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AN INVESTIGATION OF THE FIVE-TERM CONTINGENCY AND THE CONDITIONAL CONTROL OF EQUIVALENCE RELATIONS

by

Richard W. Serna

A dissertation submitted in partial fulfillment
of the requirements for the degree

of

DOCTOR OF PHILOSOPHY

in

Psychology

UTAH STATE UNIVERSITY
Logan, Utah

1987

DEDICATION

This dissertation is dedicated to my father.

ACKNOWLEDGEMENTS

I wish to acknowledge and to express my thanks to all those who provided support and encouragement of this dissertation and the completion of my graduate training. In particular, I wish to thank my dissertation chairman and mentor, Dr. J. Grayson Osborne for his insightful ideas, his enthusiasm, and his high standards of excellence. I also wish to thank the members of my committee , Dr. Richard West, Dr. Charles Salzberg, Dr. Edward K Crossman, and Dr. Carl Cheney for their contributions. I also wish to express my thanks to Dr. Joseph Parsons who gave me encouragement and confidence as an undergraduate.

I would also like to express my deep appreciation to all those who provided secretarial and technical assistance. Chief among them, every individual connected with Systems Impact, Inc. and the Artificial Intelligence Research and Development Unit. Also, I would like to express my appreciation to Kristin E. Lennox for her excellent proofreading skills.

My deepest appreciation goes out to my wife Barbara and my daughter Wray for their constant support of my efforts toward completion of the dissertation and the PhD. To my mother, Barbara Wray Serna, and my father, the late E. C. "Dave" Serna, to whom this dissertation is dedicated, I wish to thank for providing the drive to achieve great things in life.

Richard W. Serna

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ABSTRACT

An Investigation of the Five-Term Contingency and the Conditional Control of Equivalence Relations

by

Richard W. Serna, Doctor of Philosophy

Utah State University, 1987

Major Professor: J. Grayson Osborne
Department: Psychology

In recent years, there has been an increasing interest in the study of human operant behavior. One area of study reflecting this interest is the study of the formation of equivalent classes of stimuli by human subjects. The focus of the present research was the study of the conditions under which classes of equivalent stimuli can be inferred to be under conditional control.

In Experiment 1-A, three college students were trained to respond to a balanced five-term contingency via a visual-visual simultaneous matching-to-sample task with two choices of comparison stimuli. Probe tests showed that subjects' behavior could be described as being controlled by positive and negative stimulus relations. When the second-order stimulus was removed during subsequent probes, none of the three subjects demonstrated strong correct responses to the four-term

unit relations. Also, none of the three subjects demonstrated the expected transitive relations when the second-order (five-term) stimulus was removed. In Experiment 1-B--with the same three subjects--explicit training of the four-term unit relations showed the expected transitive relations in the absence of the second-order stimulus.

In Experiments 2 through 5--using a matching-to-sample task similar to that used in Experiments 1-A and 1-B--five subjects were trained to respond to comparison stimuli C and E in the presence of sample A and second-order stimulus X and to comparison stimuli B and F in the presence of sample D and second-order stimulus X. Likewise, the subjects were trained to respond to comparison stimuli B and F in the presence of sample A and second-order stimulus Y and to comparison stimuli C and E in the presence of sample D and second-order stimulus Y. Probe tests for transitive relations showed that four of the five subjects eventually demonstrated four three-member classes of equivalent stimuli that functioned separately under the control of the second-order stimuli. The four subjects demonstrating the classes of equivalent stimuli either a) demonstrated the transitive relations immediately or b) demonstrated the transitive relations after explict retraining of the underlying four-term unit relations.

The results of all experiments together indicated that the composition of classes of equivalent stimuli can be conditionally controlled by either a) removing the second-order stimulus or b) training subjects to respond to classes of equivalent stimuli under the control of other explicit visual second-order stimuli. The results are discussed in terms of verbal behavior, emergent behavior, and conceptual development.

(236 pages)

INTRODUCTION

In recent years, the field of the experimental analysis of behavior has seen an increasing interest in the analysis of human behavior. This interest coincides with the current dominance of cognitive-related areas within the scientific study of psychology. Within the experimental analysis of human behavior, a number of research issues such as rule-governed behavior, self-control, instructional control, and stimulus equivalence are receiving increased attention. Each of these areas involves the study of phenomena that relate primarily to human behavior. Particularly in studies investigating stimulus equivalence phenomena, the focus has been on aspects of human behavior traditionally studied as language and cognitive behavior. Nevertheless, while the focus may be on behavior traditionally studied within the realm of non-behavioral psychology, the theoretical and conceptual view of such phenomena remains solidly grounded in the experimental analysis of behavior. The focus of the present research is the study of stimulus equivalence relations in humans.

In studying stimulus equivalence, operant researchers have relied primarily on the use of match-to-sample procedures. On a typical match-to-sample trial, a subject is presented with a sample stimulus and two or more comparison stimuli. The subject's task is to "match" by choosing the correct comparison stimulus in the presence of a given sample. A correct choice is followed by some form of reinforcement while an incorrect choice is not followed by reinforcement. In this manner, a number of different stimulus-stimulus relations have been taught between the sample stimulus and the correct comparison stimulus. Using the above procedures, relations can be formed between sets of stimuli such that two sets, A and B, are matched to each other while sets A and C are also matched. Tests for transitivity have been conducted (cf. Sidman, 1971) in which C and B stimuli are found to be related without direct training through the common relation with A stimuli. If reflexivity (matching a stimulus to itself) and symmetry (interchangability of sample and comparison) can also be shown in addition to transitivity, then a class of equivalent stimuli has formed.

Sidman (1971) used the above procedure with a mentally retarded subject to test for the emergence of untrained relations between pictures of various objects (B stimuli) and corresponding printed picture names (C stimuli) given their common training to dictated object names (A stimuli). The result was twenty, three-member classes of stimuli. Sidman (1971) discussed the results of his study in terms of elementary reading comprehension. Using stimulus equivalence training procedures, a number of other investigators have demonstrated the emergence of untrained relations between stimuli (Devany, Hayes, & Nelson, 1986; Dixon, 1978; Dixon & Spradlin, 1976; Fucini, 1982; Gast, VanBiervliet, & Spradlin, 1979; Green, 1985; Lazar, Davis-Lang, & Sanchez, 1984; Lazar & Kotlarchyk, in press; McDonagh, McIlvane, & Stoddard, 1984; Sidman, Cresson, & Willson-Morris, 1974; Sidman & Cresson, 1973; Sidman & Tailby, 1982; Sidman, Kirk, & Willson-Morris, 1985; Spradlin, Cotter, & Baxley, 1973; Spradlin & Dixon, 1976; Stromer & Osborne, 1982; VanBiervliet, 1977; Wetherby, Karlan, & Spradlin, 1983)

Several investigators (e.g., Spradlin & VanBiervliet, 1980; Sidman, 1986; Wetherby, 1983; Wetherby et al., 1983) have suggested that many human behaviors traditionally referred to as "cognitive"--such as linguistic and conceptual behavior--should be studied using stimulus equivalence procedures. The logic behind this suggestion is that stimulus equivalence classes can be viewed as the demonstration of conceptual behavior: a concept has been formed that includes, for example, the three stimuli demonstrated in one of the classes formed in Sidman (1971). A subject who demonstrates stimulus equivalence between the dictated name "dog", a picture of a dog, and the printed word, D-O-G, could be said to "understand the meaning of" or be demonstrating an "understanding of the concept of" dog. If additional stimuli are added to the three-member class (cf. Sidman & Tailby, 1982), the concept can be said to have been broadened. Humans emit such behavior that is described as linguistic or conceptual. It seems logical that such behavior is potentially under the control of factors that lead to stimulus equivalence. The variables that are responsible for language and conceptual development will likely be found through a determination of the conditions that aid and restrict the development of stimulus equivalence relations (Wetherby, 1983). To a large, though by no means complete, extent, the numerous studies that have investigated stimulus equivalence have successfully investigated such conditions.

While the notion of the class of equivalent stimuli as a concept has proven useful, it is not sufficient in an analysis of complex linguistic and conceptual behavior. For humans, the composition of equivalence classes does not remain the same in all contexts of usage. Using an example from Fucini (1982), the substance mercury can be classified (can be in a relation with) lead and gold. These three substances can be viewed as a class of equivalent stimuli of three members. If a single term was used to describe the "concept" it would be metal. However, mercury can also be classified as a liquid; as such, it is in an equivalence relation with other liquids. While mercury, in this case, can be a member of both classes, it does not follow that another member of the liquid class would be in a relation with another member of the metal class of stimuli. With which class of stimuli mercury will be classified depends on the context in which the stimulus mercury is presented. If it is presented in the context of liquid, then it is classified as such. If it is presented in the context of metals, then it is classified as a metal. The composition of the class of equivalent stimuli is conditional upon contextual cues. Contextual cues might include: (a) the presence of certain members of a given class; (b) explicit single stimuli such as the words, "metal" versus "liquid"; or (c) the presence versus absence of conditional cues.

The conditions that are necessary for the conditional control of equivalence relations are poorly understood (Green, 1985). Only a few such studies have been reported (Fucini, 1982; Lazar & Kotlarchyk, in press). What is necessary is an examination of the conditions that lead to the conditional control of equivalence relations. An operant analysis of such conditions using the methodology of investigations of equivalence relations should be used.

Recall that the procedures used to form classes of equivalent stimuli made use of the conditional discrimination in a match-to-sample task. As noted earlier, the composition of classes of equivalent stimuli is potentially under the control of contextual or conditional cues. Logically, a demonstration of the conditional control of equivalence relations must involve the conditional control of the conditional discrimination. Sidman (1986) discussed how the conditional control of conditional discriminations should be conceptualized. In this conception, just as the three-term contingency is controlled by a fourth term to form a conditional discrimination, so is the four-term contingency controlled by the fifth term (called the second-order stimulus). Thus, Sidman (1986) provided the conceptual tools with which the conditional control of equivalence relations can be studied. However, only a few studies (Nevin & Liebold, 1966; Santi, 1978, 1982) have been conducted that fit the conceptualization of the five-term contingency as noted by Sidman (1986). These studies demonstrated second-order control of identity versus oddity matching. No study has investigated the five-term contingency in an arbitrary matching task.

