained from #78 who had responded at an intermediate rate to the novel stimulus. Thus it appears that there is no clear relationship between the rates of response to the novel stimulus and the form of the generalization gradient from either stimulus for these birds trained with one S-.

All birds in Group II exhibited S+ gradients as shown in Figure 6. S- tests were performed on the two

symmetrical S-'s (objects B and C). Gradients for object B were for the most part flat or at least did not show minimal responding at the training orientation with systematic increments in responding as the orientations increasingly deviated from the training orientation. Tests on object C, however, resulted in fairly consistent incremental gradients for all birds with #77 demonstrating the most dramatic difference between the two S- gradients. Despite the consistencies in the generalization gradients, there are no corresponding consistencies in the response rates to the novel stimuli across all birds in this group.

The generalization gradients obtained from birds in Group III were highly unsystematic (Fig. 7). As for Group II, tests were run on the symmetrical S-'s with the exception of #79 who was not tested on object E. While the S+ gradients were not flat across orientations, they did show several extreme reversals. Incremental gradients for object B were obtained from birds #76 and 80 while the other two birds showed unsystematic gradients for this object. As was found for the animals in Group II, tests on object C resulted in gradients with a steeper slope for birds #80 and 81. Tests on object E showed no consistency across Ss, i.e., #76 responded with considerable variability to the orientations, #80 showed a broad and shallow gradient, and non-differential responding was obtained from #81. As for the other two groups, these data could not have been predicted on the basis of

rates of response to the novel stimulus.

DISCUSSION

It was suggested in the introduction that when differential training with many S-'s results in conditioning to respond only in the presence of the S+ it is by way of differential reinforcement with respect to many dimensions. That is, perhaps it is by extinguishing to a multiple set of dimensions that the S will come to respond only in the presence of the S+. In the situation where there is only one S-, the S must learn when not to respond since prior to introduction of the negative stimulus the occasion for responding being reinforced was quite unspecific. Thus in the simple operant discrimination task, responding may come under the control of the S-. Such an hypothesis proposes that rate to a novel stimulus is an indicant of the source of stimulus control.

The results of Experiment I demonstrate that the rate of responding to a novel stimulus was a function of the number of S-'s used in training an operant discrimination between forms of three-dimensional objects. Considering only the data of those Ss in Experiment II who evidenced criterion stimulus control during the session in which the novel stimulus data were obtained, it can be seen that the findings of Experiment I were replicated. That is, following discrimination training

with one S-, response rate to the novel object will be similar to that to the S+; whereas following training with multiple S-'s, the rate of responding to the novel object will approach the rate to the S-s'.

If the novel stimulus data did, in fact, reflect the source of stimulus control, they should show some systematic relation with the accepted measure of the sources of stimulus control: generalization gradients obtained along some dimension. This was the purpose of Experiment II and no consistent relationship between rate of response to the novel stimulus and differential responding along the orientation dimension was obtained. It is, of course, possible that different results could have occurred had some other aspect of the training stimulus been used as the testing dimension.

It is difficult to identify the source of the extensive variability in the form of the generalization gradients. The steeply-sloped gradients obtained by Lumsden and Pullen (1970) demonstrated unequivocally that orientation can be a dimension of stimulus control for three-dimensional objects. One possible source of this variability probably lies in the objects themselves. The training stimulus per se was not actually rotated for testing; the test stimuli were separate objects, intended to be identical in shape, size and color to the training objects but positioned at the various testing orientations. It is possible that there were artifactual differences between these objects. One might wonder, however,

why such small differences in stimuli would come to control responding whereas an apparently salient (to the experimenter) difference would not. Nevertheless, in the Lumsden and Pullen study the same object was rotated during the test which is consistent with the above suggestion as to an artifactual source of variability. This suggestion does not account for the increase in variability as a function of the number of negative stimuli i.e., why Group III birds showed more reversals and general variability than those in Group I and II. In general, the results of rates to the novel stimuli and generalization gradients were inconclusive for Group III in the second experiment. The only tenable suggestion for this inconsistency is that discrimination learning with many S-'s at a low criterion of .80 DR is, at best, unstable.

The inconsistent gradients obtained from all groups could conceivably be related to different amounts of training. Farthing and Hearst (1968) demonstrated a direct relationship between the steepness of the slope of the S- generalization gradients and the amount of training, i.e., the slope of the gradients became steeper with increasing amounts of training prior to the test. The number of exposures per stimulus during training is presented in Appendix B. Despite sizeable differences in amount of training, both within and between groups, no consistent relationship between these data and the slope or shape of the gradient can be seen.