STATEMENT OF THE PROBLEM

The formation of classes of equivalent stimuli has been demonstrated in numerous studies (Devany, et al., 1986; Dixon, 1978; Dixon & Spradlin, 1976; Fucini, 1982; Gast, et al., 1979; Green, 1985; Lazar, et al., 1984; Lazar & Kotlarchyk, in press; McDonagh, et al., 1984; Sidman, et al., 1974; Sidman & Cresson, 1973; Sidman & Tailby, 1982; Sidman, et al., 1985; Spradlin, et al., 1973; Spradlin & Dixon, 1976; Stromer & Osborne, 1982; VanBiervliet, 1977; Wetherby, et al., 1983). In addition, it has been suggested that behaviors traditionally viewed as linguistic and cognitive (such as conceptual behavior) can be studied in of stimulus equivalence (Spradlin & VanBiervliet, 1980; Sidman, 1986; Wetherby, 1983; Wetherby et al., 1983).

The problem is that while the notion of the stimulus equivalence class as a concept is useful, it is not sufficient for a study of complex linguistic or conceptual behavior. What is needed is an investigation of the control of equivalence relations by other, second-order stimuli. Only a few such studies (Fucini, 1982; Lazar & Kotlarchyk, in press) have been conducted. The basic paradigm for the study of the conditional control of equivalence relations was provided by Sidman (1986). While second-order control of conditional discriminations has been demonstrated in identity and oddity matching (Nevin & Liebold, 1966; Santi, 1978, 1982), the five-term contingency, as conceptualized by Sidman (1986) in an arbitrary match-to-sample task has not been investigated.

The present research investigated the five-term contingency and conditional control of equivalence relations by explicit second-order stimuli. In the first experiment, college students were reinforced for responding to correct choices in a five-term contingency task. When the task was learned, tests were conducted to: (a) determine whether an inference of positive and negative stimulus relations could be made in the presence of the second-order stimulus (cf. Stromer & Osborne, 1982); (b) determine the effect of removing the second-order stimulus; and (c) determine whether the presence or absence of the second-order stimulus controlled equivalence relations. In Experiments 2, 3, 4, and 5, new subjects were trained to match sets of two stimuli to the same stimulus set (e.g., A to B and A to C) with the composition of each set dependent upon the presence of a specific second-order (contextual) stimulus. Tests were conducted to: (a) determine if transitive relations were present between pairs of stimuli not explicitly trained; and (b) whether the transitive relations were exclusive to classes of equivalent stimuli under the separate control of second-order stimuli, even when the classes had stimuli in common. Where subjects failed to demonstrate appropriate transitive relations, functional analyses were conducted to determine conditions that would lead to appropriate transitive responding.

In short, it was the purpose of the present research to investigate the controlling relations in conditional discriminations under conditional control.

REVIEW OF THE LITERATURE

The Five-Term Contingency

Consider the basic unit of analysis for modern behavior analysis, the two-term reinforcement contingency (Skinner, 1938). If, for example, a laboratory rat presses a lever, it immediately is presented with food. What makes this a contingency is that the food is not presented if the rat does anything else. Within the limits of the deprivation state of the rat, the consequence (food) will affect the future likelihood of the behavior (pressing the lever).

One of the major goals of behavior analysis is the control of behavior (Skinner, 1938). In order to control behavior, more is needed than simply the response-consequence relation described above. To accomplish this, the response-consequence relation can be placed under discriminative control. For example, in the presence of a red light, a response to the lever by the laboratory rat leads to food, and, just as important to the process of establishing discriminative control, in the presence of a green light, a response to the lever does not lead to food. The red light does not elicit the response; rather it activates the response-consequence (lever-food) relation. Thus, the probability of the occurrence of the two-term, response-consequence relation is selectively altered by the

<u>discrimination training</u> just described. The red light becomes the third term in a three-term contingency and as such is a part of the unit of analysis. This, the three-term contingency, is noted as the fundamental unit of stimulus control (Skinner, 1938).

Beyond the analytic level of the three-term contingency, Sidman (1986) has conceptualized a hierarchy of controlling relations which specify different levels of conditional stimulus control. For example, the three-term contingency itself can be placed under discriminative control. Using the same logic as in the expansion of the two-term contingency to the three-term contingency, Sidman (1986) refers to the three-term contingency under discriminative control as a four-term contingency. As shown in Table 1, the three-term stimulus, S1, activates the two-term contingency, response-consequence relation, but, only in the presence of the fourth term stimulus, S3. Also, S2 activates the two-term contingency, but only in the presence of S4.

In practice, the four-term contingency describes the <u>conditional discrimination</u>, a representative example being the match-to-sample task (cf. Cumming & Berryman, 1965). In the match-to-sample task, a subject is first presented with a sample stimulus to which, in whatever manner the contingency specifies, the subject must respond. Then, two or more comparison stimuli are

Table 1*

A Balanced Four-Term Contingency (Conditional Discrimination)

Four-Term Stimulus	Three-Term Stimulus		Response		Consequence
S3 -------	S1	---------	R	--------->	SR+
	S2	---------	R	----/---->	SR+
S4 -------	S1	---------	R	----/---->	SR+
	S2	---------	R	--------->	SR+

Note. *Adapted from Sidman (1986)

presented and the subject responds to one in order to obtain the reinforcer. Which choice is correct depends upon which sample is present. Such a procedure is widely used in the study of the conditional discrimination (Cumming & Berryman, 1965).

The hierarchy of conditional control progresses with what Sidman (1986) refers to as the five-term contingency. At that level, the conditional control by a fifth-term stimulus is exerted over the entire four-term contingency. Thus, conditional discriminations themselves are under the conditional control of different stimuli. For example, as shown in the uppermost path of Table 2, the activation of the two-term contingency, in the presence of the third term stimulus, S1, will only be activated in the presence of the fourth-term stimulus, S3. Yet, this four-term contingency itself can only be activated in the presence of the fifth-term stimulus, S5. (Whether the four-term contingency remains "intact" in the absence of the fifth-term stimulus is an empirical question and a focus of the present research. As such, it will be discussed in greater detail later.) As is the case with the three- and four-term contingencies, a second case of the five-term contingency leading to reinforcement must be present in order to make the contingency conditional: hence the presence of S6 in Table 2. The five-term contingency is referred to as the unit of <u>second-order</u>

Table 2*

The Five-Term Contingency

Five-Term Stimulus	Four-Term Stimulus	Three-Term Stimulus	Response	Consequence
		S1 ---------	R	---------> SR+
	S3 -------			
		S2 ---------	R	----/----> SR+
S5 -----				
		S1 ---------	R	----/----> SR+
	S4 -------			
		S2 ---------	R	---------> SR+
		S1 ---------	R	----/----> SR+
	S3 -------			
		S2 ---------	R	---------> SR+
S6 -----				
		S1 ---------	R	---------> SR+
	S4 -------			
		S2 ---------	R	----/----> SR+

Note. *Adapted from Sidman (1986)

conditional control (Sidman, 1986). The fifth-term stimulus, then, is the second-order stimulus.

Although a large number of studies have investigated four-term contingency relations, only a few studies (Fucini, 1982; Lazar & Kotlarchyk, in press; Nevin & Liebold, 1966; Santi, 1978; 1982) have investigated five-term contingencies, and then not in arbitrary matching to sample.

Within research investigating stimulus control factors in the four-term contingency, two major areas of focus are relevant to the present research: (a) controlling relations between stimuli; and (b) stimulus equivalence. The study of controlling relations involves ascertaining whether a relation between the sample and the correct comparison or a relation between the sample and the incorrect comparison or both is responsible for subjects' performances in a match-to-sample task. Stimulus equivalence refers to the functional equivalence between members of a class of stimuli as evidenced, in part, when sample stimuli become equivalent to their corresponding comparison stimuli. If they are equivalent, then the defining properties of equivalence--reflexivity, symmetry, and transitivity--will be evident (these properties are defined below).

Controlling Relations Within the Four-Term Contingency

One focus within the study of conditional discriminations at the four-term contingency level has been to ascertain the sample-comparison relations that control responding in a match-to-sample task. Two relations that have been identified are the positive relation between samples and correct comparisons and the negative relation between samples and incorrect comparisons (Berryman, Cumming, Cohen, & Johnson, 1965; Dixon & Dixon, 1978; Stromer & Osborne, 1982). The positive relation describes the situation in which the sample acts as a cue for which one of the (several) comparisons is the correct choice. Under the negative relation, the sample acts as a cue for which comparison not to select. Whether one or both of these relations or "rules" controls responding has been the focus of some investigation.

Berryman et al. (1965) trained pigeons to select the nonmatching comparison hue in a conditional discrimination where, of the two comparisons, one was identical to the sample and the other was different. After 20 sessions of this training, a novel color was substituted for the correct choice, i.e., the nonmatching hue. If the sample was instructing which comparison not to select (negative relation), then responding should not have been disrupted with this change. If the sample was instructing only which comparison was the correct choice (positive relation), then responding would be incorrect. The results, which showed reduced correct responding, suggested that the sample functioned to instruct which comparison was correct and not to instruct which comparison was incorrect.

While only the positive relation was evident in the results of Berryman et al. (1965), Dixon and Dixon (1978) sought to discover the negative relation in the control of conditional behavior of young children. In their first match-to-sample experiment, six preschool children were trained to choose one of two comparison stimuli that was identical in shape to the sample stimulus. After subjects met a criterion of 100% correct responding for one session, the schedule of reinforcement (correct feedback) was reduced to 33% of correct trials until subjects met a criterion of 100% correct responding for two consecutive sessions. During one test session, eight probes were randomly interspersed among the training trials. The probe trials contained a novel stimulus that was substituted for the correct (identically matching) comparison. If the subjects had learned during training which of the comparisons not to respond to (the negative relation between sample and comparisons), then they should have demonstrated a high percentage of responding to the novel stimulus. For five of the six subjects, this was the result indicating the presence of a negative controlling relation between the sample and the incorrect comparison). However, Dixon and Dixon (1978) noted a potential confound between the presumed negative relation and the mere novelty of the substitute stimulus. Thus, in the second experiment, three preschool children were given identity matching training with additional stimuli. These additional stimuli were subsequently used as substitute stimuli. In this way, the substitute stimuli were not novel as in the first experiment. This controlled for the possibility that the subjects in the first experiment responded on the basis of stimulus novelty and not according to a relation between the sample and the incorrect comparison. The results were the same as in the first experiment: high rates of responding to the substitute stimuli. Thus, evidence for the existence of a relation between samples and incorrect comparisons was demonstrated for children.

While Berryman et al. (1965) showed only a positive relation controlling the responding of pigeons, and Dixon and Dixon (1978) demonstrated the negative relation with young humans, Stromer and Osborne (1982) sought to demonstrate both the positive and negative controlling relations at the same time in an arbitrary match-to-sample task with developmentally delayed adolescents. In arbitrary match-to-sample, subjects are taught to respond to an arbitrarily designated comparison stimulus in the presence of a sample which is not physically identical (Cumming & Berryman, 1965).

In a two-choice task, Stromer and Osborne (1982) first taught subjects to select comparison B1 in the presence of sample A1 and to select B2 in the presence of A2. After subjects met a criterion of 95% correct responding under continuous reinforcement (correct feedback) conditions, the condition was changed such that reinforcement occurred on only 33% of the trials. Then, various testing conditions were introduced. First, a test for symmetry of the sample and correct comparison was run in which unreinforced probes with the sample and correct comparison reversed were inserted into a baseline of training trials. Appropriate matching occurred to the probes. Next, a test for control by the sample--S+ (positive) relation was run. This consisted of probes containing the sample, the correct comparison, and a novel stimulus which had previously been determined to be most preferred against another novel stimulus in the presence of a sample. Control of the subjects' comparison selections by the positive relation would be demonstrated if the subject continued to respond to the correct comparison with a novel comparison substituted for the incorrect comparison. (It is important to note that the use of a "most-preferred" novel stimulus as the incorrect comparison might actually bias responding away from the appropriate choice.) In addition, similar probes were inserted which tested the positive relation with the symmetrical sample-comparison relation. The results showed that virtually all responding occurred to the appropriate correct comparison. This suggested that the positive relation was in effect.

Next, a test for control by the sample and S- (negative) relation was introduced. The probes for this test consisted of the sample, the incorrect comparison, and a novel stimulus which was previously determined to be the "least-preferred" in the presence of the sample. In this test, control of the subjects' choices by the negative relation would be demonstrated if the subjects responded to the novel comparison (away from the familiar incorrect comparison). The use of the least preferred novel stimulus in place of the correct comparison should bias responding away from that stimulus. The results showed that all subjects responded to the novel comparisons instead of the incorrect comparison stimulus. This suggested that the negative relation was controlling responding on these probes.

In sum, within the four-term conditional discrimination, positive and negative sample-comparison relations have been a focus of research using match-to-sample procedures. Berryman et al. (1965) did not find evidence of the negative relation using pigeons as subjects. This is consistent with other studies using pigeons which suggest that the sample instructs only which comparison is correct and not which is incorrect (Cumming & Berryman, 1965; Farthing & Opuda, 1974; Urcuioli & Nevin, 1975). With human subjects, however, responding seems to be a function of both positive and negative sample-comparison relations (Dixon & Dixon, 1978; Stromer & Osborne, 1982).

Stimulus Equivalence Relations in the Four-Term Contingency

Another area of study within the four-term conditional discrimination involves training subjects to demonstrate classes of equivalent stimuli. In order to demonstrate that the stimuli in a class are equivalent, training and testing must be arranged such that the controlling relations of reflexivity, symmetry, and transitivity are demonstrated (see Table 3) (Sidman et al., 1982; Sidman & Tailby, 1982). For example, reflexivity can be demonstrated only if the subject can match new stimuli to themselves without differential reinforcement or instructions, i.e., generalized identity matching. Symmetry requires that the subject

Table 3

*The Equivalence Relation**

Equivalence Relation Properties		
Number	Property	Expression
1.	Reflexive	aRa
2.	Symmetric	if aRb, then bRa
3.	Transitive	if aRb and bRc, then aRc

Note. *R=relation. Throughout, discussion is of the equivalence relation in particular.

show functional reversibility of the sample and correct comparison. If, for example, the subject was taught to match A to B then the subject must be able to demonstrate matching of B to A without instruction or differential reinforcement. Finally, if subjects are taught to match A to B and B to C, a transitive relation is demonstrated if C is chosen in the presence of A without instruction or differential reinforcement. Each of the foregoing relations is necessary to fulfill the requirement that the stimuli are related by equivalence.

Sidman (1971) conducted the first study that showed the emergence of untrained behavior using an auditory-visual matching-to-sample task. Figure 1 shows a schematic representation of the basic equivalence paradigm. The subject, a retarded adolescent boy, entered the experimental situation able to select 20 pictures conditionally given each of 20 corresponding dictated picture names. This is represented by the line labelled AB in Figure 1. The subject was then taught to select 20 printed names conditionally given each of the 20 dictated picture names (AC in Figure 1). Given the training of AB and AC the subject was then able to match the pictures to their appropriate printed picture names (BC) and the printed names to the pictures (CB) in probe tests for transitivity. The transitive relation is termed emergent or derived because it has not been

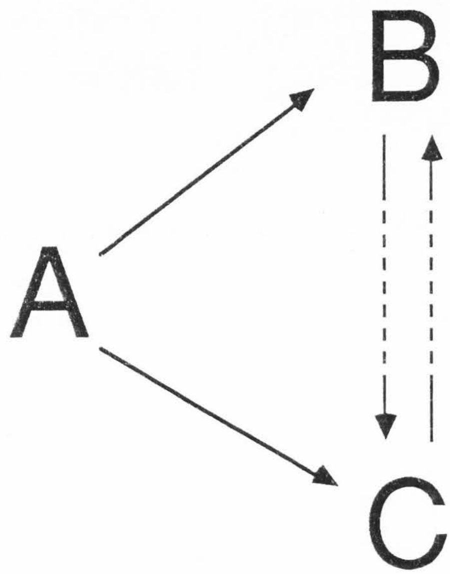


Figure 1. Basic stimulus equivalence paradigm. Trained relations (solid lines) and untrained relations (dashed lines) are shown between different stimuli.

taught directly. The training in Sidman (1971) resulted in the formation of 20 three-member classes of equivalent stimuli. This study was replicated by Sidman and Cresson (1973) with two severely retarded boys.

The study by Sidman (1971) demonstrated 20 separate classes of equivalent stimuli. As shown by the broken arrows in Figure 1, tests were conducted for both CB and BC. This constituted a combined test for symmetry and transitivity since the CB relation was tested in reverse (BC) and both represented tests for the unlearned transitive relation resulting from AB and AC training. A number of studies investigating stimulus equivalence using Sidman's (1971) basic equivalence paridigm have since been conducted. For example, Sidman and Cresson (1973) trained auditory-visual matching with two severely retarded subjects. Unlike Sidman (1971) where AB and AC training was followed by BC and CB tests for transitivity (see Figure 1), Sidman and Cresson (1973) first trained the AB and BC relations. The remaining relations did not emerge with only AB training but did emerge with BC training. This demonstrated the necessity of training two of the three possible relations before an equivalent class of stimuli will emerge.

One notable feature of the above studies was that each achieved equivalence classes using auditory and visual stimuli. A number of other studies (Dixon, 1978;

Dixon & Spradlin, 1976; Sidman, Kirk, & Willson-Morris, 1985; Sidman & Tailby, 1982; Spradlin & Dixon, 1976) have trained equivalence classes using auditory-visual matching. Would conditional discrimination training result in equivalence classes if all stimuli used were visual? Spradlin, Cotter, and Baxley (1973) trained mentally retarded adolescents to match nonidentical forms. Using only these visual stimuli, untrained relations emerged. In the second experiment of Stromer and Osborne (1982) (discussed earlier), mentally retarded subjects were trained on two conditional relations. Each of the two relations trained contained one element in common with the other. Probes for transitivity showed most of the subjects demonstrated the emergent relations.

A number of studies have investigated methods of expanding stimulus classes through transitive relations. For example, Sidman and Tailby (1982) trained normal children to select three Greek letters from Set B and three Greek letters from Set C conditionally given three dictated names in Set A. Given this training, a transitive relation between the B and C stimuli and three equivalent classes of ABC stimuli would be possible. In addition, the subjects were trained to select three Greek letters in Set C conditionally given a fourth set of Greek letters, Set D. The question was whether the stimuli in the fourth set, D, would become incorporated into the ABC class of stimuli as a result of conditional discrimination training to C. This was confirmed by the subjects' performances on probes for the remaining relations: three, 4-member classes of stimuli (ABCD) were formed.

Also with children, but using all visual stimuli (Greek and Hebrew letters), Lazar, Davis-Lang, and Sanchez (1984) initially trained AD and DC relations. Testing for the untrained AC and CA relations established a three-member class of stimuli (ADC). As in Sidman and Tailby (1982), a fourth set of stimuli (E) was added by training the ED relation. This training established the ACDE class of equivalent stimuli. Finally, a fifth set of stimuli (B) was added by training the CB relation. Tests for the remaining transitive and symmetric relations showed that the training was successful for two of the subjects. With additional training and tests, two other children eventually demonstrated the remaining relations. This study demonstrated that training four relations resulted in the emergence of twelve symmetric and transitive relations.

With this type of conditional discrimination training, the classes could theoretically be expanded to _n_ equivalent stimuli. Logically, as class size increases, there is a geometrical increase in the number of possible emergent relations (Fields, Verhave, & Fath, 1984). This increase was demonstrated with addition of a fourth member of the class (Lazar et al. 1984; Sidman & Tailby, 1982) and the fifth member of the class (Lazar et al., 1984).

Another approach to expanding classes with emergent relations was demonstrated in a study by Sidman, et al., (1985) (see Figure 2). Using three sets of stimuli, A (spoken names), B (upper-case Greek symbols), and C (lower-case Greek symbols) with three stimuli per set, Sidman et al. (1985) first trained AB and AC matching with normal children and adults. If the relations among these stimuli were equivalent, then three, 3-member classes, ABC, would be demonstrated. The subjects did in fact demonstrate such relations. Subsequently, with three different sets of stimuli, D (spoken names), E (upper-case Greek symbols), and F (lower-case Greek symbols), Sidman et al. (1985) trained DE and DF relations with the same subjects. This established a second group of three, 3-member classes of stimuli, DEF. Could the two classes of stimuli, ABC and DEF be combined into a single, 6-member class with minimal training? The procedure for accomplishing this was to train subjects to choose C stimuli conditionally upon the presence of E stimuli. The two groups of stimuli were successfully combined with this procedure for five

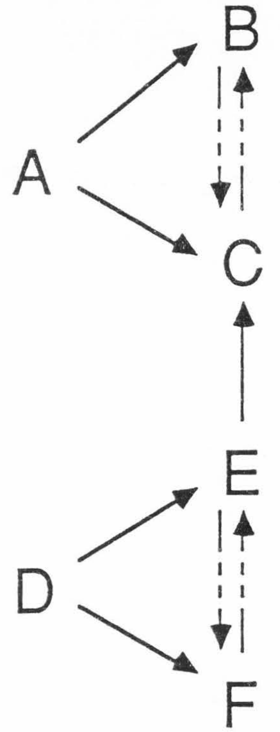


Figure 2. Two three-member classes of equivalent stimuli linked in Sidman et al. (1985). Classes ABC and DEF were linked by training the relation EC to form one large class, ABCDEF. (Adapted from Sidman et al. 1985)

of eight subjects. Thus, two classes of three stimuli, ABC and DEF, became one class, ABCDEF, by "linking" the two classes through the conditional discrimination training of members from each class, C and E.