One of the consistent findings regarding the gradient is found in comparing the forms of gradients for objects B and C. With the exception of bird #76, gradients for object C were steeper and more U-shaped than the gradients obtained by testing object B. It is difficult to understand why one S- object would exhibit greater control over responding than other S- objects since the bird had equal exposure to each object during training. It is precisely this result which raises the question of "orthogonality", i.e., perhaps object C is not orthogonal to the S+. When this object is rotated away from the training orientation which has been explicitly extinguished, it may move (on some dimension) closer to the S+. Possible dimensions might be the width of the stimulus at the base, width at the top, verticality of the sides, etc. Tests on orientation of object E resulted in gradients similar in form as gradients for object B for two of the birds. This is consistent with the notion that object C is not orthogonal to the S+.

These results leave little doubt also that the three-dimensional objects are indeed complex stimuli, any aspect of which may come to control responding. Even relatively simpler stimuli may be subject to the same uncertainty. For example, Lashley (1938) found that a rat's jumping behavior was controlled by only the lower halves of circles and squares used in training the discrimination. Touchette (1969) demonstrated that tilted lines may function as complex stimuli since in that experiment, the aspect of the test stimulus

controlling responding differed among Ss.

The method used in Experiment II contained a procedure which may have contributed to the overall conflicting results. In order to insure some responding to the S- or S-'s, a relatively low criterion of .80 DR was established. To permit a situation in which typical incremental gradients were possible it was necessary to stop the discrimination learning before responding to the S- extinguished altogether. Consequently, the amount of stimulus control (by either stimulus) was less than might otherwise have been obtained if the criterion had been higher. In other words, a reliable discrimination had not yet been established when the testing procedure were initiated. This is most likely the reason why even the response rates to the novel stimulus were more variable compared to those data from Experiment I. It was this procedure which diminished the very aspect of performance being measured, stimulus control. Provisions for obtaining critical measures of the source of stimulus control militated against any substantial amount of stimulus control.

Hearst, Besley, and Farthing (1970) have suggested a procedure which may avoid such a dilemma. Instead of testing responding to the various values of the testing dimension under extinction conditions, they proposed that a sensitive measure of stimulus control may be obtained by reinforcing responding in the presence of all the test values and thereby measuring the resistance to reinforcement. If some stimulus

values along the S- dimension are more inhibitory than other values, then they should be less susceptible to the effects of reinforcement. They trained a discrimination between a blank key (S+) and a thin black line bisecting the blank key (S-) to a criterion of approximately a DR of .96. Various degrees of line tilt were tested for their resistance to reinforcement yielding typical incremental S- gradients with the added feature that absolute responding was elevated to rates commonly found in excitatory gradients obtained by the resistance to extinction method.

Such a procedure would appear to avoid the predicament that existed in Experiment II and perhaps would yield data of suitable consistency to test the hypothesis that rates of responding to a novel stimulus may indeed be an indicant of the source of stimulus control compatible with the accepted measures.

The problems with the objects themselves cannot be remedied as easily. Touchette's experiment demonstrated that simple line-tilts are not so simple and both a logical extension as well as an empirical extension (based on the difference between the gradients obtained by testing B and C) would be to assume that three-dimensional objects are not so simple either. Until more is known about complex stimuli and the methods by which orthogonality may be demonstrated, a more profitable route of investigation would appear to be one in which simpler stimuli are used, e.g., wavelength vs.

line-tilt (although Hearst et. al., 1970, have raised questions of orthogonality between these stimuli). The difficulty with these two stimuli is, of course, finding the third orthogonal stimulus to serve as a probe stimulus.

The results of the novel stimulus data from Experiments I and II are the post-discrimination gradients normally obtained (Terrace, 1966a) appear to be conflicting with regard to the rule best describing what is learned as a simple operant learning task. The novel stimulus data from Group I might suggest that the animal has learned Jenkins' Rule 2 (do not respond if S-; otherwise respond) and the data from Group II suggest Rule 1 (respond if S+; otherwise do not respond). On the other hand, the post-discrimination generalization gradients typically suggest Rule 3 (Respond if S+ and do not respond if S-).

Although rate of response to a novel stimulus has not yet been sufficiently demonstrated to be a measure of the source of stimulus control, the results of this study raise the possibility that a post-discrimination gradient may not be an accurate measure of which stimulus controls responding. If, for example, the subject responds equally to the S+ and the novel stimulus, control over responding cannot be exclusively from the S+ (provided that the two stimuli are orthogonal) even if a sharp S+ gradient is obtained by varying some characteristic of the S+. Conversely, if a subject responds equally to the S- and the novel stimulus control cannot be exclusively

from the S- even if a flat S+ gradient and incremental S- gradient is obtained.

No data from the present study provided a clear instance of such conflict although #73 yielded a high rate to the novel stimulus in addition to a relatively steep S+ gradient. A low rate to the novel stimulus and an incremental S- gradient (from one of the S-'s) were obtained from #75. As mentioned before, however, it is impossible to state unequivocally that either measure accurately assesses the source of stimulus control due to the nature of the complex stimulus.