Summary. Within the level of the four-term contingency, the stimulus equivalence procedure has proven to be a powerful technique in the development of new controlling relations without explicit training. As shown, this procedure has been successfully used with retarded humans to teach rudimentary reading comprehension (Sidman, 1971; Sidman & Cresson, 1973; Sidman, Cresson, & Willson-Morris, 1974). Also, Sidman and Tailby (1982) and Lazar et al. (1984) and Sidman et al. (1985) demonstrated that stimulus equivalence procedures which expand the number of elements in a class produce many more relations than were explicitly taught. The stimulus equivalence procedure at the four-term contingency level has also been used to train a number of applied skills such as solving math problems and coin equivalences (e.g., Gast et al., 1979; McDonagh et al., 1984) as well as conceptual behavior in humans (Green, Serna, & Osborne, 1985; Spradlin & Dixon, 1976).

Second-Order Conditional Control

Recall that in the five-term contingency (the unit of second-order control) the four-term, conditional discrimination is itself under conditional, or second-order control. Only a few studies have demonstrated such control using second-order conditional discrimination procedures. Moreover, the procedures and goals of the studies have varied.

Santi (1978) taught pigeons to choose identical or nonidentical stimuli as a function of the presence of a second-order stimulus. Using different hues as stimuli, the subjects were required to respond to a sample key. This was followed by the presentation of identical and nonidentical hue stimuli on the comparison keys. Also, one of two line orientations was superimposed on each of the comparison keys. Depending on which line orientation was present, the subjects were required to choose either the identical or nonidentical hue comparison. The pigeons successfully learned this task in 80 to 90 sessions of 288 trials each. Thus, the four-term conditional discriminations of matching and nonmatching were under the second-order control of the line orientations. These findings were replicated in the first experiment of Santi (1982). Similar findings with identical and nonidentical stimuli have been demonstrated using the presence or absence of a yellow light (Nevin & Liebold, 1966).

While these studies represent a chain of responding procedurally consistent with the notion of the five-term contingency, it is not likely that the pigeons were demonstrating conditional control of "matching" or "oddity" relations. Though not an explicit part of the studies just reviewed, an important test would have been to determine if generalized "matching" or "oddity" occurred under the conditional control of a second-order stimulus. The likelihood is that this would not have occurred given the Berryman et al. (1965) demonstration that pigeons use only S+ rules. The demonstration of five-term contingencies--four-term units controlled conditionally by a second-order stimulus--has, to date, not been demonstrated in humans or with arbitrary match-to-sample procedures.

Given Sidman's (1986) notion of second-order conditional control over four-term contingencies, the question arises as to whether this type of conditional control can be exerted over equivalence relations. Only two studies have examined equivalence classes in conjunction with second-order conditional control (Fucini, 1982; Lazar & Kotlarchyk, in press). Lazar and Kotlarchyk (in press) established two classes of equivalent stimuli through a match-to-sample task. In Phase 1, subjects were taught to respond to four Greek letters given the presentation of a red hue. Subjects were also taught to respond to four different Greek letters given the presentation of a green hue. Phase 2 testing established the fact that two classes of five stimuli each (four Greek symbols and one hue in each class) were formed. In Phase 3, the subjects were trained to respond to the red and green stimuli in sequence, i.e., red then green, or green then red. Which sequence was correct depended on which of two tones was present. In Phase 4 testing, subjects were presented with a Greek letter from each of the two classes in the presence either Tone 1 or Tone 2. The results showed that the subjects responded to the Greek letters in the same sequence as the corresponding class-member hues depending on which tone was present. Lazar and Kotlarchyk (in press) described the untaught sequence behavior as being under second-order control.

Recall that in Sidman and Tailby (1982), 4-member classes (ABCD) were formed by training AB AC and CD. Viewing this class from a different perspective, it could be conceptualized as two classes, ABC and ACD, that have the stimuli A and C in common. In practice, as noted from the results of Sidman and Tailby (1982), ABC and ACD function as only one class. Given this perspective, Fucini (1982) posed the following questions: (1) Will two classes that have a <u>single</u> stimulus in common merge into one large class; and (2) are there procedures that would make the two classes of stimuli function separately, even if they have a stimulus in common? Using second-order conditional control procedures, Fucini (1982) was able to accomplish this.

In the first Experiment (see Figure 3), Fucini trained five children and one adult to respond to B1 and X1 given A1 (see upper set of classes in Figure 3). Correspondingly, they were trained to choose X4 and F4 given E4 (lower set of classes in Figure 3). X4 and X1 were the same stimulus. Thus, Fucini (1982) conceptualized this as two separate classes of stimuli containing one stimulus in common (X). She also trained subjects to respond to two classes of stimuli with no element in common (A2,B2,C2 and E3,D3,F3). The results from Sidman and Tailby (1982) would predict that the classes that had X in common would form a larger 6-member class and that the classes that had no stimuli in common would remain separate. The results showed this to be the case.

In the second experiment, second-order conditional discrimination procedures were introduced with four new subjects (children) to produce separate classes from two that had a stimulus in common. This procedure is shown in right-most set of classes in Figure 4. The left-most sets of classes are identical to those in Figure 3. The right-most set of classes contains trials that are not simple conditional discriminations. Rather, they are second-order conditional discriminations because the correct choice depends on the sample and a specific

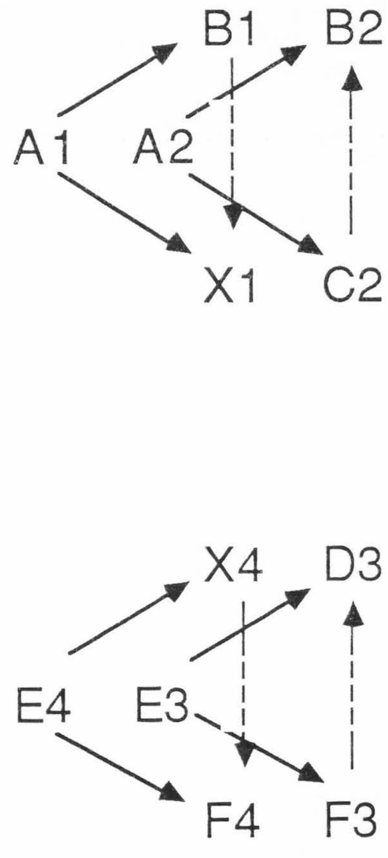


Figure 3. Two sets of stimuli trained in Experiment 1 of Fucini (1982). (Adapted from Fucini, 1982)

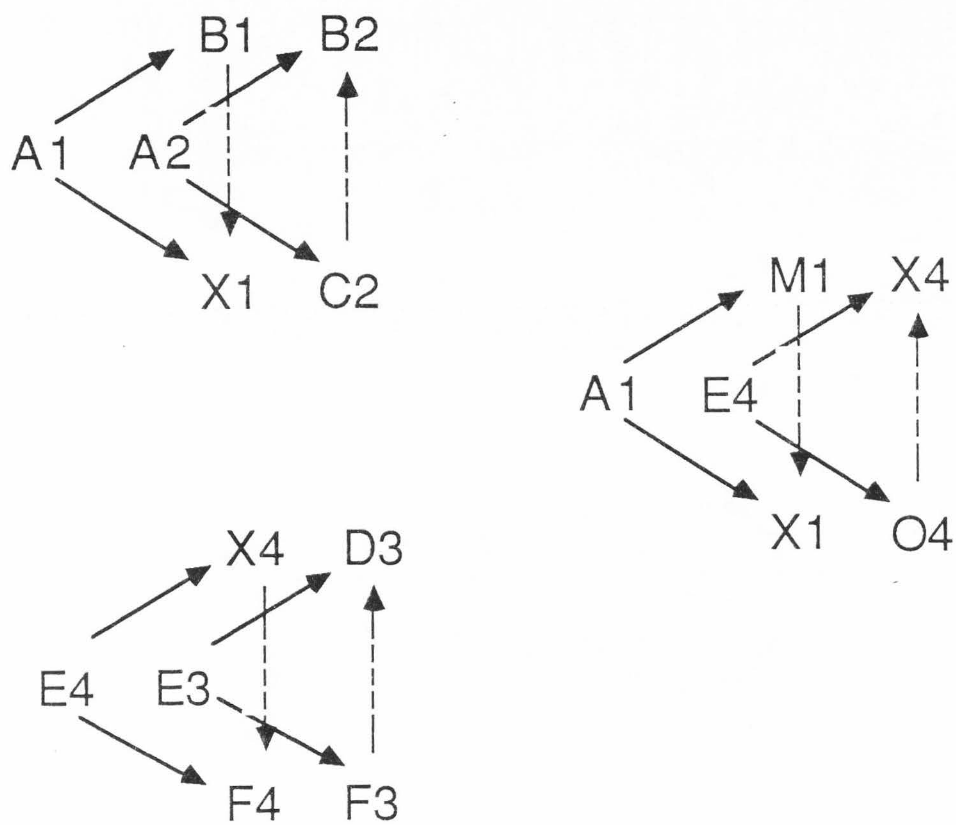


Figure 4. Second-order training procedures (right-most set of stimuli) from Experiments 2 and 3 of Fucini (1982). (Adapted from Fucini, 1982)

incorrect comparison. In these trials, A1 and E4 are conditionally related to <u>different</u> stimulus <u>configurations</u> containing X. If the stimulus control by A1 and E4 differs, then a relation between them would not be expected to develop. Thus, the classes A1,B1,X1 and E4,X4,F4 should prove functionally different even though they have X in common. Results from testing for transitive relations between all the stimuli showed this to be the case for four out of five subjects: two functionally separate classes with one element in common emerged (Fucini, 1982).

In the third experiment, the same procedure was used to separate the 6-member class of stimuli established in Experiment I into two, functionally separate, 3-member classes with one element in common. The results showed that this procedure was successful for the children but not the adult subject.

One additional study attempted to examine second-order control of conceptual behavior. In the first two experiments (run concurrently), Green (1985) trained four- and five-year old normal children to respond correctly in an identity match-to-sample of colors and shapes in the presence of a superordinate, "contextual" stimulus. For example, in a typical trial, a subject was presented with the word, "RED" (the superordinate stimulus) on a plexiglass key. A response to this stimulus produced a single red sample stimulus on a different key. A response to the red sample produced two comparison stimuli on two additional comparison keys. The comparisons were the color red and the color blue. A response to the color red on the comparison key resulted in reinforcement (tokens) while a response to blue in this trial would result in a blackout and the re-presentation of the trial. Similar trials with appropriate superordinate stimuli were presented for the color blue (e.g., superordinate stimulus = BLUE) and the shapes, circle and triangle. In the above cases, the superordinate stimuli were termed "instance" words.

The subjects also received trials in which "concept" words such as "COLOR" and "SHAPE" served as superordinate stimuli. For example, when COLOR was the superordinate stimulus, and the color red was the sample, and the color blue and a triangle were the comparison stimuli, a response to the color blue was reinforced. When the word SHAPE was the superordinate stimulus, the choice between a triangle and the color blue was reinforced when the sample was a circle. This type of training trial, combined with those described earlier produced training trials in which an identity match was reinforced in the presence of an "instance" word while an arbitrary match (e.g., circle and triangle) was reinforced in the presence of the "concept" word.

Given this training, the experimental question was whether the concept and instance words, by virtue of their contiguity with the samples, would alone come to control correct responding. In order to answer this question, probes were inserted into the training baseline that consisted of the concept or instance words as samples and appropriate stimuli. For example, would the subject correctly respond to a triangle versus the color blue given only the concept word "SHAPE"? Also, would the subject correctly respond to the color blue over the color red given only the instance word "BLUE"?

The results showed that only one of the five subjects responded above chance levels to these probes. In other words, no relation was formed between the concept or instance words and the samples. This was evidence of the lack of emergence of the nominally transitive relation between the superordinate stimuli and the comparisons. In discussing the results, Green (1985) noted that the superordinate stimulus, in every trial, was a redundant stimulus. In other words, the subjects did not _have_ to attend to the superordinate stimulus in order to make a correct choice between the comparison stimuli: only the sample was necessary. Hence, the mere contiguity of the superordinate stimulus was not sufficient to produce "contextual" control.

From the studies that have used conditional discrimination procedures under the control of a second-order conditional stimulus, i.e., a five-term contingency, the following can be concluded. First, within the identity and nonidentity matching task, it is possible to control the respective matching performance via second-order control of the four-term contingency (five-term contingency control) (Nevin & Liebold, 1966; Santi, 1978, 1982). The second-order stimulus seemed to function as an "instructing" stimulus as to whether identity or nonidentity matching would lead to reinforcement. It appears that such instructional control must come from a stimulus that is conditionally related to the four-term contingency (Green, 1985). Second, it is possible to control untaught sequencing behavior via second-order control (Lazar & Kotlarchyk, in press). Third, Fucini (1982) demonstrated that two classes of stimuli, each containing a stimulus in common, can function separately as a result of second-order training procedures.

EXPERIMENT 1-A

Experiment 1-A addressed three experimental questions. First, can control of subjects' responses be described by positive or negative relations or both in a five-term contingency match-to-sample task? Second, within a five-term contingency match-to-sample task, can the existence of four-term contingency relations in the absence of the second-order stimulus be inferred? Third, if such four-term relations can be inferred, can the existence of transitive relations that appear only in the absence of the second-order stimulus also be inferred?

The top part of Figure 5 labeled Training, shows the minimum logical training conditions necessary to produce a second-order conditional discrimination. Specific second-order relations are represented in the text and tables with letters corresponding to the second-order stimulus, sample, and comparisons in parentheses with an asterisk marking the correct, reinforced comparison. For example, the first relation in the upper part of Figure 5 would be denoted, X-A(C* B). The bottom part of Figure 5 is a conceptual diagram of the potential, resulting second-order relations.

In order to address the first experimental question, subsequent to the training of the four second-

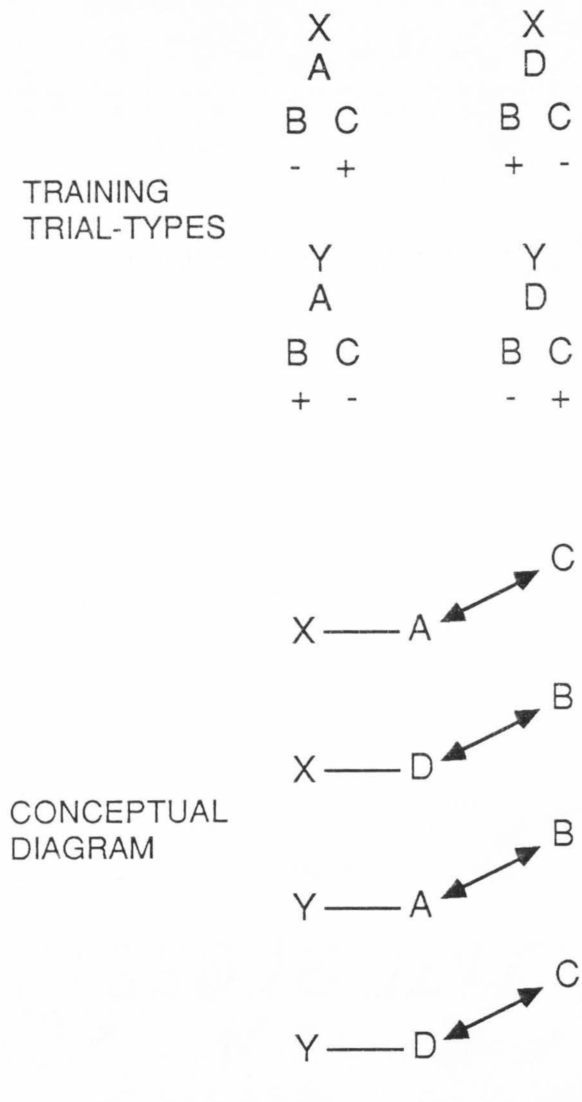


Figure 5. Second-order conditional discrimination training and conceptual result of relations.

order relations as shown in Figure 5, probes were introduced that tested for a positive relation between the second-order stimulus, the sample and the correct comparison. These probe trial-types, adapted from Stromer and Osborne (1982), contained a most-preferred novel stimulus as an incorrect comparison. For example, in X-A(C Nmp), Nmp was the most preferred novel stimulus as assessed in previous probe conditions. Comparison C was scored as a correct response though no feedback was provided to the subject. By using a most-preferred novel stimulus as an incorrect comparison, responding was actually biased away from the potential positive relation.

Probes for negative relations included the incorrect comparison and a least-preferred novel stimulus as in X-A(B Nlp). Responding to the least-preferred novel stimulus would indicate that the subject responded away from the incorrect comparison and that a negative stimulus relation could be inferred between X and A and B. If responding was equally distributed between the two choices in either of the above cases, then the likelihood would be less that responses were being controlled by positive or negative relations.

The second experimental question concerned the possible existence of four-term relations in the absence of the second-order stimulus. In order to address this question, the four-term relations were presented alone (i.e., with no second-order stimulus) in probe trials. For example, A was presented as the sample with B and C as comparisons. This is denoted as 0-A(B C). Also presented 0-D(B C). The question was whether the subjects would distribute their responding evenly between the comparison stimuli. If so, there are two separate explanations that could account for such a result: first, subjects could respond at random to the two comparisons because no relations exist between either of the comparisons and the sample in the absence of the second-order stimulus; second, subjects could respond equally to the two comparisons because each of the comparisons is in a separate relation with the sample as a result of the second-order training, i.e., the four-term relations AB, AC, DB, and DC remain "intact" in the absence of the second-order stimuli. Thus, the trial-type, 0-A(B C), establishes two competing relations.

In order to separate these two explanations, probe trials were run in which B and C were presented separately from one another as comparisons with A and D as samples. Incorrect comparisons consisted of most preferred novel stimuli (see method). For example, B and C were separated in the trial-types, 0-A(B Nmp) and 0-A(C Nmp). Responses to each of these trial-types would indicate that the controlling relations exist in the absence of the second-order stimuli. Chance level responding or responding solely to the novel stimuli would indicate no relations in the absence of the second-order stimuli. If the latter is the result, then probing the same relations with the appropriate second-order stimuli should result in appropriate performance.

The third experimental question considered further the possible result that the four-term relations, AB, AC, DB, and DC existed in the absence of the second-order stimulus. If these relations exist, then logically B and C are linked transitively to one another through both A and D. Logically, also, A and D are transitively linked. Thus, in the absence of the second-order stimulus, all of the stimuli should be equivalent. Probes that assessed this possibility were run.

Specific procedures for accomplishing the training and testing are described below.

Method

Subjects

Three normal adults served as subjects. Subjects were recruited through introductory psychology classes at Utah State University. Subject 1 was a 19-year-old, female, sophomore. Subject 2 was an 18-year-old, male, freshman. Subject 3 was a 19-year-old, male, sophomore. Subjects did not begin the study until a consent form was signed stating that: the payment procedures (described below) were understood; they could withdraw from the study at anytime; and, that they would be fully debriefed at the conclusion of the study.

Apparatus and Stimuli

An Apple IIe microcomputer presented visual stimuli on a black and white monitor and controlled all experimental events. The response manipulandum was a joystick, a 4 in. X 4 in. box with a 2 1/2 in. lever protruding upward and a button to the left of the lever. The joystick allowed the subject to manipulate graphic arrows on the monitor. A response was defined when the arrows were placed to the side of the chosen stimulus and the button was pressed. The microcomputer monitor was located 18 in. from the front edge of the table at which the subject sat. The space between the edge of the table and the monitor was where the joystick was located. No computer keyboard was visible to the subject.

The stimuli used in Experiment 1-A are shown in Figure 6. For clarity of exposition, stimulus relations are referred to by their corresponding alphabetic letters and/or numbers.