On a conceptual level, the conflict does raise a question of the accuracy of post-discrimination generalization gradients. Wilton and Godbout (1970) have discussed the ambiguity in obtaining flat generalization gradients and they are skeptical about the utility of such tests for discovering the appropriate rule best describing performance in a simple discrimination learning task. They suggest that the major contribution of such tests may be in measuring whether or not a particular characteristic of the stimulus is controlling the response.

Farthing and Hearst (1968) suggested that 'stimulus control' is, at best, an ambiguous term which has been used to assess (1) excitatory or inhibitory control (the presence of the stimulus either increases or decreases operant behavior) or (2) excitatory or inhibitory dimensional control

(differential responding to the values of one specific characteristic). Perhaps if such a distinction is maintained, many of the conflicts presented in the introduction will be more apparent than real.

In answer to the question of what is learned in a "simple" operant discrimination learning task, Weisman (1969) has indicated that no one of the three rules may apply to all situations. He proposed that there may be certain instances in which Rule #1 (S+ control only) does apply, e.g., Terrace's errorless discrimination procedure and a situation developed by Weisman in which one stimulus (S+) is correlated with a richer schedule of reinforcement relative to the schedule correlated with another stimulus (S"-"). That is, following training on a MULT VI 5 VI 5, a shift to a MULT VI 1 VI 5 does not result in S- control by the stimulus correlated with a VI 5 as indicated by a flat generalization gradient. The reverse (MULT VI 1 VI 1 shifted to MULT VI 1 VI 5) does appear to establish the stimulus correlated with VI 5 as the controlling stimulus evidenced by the incremental gradient. Weisman suggests that this latter situation is best described by Jenkins' Rule #3 (both S+ and S- control) although the S+ control was not specifically tested.

Thus which of the three rules best describes what is learned in a simple discrimination task using complex three-dimensional stimuli is not yet determined. It is probable, however, that which rule does apply depends upon

the conditions of training. One important condition might be the number of S-'s or for that matter, S+'s used in training and one important measure of what is learned might well be the rate of response to a novel stimulus. Until the difficult problem of orthogonality is solved, these hypotheses remain untested.

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APPENDIX A

Absolute Rates of Responding Obtained during Day in which Novel Stimulus was Presented

Experiment I:

Group	S	Responses per Minute						
		S+	Novel	S- B	S- C	S- D	S- E	S- F
I	2	180.9	207.2	2.5				
	10	37.2	41.2	0.7				
II	1	105.1	22.0	7.8	7.6	9.8		
	4	165.1	95.2	12.6	3.4	4.2		
III	5	123.9	2.8	3.7	7.0	8.3	1.3	7.3
	8	145.7	24.8	14.3	6.7	3.7	21.0	28.3

Experiment II:

Group	S	Responses per Minute						
		S+	Novel	S- B	S- C	S- A	S- E	S- F
I	52	105.1	42.8	37.1				
	71	82.0	89.2	10.5				
	74	145.5	72.0	7.3				
	78	74.9	47.2	7.7				
II	72	168.8	109.6	40.0	13.6	31.6		
	73	130.6	104.4	2.8	8.6	19.8		
	75	64.9	1.6	3.0	1.6	7.6		
	77	58.9	25.2	2.0	1.8	12.2		
III	76	156.1	40.4	12.4	24.0	119.7	49.0	30.3
	79	96.2	42.0	32.0	16.3	79.3	9.6	63.7
	80	142.9	127.6	3.0	35.7	115.0	41.7	58.0
	81	46.7	6.4	0.0	3.0	4.0	5.7	1.7

APPENDIX B

Number of Exposures per Stimulus during Training

Experiment I: Criterion = 15 days training

Group	<u>S</u>	Days to Criterion	Number 30 sec Exposures/ Stimulus	
			S+	Each S-
I	22	15	450	450 (1 S-)
	10	15	450	450 "
II	1	15	450	150 (3 S-'s)
	4	15	450	150 "
III	5	15	450	75 (5 S-'s)
	8	15	450	75 "

Experiment II: Criterion = .80 Discrimination Ratio

Group	<u>S</u>	Days to Criterion	Number 30 sec Exposures/ Stimulus	
			S+	Each S-
I	52	5	150	150 (1 S-)
	71	4	120	120 "
	74	2	60	60 "
	78	4	120	120 "
II	72	3	90	30 (3 S-'s)
	73	5	150	50 "
	75	7	210	70 "
	77	4	120	40 "
III	76	19	570	114 (5 S-'s)
	79	5	150	30 "
	80	9	270	54 "
	81	11	330	66 "