General Procedures

Subjects were seated at a table facing the

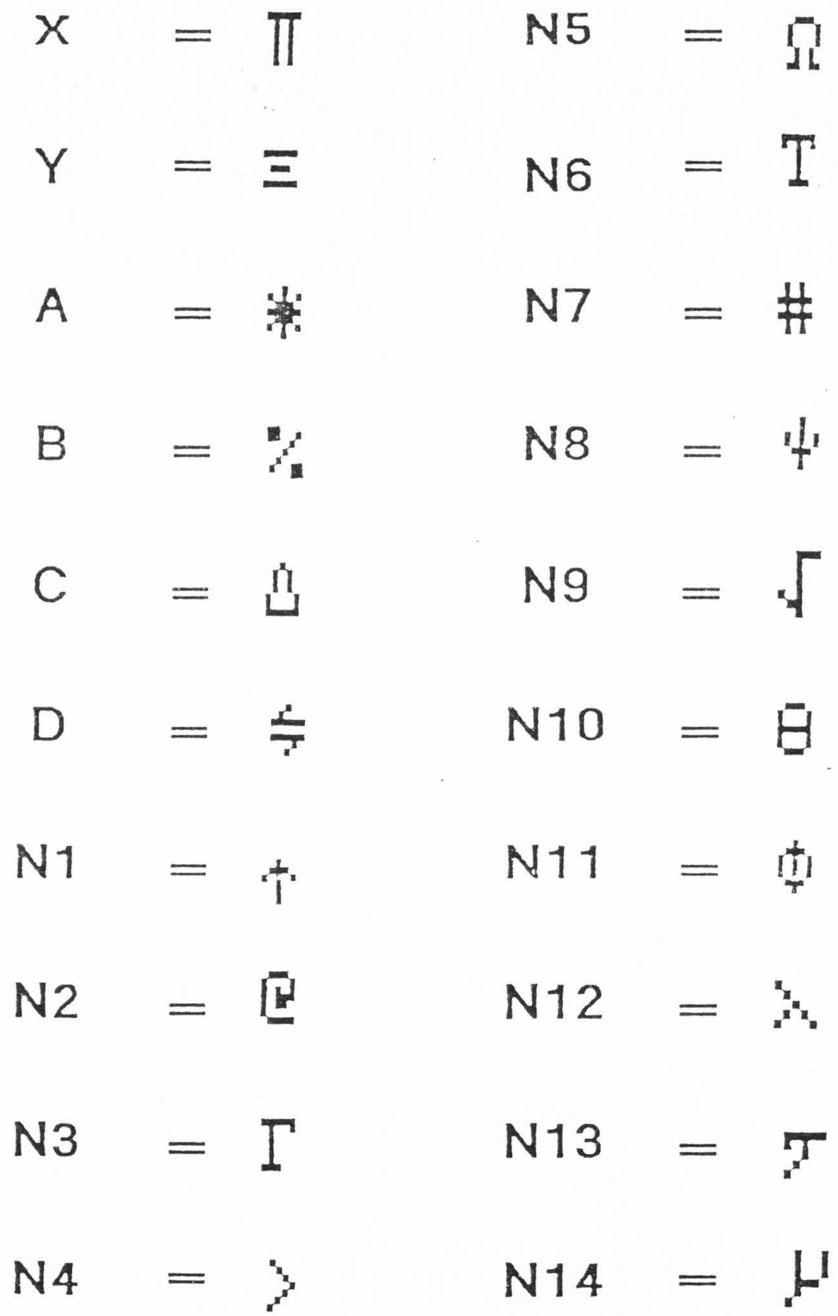


Figure 6. Stimuli used in Experiment 1-A

microcomputer. Using the three-stimulus trial-type in Phase 1 (described below), the experimenter described and demonstrated the use of the joystick. The subject was then instructed to respond to the stimuli on the monitor using the joystick. During this session, any questions from the subject regarding the use of the manipulandum were answered.

Experimental task. The task in this experiment was a visual-visual, four-stimulus trial-type, simultaneous second-order conditional discrimination (match-to-sample). The stimulus positions on the screen are shown in Figure 7. A session and trial began when a stimulus appeared on the screen in the area labeled "second-order stimulus" except during conditions where no second-order stimulus was present. A response occurred when the subject manipulated the graphic arrows beside any portion of the stimulus on the screen and pressed the button located left of the joystick. Such a response produced the sample while the second-order stimulus remained on the screen. A response to the sample produced the two comparison stimuli while the sample and second-order stimulus remained on the screen. The positioning of the correct and incorrect comparisons on either the left or right hand positions of the screen was at random.

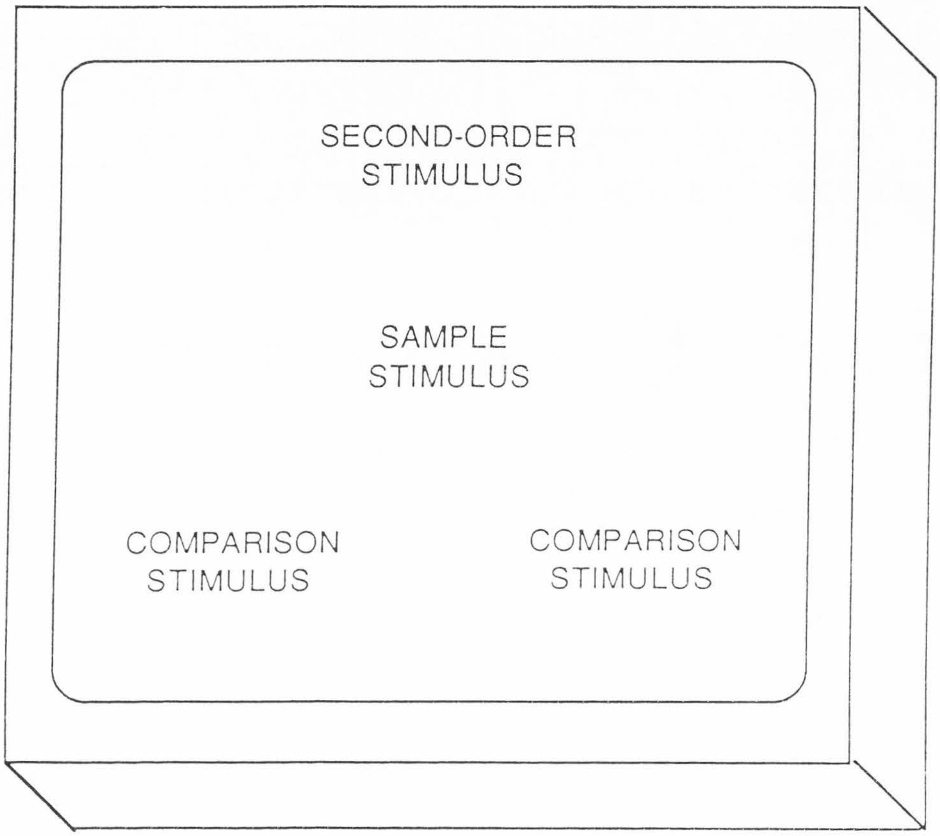


Figure 7. Position of stimuli on computer screen

Feedback procedures. Two feedback conditions were used in Experiment 1-A: 100% feedback and 25% feedback. During the 100% feedback condition, a correction procedure was in effect. This consisted of the following: If the subject responded to the correct comparison on the first try, the configuration on the screen was replaced with the word "CORRECT", centered on the screen. On the line below the word "CORRECT" was a points-counter that read, "POINTS = ", followed by the number of points accumulated thus far. This message remained on the screen for two seconds followed by a two-second blackout and the presentation of the next trial. Each response to the incorrect comparison produced a three-second blackout followed by the re-presentation of the same entire stimulus configuration. This procedure was repeated if the subject continued to respond to the incorrect comparison. Once a correct response occurred on this trial, the word "CORRECT" appeared on the screen, but no points were awarded; "POINTS = " did not appear. Thus, the subject could only earn points if he/she responded correctly on the first try. During the 25% feedback condition, there was a .25 probability that a given correct response would result in correct feedback as described above. Responses to the correct comparison that did not result in correct feedback and responses to incorrect comparison stimuli were followed by a two-second blackout of all stimuli before the next trial was presented. Thus, no correction procedure was in effect. When the session was over, the words, "SESSION OVER" appeared on the screen. Under this was a line which read, "POINTS EARNED = " and the number of points earned for that session. During the 25% feedback condition, total points possible were reduced by 75%.

Dependent measure. The dependent measure used in this experiment was the frequency of responses to comparison stimuli conditional upon certain sample and/ or second-order stimulus combinations. Frequencies were summarized and/or converted to percentages based on correct responding or experimenter-defined types of response patterns.

Sessions. Each session consisted of 80 trials. Each session day was 45-50 minutes in length which allowed approximately five, 80-trial sessions.

Subject payment. During 100% correct feedback conditions, subjects received pay at the rate of one cent to each four correct choices (i.e., $.20/session possible). Payment was made at the end of each day of sessions. Some subjects opted for end-of-the-week payment. For these subjects, the total number of points earned that day was reported to them at the conclusion of the sessions for that day. During the reduced feedback condition (see below), subjects received one cent for each correct choice. Subjects also received a bonus of $20 if they completed the experiment to its conclusion. All of the above was clearly outlined to the subject before he/she agreed to participate.

Specific Training Procedures

Pretraining. In order to assess the subjects' ability to match the stimuli to themselves, stimuli A through D, (see Figure 6) were used in an identity match-to-sample procedure. Specifically, each stimulus used appeared as a sample with an identical stimulus in one comparison position and a remaining randomly chosen non-identical stimulus in the other comparison position. The second-order stimulus position was not used here. The subject was instructed to choose the shape that went with the one in the middle. The experimenter demonstrated the use of the joystick. During this phase feedback was 100% and the correction procedure was in effect. The subject was required to reach a criterion of 100% correct for one session before moving to the next condition.

Training. Training proceeded in a bidirectional fashion, i.e., each correct comparison appeared as a sample and each sample appeared as a correct comparison. For Experiment 1-A, the relations, X-A(B C*), X-D(B* C), Y-A(B* C), and Y-D(B C*) and their symmetrical counterparts, X-C(A* B), X-B(D* C), Y-B(A* C), and Y-B(D* C), were trained to criterion (see Figure 5). All eight configurations (the four relations and their symmetrical counterparts) were presented in each session. Criterion for learning the training task was 90% or better correct responding for two 80-trial sessions. When correct responding was 90% or greater to two eight-configuration sessions, the probability of correct feedback was lowered to 25% as long as correct responding remained at 90% or greater. If correct responding fell below 90%, then the percentage of feedback for correct responses was increased to 100% and the procedure for lowering it was repeated.

Probe Test Procedures

General probe procedures. In each of the probe sessions, twenty-four unreinforced probe configurations were randomly inserted into a baseline of eight-configuration (training) review trials. Feedback for correct responses to the baseline training trials-trials was 25%. A criterion of 90% correct responding or better on the baseline training trials was required in order to continue probe testing. The correction procedure was never in effect during probe sessions. No instructions were given that introduced the probe sessions nor were instructions given that introduced those probes that did not use the second-order stimulus. The specific probe tests are shown in Figures 8 and 9. The different probe tests (described below) were designed to test different experimental questions and hypotheses. Preceding each test that used novel stimuli as comparisons, a test for preferences of those stimuli in the presence of a given sample or sample and second-order stimulus combination was conducted. Subsequent tests used the novel stimulus (most- or least-preferred) that should bias responding against specific sample or sample and second-order stimulus control. Sequences of tests for preference of novel comparisons and tests for stimulus control were always replicated. The order of presentation of the probe tests and the number of sessions run with each probe test was almost identical from subject to subject. The order of presentation of the probe tests and the number of sessions run with each is shown in Table 4.

Test 1: Preference for novel comparisons. This test was designed to determine the most- and least-preferred of two novel comparison stimuli in the presence of each familiar sample/second-order stimulus combination (cf. Stromer & Osborne, 1982). The results of this test were used to create the configurations in Test 2. For example, trials in Test 1 took the form, X-

Test 1 Preference for novel comparisons	X	X	Y	Y
	A	D	A	D
	N1 N2	N1 N2	N1 N2	N1 N2
	X	X	Y	Y
	C	B	B	C
	N3 N4	N3 N4	N3 N4	N3 N4
Test 2 Control by matching stimuli with novel comparisons	X	X	Y	Y
	A	D	A	D
	Nmp C	B Nmp	B Nmp	Nmp C
	X	X	Y	Y
Symmetrical configurations	C	B	B	C
	Nmp A	D Nmp	A Nmp	Nmp D
Test 3 Preference for novel comparisons	X	X	Y	Y
	A	D	A	D
	N5 N6	N5 N6	N5 N6	N5 N6
	X	X	Y	Y
	C	B	B	C
	N7 N8	N7 N8	N7 N8	N7 N8
TEST 4 Control by nonmatching stimuli with novel comparisons	X	X	Y	Y
	A	D	A	D
	B Nlp	Nlp C	Nlp C	B Nlp
	X	X	Y	Y
	C	B	B	C
	B Nlp	Nlp C	Nlp C	B Nlp

Figure 8. Probe trial-types for Tests 1-4, Experiment 1-A

Test	Description	Trial 1	Trial 2	Trial 3	Trial 4
TEST 5	Potential competing relations	0 A B C	0 D B C		
TEST 6	Preference for novel comparisons	0 A N9 N10	0 D N9 N10		
TEST 7	Control by sample without second-order stimulus	0 A B Nmp	0 A Nmp C	0 D B Nmp	0 D Nmp C
TEST 8	Control with appropriate second-order stimulus	Y A B Nmp	X A Nmp C	X D B Nmp	Y D Nmp C
TEST 9	Preference for novel stimuli	0 A N11 N12	0 D N11 N12	0 B N13 N14	0 C N13 N14
TEST 10	Potential transitive relations without second-order stimulus	0 A D Nmp	0 D Nmp A	0 B C Nmp	0 C Nmp B
TEST 11	Control Test for familiarity	X A D Nlp	Y D Nlp A	X B C Nlp	Y C Nlp B

Figure 9. Probe trial-types for Tests 5-11, Experiment 1-A

Table 4

Order of Probe Tests and Number of Sessions Run for Each Subject

Probe Test Number (Number of sessions)		
Subjects		
1	2	3
1. (2)	1. (2)	1. (2)
2. (2)	2. (2)	2. (2)
1. (2)	1. (2)	1. (2)
2. (2)	2. (2)	2. (2)
3. (2)	3. (2)	3. (2)
4. (2)	4. (2)	4. (2)
3. (2)	3. (2)	3. (2)
4. (2)	4. (2)	4. (2)
5. (1)	5. (1)	5. (1)
6. (1)	6. (1)	6. (1)
7. (2)	7. (2)	7. (1)
6. (1)	6. (1)	7. (2)
7. (2)	7. (2)	6. (1)
8. (2)	8. (2)	7. (2)
9. (2)	9. (2)	8. (2)
10. (2)	10. (2)	9. (2)
9. (2)	9. (2)	10. (2)
10. (2)	10. (2)	9. (2)
11. (2)	11. (2)	10. (2)
		11. (2)

A(N1 N2), where N1 and N2 were two different novel stimuli. (see Figure 8). Each probe in Test 1 was presented three times per session. Two sessions of probes from Test 1 were presented to all subjects per sequence.

Test 2: Control by matching stimuli with novel comparisons. These probes tested for control by positive stimulus relations. Specifically, did the subjects respond to the correct familiar comparison even when the other choice was a most-preferred novel stimulus? Trials took the form, X-A(C Nmp), where Nmp was the most preferred novel stimulus in presence of X and A. The preference was determined by totalling the number of responses made to a given novel stimulus over the two sessions run in Test 1. If an equal number of responses occurred to the two novel stimuli, then one of the two stimuli was randomly selected to be used with that trial-type for the duration of Test 2. A new novel stimulus would be chosen either randomly or by preference when Test 1 was replicated. (This procedure was used throughout Experiments 1-A and 1-B.) Use of a most-preferred novel stimulus from the previous preference test should bias responding away from the correct comparison. Responses to the familar correct comparison were scored as correct. Each probe in Test 2 was presented three times per session. Two sessions with probes from Test 2 were presented to all subjects per sequence. The sequence of Test 1 and Test 2 was replicated for all subjects (see Table 4).

Test 3: Preference for novel comparisons. This test was identical to Test 1 except that new novel stimuli were used. Figure 8 shows that this test preceded the test for control by nonmatching stimuli with novel comparisons.

Test 4: Control by nonmatching stimuli with novel comparisons. This test assessed control by negative stimulus relations (see Figure 8). Specifically, did the subjects respond away from the familiar, incorrect comparison even though the other comparison was one that was the least-preferred from the previous preference test? These probes took the form, X-A(B Nlp), where the comparisons were a familiar incorrect choice in the presence of the second-order stimulus and sample, and a least-preferred novel stimulus. Use of a least-preferred novel stimulus should bias responding toward the incorrect comparison. Responses to the least-preferred novel stimuli were scored as correct. Two sessions each of Test 4 were run for each subject per sequence. The sequence of Test 3 and Test 4 was replicated for all subjects (see Table 4).

Test 5: Potential competing relations. Test 5 was designed to assess the possibility that equal choice of B and C would occur when they appeared as comparisons together in the absence of the second-order stimulus (see Figure 9). Each probe in Test 5 appeared 12 times per session. One session with probes from Test 5 was run for all subjects per sequence (see Table 4).

Test 6: Preferences for novel comparisons. Test 6 was designed to determine the most- and least-preferred of two novel comparison stimuli in the presence of the familiar stimuli, A and D (see Figure 9). No second-order stimuli were present. For example, trial-types took the form, 0-A(N9 N10). One session of Test 6 probes was run for each subject per sequence.

Test 7: Control by sample without second-order stimulus. This test was designed to separate the two hypotheses for the expected chance level responding in Test 5. The four-term relations, AB, AC, DB, and DC are correct matches in the presence of the appropriate second-order stimuli, X and Y (as in the baseline trials). However, in Test 7, the second-order stimulus was removed. Thus, B and C, presented together as comparisons in Test 5, were presented separately with A and D as samples in Test 7. Whichever novel stimuli were determined from the preceding preference tests to be the most-preferred in the presence of a given familiar sample (see Figure 9) were used as the incorrect comparisons as in the trial-type, 0-A(B Nmp). This should bias responding toward the novel stimulus. Responses to the familiar comparisons were scored as correct. Correct responses would indicate that the four-term relations AB, AC, DB, and DC remained "intact" in the absence of the second order stimulus. Each probe in Test 7 appeared six times per session. Two sessions of Test 7 were run for each subject per sequence. The sequence of Test 6 and Test 7 was replicated once for each subject (see Table 4).

Test 8: Control with appropriate second-order stimulus. This test was identical to Test 7 except that the appropriate second-order stimulus from training appeared. This test served as a control for Test 7. If responding to Test 7 was at chance levels, indicating that no four-term relations existed in the absence of second-order stimuli, then responses to Test 8 probes should be correct because the second-order stimulus is present. Two sessions with probes from Test 8 were run with each subject.

Test 9: Preference for novel stimuli. This was a new preference test using familar samples with no second-order stimulus from which the novel comparisons used in Test 10 and 11 were derived.

Tests 10: Potential transitive relations without second-order stimulus. This test assessed potential transitive relations between the four-term stimuli in the absence of the second-order stimulus (see Figure 9). Most-preferred stimuli from Test 9 were used as incorrect comparisons. Two sessions of probes from Test 10 were run per sequence. The sequence of Test 9 and Test 10 was replicated once for each subject.

Test 11: Control test for familiarity. These probes were designed to control against a bias toward the familiar comparison stimuli in Test 10. This test was similar to Test 10 except that a second-order stimulus was added for each trial-type. In addition, the least preferred novel stimulus from the most recent presentation of Test 9 preference probes was used to bias responding toward the familiar comparisons. If responding correctly to probes from Test 10 is a function of familiarity only, then responding to the familiar stimuli should occur for Test 11 as well. Otherwise, responding should be at chance levels or toward the novel comparisons during Test 11 probes.

Results and Discussion

Identity Matching and Training

All subjects performed the eight-trial identity-matching task at 100% accuracy.

The results of training for Subjects 1, 2, and 3 are shown in Table 5. Subjects 1 and 3 both responded with greater than 90% accuracy by the end of the second session. For these subjects, high percentages of correct responding continued through reduced feedback. For Subject 2, however, 90% or better correct responding did not occur until the ninth session and the criterion for introducing probes was not met until the thirteenth session. No explanation for the discrepancy between the subjects is immediately apparent.

Probe Tests

Tables 6, 7, and 8 show the results of all probe tests for Subjects 1, 2 and 3 respectively. Each probe test appears in the actual order in which it was run. For those tests in which responses were scored as correct, a percent correct has been calculated from the sessions run for that test. The numbers in parentheses show the number of sessions each probe test was run. Below each comparison in the stimulus array appears a number representing responses to that comparison stimulus out of the total number of times that stimulus in that array appeared. All major probe tests were preceded by a test for preferences of novel comparisons. Each major probe test, including the test for preferences, was replicated once. At no time during probe tests of Experiment 1-A did percent correct

Table 5

Percentage of Correct Responding for each Training Session for each Subject

Session Number	Percent Correct Responding S1	S2	S3
1.	63	56	72
2.	98	59	96
3.	99	71	100
4.	100*	63	98*
5.	100*	71	100*
6.		76	
7.		80	
8.		75	
9.		90	
10.		74	
11.		83	
12.		93	
13.		98	
14.		100*	
15.		99*	

Note. * indicates feedback occurred on 25% of correct responses

Table 6

Number of Responses to each Stimulus Array, Percent Correct, and Number of Sessions Run per Test for Subject 1

Test Description	Percent Correct	Test #/ (# of sessions)	Test Arrays and # Responses/Total			
Preference Test		1.(2)	X-A(N1, N2)	X-D(N1, N2)	Y-A(N1, N2)	Y-D(N1, N2)
			6/6 0/6	2/6 4/6	2/6 4/6	4/6 2/6
			X-C(N3, N4)	X-B(N3, N4)	Y-B(N3, N4)	Y-C(N3, N4)
			1/6 5/6	4/6 2/6	0/6 6/6	5/6 1/6
Control by Matching Stimuli	98%	2.(2)	X-A(C , N1)	X-D(B , N2)	Y-A(B , N2)	Y-D(C , N1)
			6/6 0/6	6/6 0/6	6/6 0/6	6/6 0/6
			X-C(A , N4)	X-B(D , N3)	Y-B(B , N4)	Y-C(D , N3)
			6/6 0/6	6/6 0/6	6/6 0/6	5/6 1/6
Preference Test		1.(2)	X-A(N1, N2)	X-D(N1, N2)	Y-A(N1, N2)	Y-D(N1, N2)
			1/6 5/6	5/6 1/6	5/6 1/6	1/6 5/6
			X-C(N3, N4)	X-B(N3, N4)	Y-B(N3, N4)	Y-C(N3, N4)
			0/6 6/6	5/6 1/6	1/6 5/6	6/6 0/6
Control by Matching Stimuli	98%	2.(2)	X-A(C , N2)	X-D(B , N1)	Y-A(B , N1)	Y-D(C , N2)
			6/6 0/6	6/6 0/6	6/6 0/6	5/6 1/6
			X-C(A , N4)	X-B(D , N3)	Y-B(B , N4)	Y-C(D , N3)
			6/6 0/6	6/6 0/6	6/6 0/6	6/6 0/6
Preference Test		3.(2)	X-A(N5, N6)	X-D(N5, N6)	Y-A(N5, N6)	Y-D(N5, N6)
			6/6 0/6	4/6 2/6	6/6 0/6	1/6 5/6
			X-C(N7, N8)	X-B(N7, N8)	Y-B(N7, N8)	Y-C(N7, N8)
			6/6 0/6	0/6 6/6	6/6 0/6	0/6 6/6
Control by Non-Matching Stimuli	96%	4.(2)	X-A(N6, B)	X-D(N6, C)	Y-A(N6, C)	Y-D(N5, B)
			6/6 0/6	5/6 1/6	6/6 0/6	5/6 1/6
			X-C(N8, B)	X-B(N7, C)	Y-B(N8, C)	Y-C(N7, B)
			6/6 0/6	6/6 0/6	6/6 0/6	6/6 0/6
Preference Test		3.(2)	X-A(N5, N6)	X-D(N5, N6)	Y-A(N5, N6)	Y-D(N5, N6)
			0/6 6/6	0/6 6/6	0/6 6/6	6/6 0/6
			X-C(N7, N8)	X-B(N7, N8)	Y-B(N7, N8)	Y-C(N7, N8)
			1/6 5/6	6/6 0/6	0/6 6/6	6/6 0/6

(Table 6 continued)

Control by Non-Matching Stimuli	96%	4.(2)	X-A(N5, B)	X-D(N5, C)	Y-A(N5, C)	Y-D(N6, B)
			6/6 0/6	5/6 1/6	6/6 0/6	5/6 1/6
			X-C(N7, B)	X-B(N8, C)	Y-B(N7, C)	Y-C(N8, B)
			6/6 0/6	6/6 0/6	6/6 0/6	6/6 0/6
Potential Competing Relations		5.(1)	0-A(B , C)	0-D(B , C)		
			8/12 4/12	3/12 9/12		
Preference Test		6.(1)	0-A(N9, N10)	0-D(N9, N10)		
			3/12 9/12	6/12 6/12		
Control by Sample without Sec. Ord. Stimulus	46%	7.(2)	0-A(B , N10)	0-A(C , N10)	0-D(B , N10)	0-D(C , N9)
			5/12 7/12	5/12 7/12	8/12 4/12	4/12 8/12
Preference Test		6.(1)	0-A(N9, N10)	0-D(N9, N10)		
			5/12 7/12	8/12 4/12		
Control by Sample without Sec. Ord. Stimulus	48%	7.(2)	0-A(B , N10)	0-A(C , N10)	0-D(B , N9)	0-D(C , N9)
			5/12 7/12	9/12 3/12	4/12 8/12	5/12 7/12
Control with appropriate Sec. Ord. Stimulus	0%	8.(2)	Y-A(B , N10)	X-A(C , N10)	X-D(B , N9)	Y-D(C , N9)
			12/12 0/12	12/12 0/12	12/12 0/12	12/12 0/12
Preference Test		9.(2)	0-A(N11, N12)	0-D(N11, N12)	0-B(N13, N14)	0-C(N13, N14)
			6/12 6/12	8/12 4/12	7/12 5/12	3/12 9/12
Potential Transitive Relations	8%	10.(2)	0-A(D , N12)	0-D(A , N11)	0-B(C , N13)	0-C(B , N14)
			1/12 11/12	1/12 11/12	1/12 11/12	1/12 11/12
Preference Test		9.(2)	0-A(N11, N12)	0-D(N11, N12)	0-B(N13, N14)	0-C(N13, N14)
			0/12 12/12	12/12 0/12	12/12 0/12	0/12 12/12
Potential Transitive Relations	0%	10.(2)	0-A(D , N11)	0-D(A , N12)	0-B(C , N13)	0-C(B , N14)
			0/12 12/12	0/12 12/12	0/12 12/12	0/12 12/12
Control Test for Familiarity	6%	11.(2)	X-A(D , N12)	Y-D(A , N11)	X-B(C , N14)	Y-C(B , N13)
			1/12 11/12	0/12 12/12	1/12 11/12	1/12 11/12

Table 7

Number of Responses to each Stimulus Array, Percent Correct, and Number of Sessions Run per Test for Subject 2

Test Description	Percent Correct	Test #/ (# of sessions)	Test Arrays and # Responses/Total			
Preference Test		1.(2)	X-A(N1, N2) 6/6 0/6	X-D(N1, N2) 1/6 5/6	Y-A(N1, N2) 2/6 4/6	Y-D(N1, N2) 2/6 4/6
			X-C(N3, N4) 2/6 4/6	X-B(N3, N4) 4/6 2/6	Y-B(N3, N4) 3/6 3/6	Y-C(N3, N4) 3/6 3/6
Control by Matching Stimuli	92%	2.(2)	X-A(C , N1) 6/6 0/6	X-D(B , N2) 6/6 0/6	Y-A(B , N2) 5/6 1/6	Y-D(C , N2) 6/6 0/6
			X-C(A , N4) 5/6 1/6	X-B(D , N3) 6/6 0/6	Y-B(B , N3) 5/6 1/6	Y-C(D , N4) 5/6 1/6
Preference Test		1.(2)	X-A(N1, N2) 3/6 3/6	X-D(N1, N2) 2/6 4/6	Y-A(N1, N2) 2/6 4/6	Y-D(N1, N2) 4/6 2/6
			X-C(N3, N4) 3/6 3/6	X-B(N3, N4) 4/6 2/6	Y-B(N3, N4) 5/6 1/6	Y-C(N3, N4) 4/6 2/6
Control by Matching Stimuli	100%	2.(2)	X-A(C , N2) 6/6 0/6	X-D(B , N2) 6/6 0/6	Y-A(B , N2) 6/6 0/6	Y-D(C , N1) 6/6 0/6
			X-C(A , N4) 6/6 0/6	X-B(D , N3) 6/6 0/6	Y-B(B , N4) 6/6 0/6	Y-C(D , N3) 6/6 0/6
Preference Test		3.(2)	X-A(N5, N6) 4/6 2/6	X-D(N5, N6) 4/6 2/6	Y-A(N5, N6) 3/6 3/6	Y-D(N5, N6) 4/6 2/6
			X-C(N7, N8) 4/6 2/6	X-B(N7, N8) 3/6 3/6	Y-B(N7, N8) 5/6 1/6	Y-C(N7, N8) 4/6 2/6
Control by Non-Matching Stimuli	94%	4.(2)	X-A(N6, B) 6/6 0/6	X-D(N6, C) 5/6 1/6	Y-A(N6, C) 5/6 1/6	Y-D(N6, B) 4/6 2/6
			X-C(N8, B) 5/6 1/6	X-B(N8, C) 6/6 0/6	Y-B(N8, C) 6/6 0/6	Y-C(N8, B) 6/6 0/6

(Table 7 continued)

Preference Test		3.(2)	X-A(N5, N6) 5/6 1/6	X-D(N5, N6) 5/6 1/6	Y-A(N5, N6) 3/6 3/6	Y-D(N5, N6) 3/6 3/6
			X-C(N7, N8) 4/6 2/6	X-B(N7, N8) 3/6 3/6	Y-B(N7, N8) 4/6 2/6	Y-C(N7, N8) 4/6 2/6
Control by Non-Matching Stimuli	98%	4.(2)	X-A(N6, B) 5/6 1/6	X-D(N5, C) 6/6 0/6	Y-A(N6, C) 6/6 0/6	Y-D(N5, B) 6/6 0/6
			X-C(N8, B) 6/6 0/6	X-B(N8, C) 6/6 0/6	Y-B(N8, C) 6/6 0/6	Y-C(N8, B) 6/6 0/6
Potential Competing Relations		5.(1)	0-A(B , C) 5/12 7/12	0-D(B , C) 5/12 7/12		
Preference Test		6.(1)	0-A(N9, N10) 6/12 6/12	0-D(N9, N10) 7/12 5/12		
Control by Sample without Sec. Ord. Stimulus	50%	7.(2)	0-A(B , N9) 7/12 5/12	0-A(C , N9) 4/12 8/12	0-D(B , N9) 6/12 6/12	0-D(C , N9) 7/12 5/12
Preference Test		6.(1)	0-A(N9, N10) 3/12 9/12	0-D(N9, N10) 3/12 9/12		
Control by Sample without Sec. Ord. Stimulus	92%	7.(2)	0-A(B , N10) 11/12 1/12	0-A(C , N10) 11/12 1/12	0-D(B , N10) 11/12 1/12	0-D(C , N10) 11/12 1/12
Control with appropriate Sec. Ord. Stimulus	100%	8.(2)	Y-A(B , N9) 12/12 0/12	X-A(C , N9) 12/12 0/12	X-D(B , N9) 12/12 0/12	Y-D(C , N9) 12/12 0/12
Preference Test		9.(2)	0-A(N11, N12) 9/12 3/12	0-D(N11, N12) 11/12 1/12	0-B(N13, N14) 8/12 4/12	0-C(N13, N14) 2/12 10/12
Potential Transitive Relations	100%	10.(2)	0-A(D , N11) 12/12 0/12	0-D(A , N11) 12/12 0/12	0-B(C , N13) 12/12 0/12	0-C(B , N14) 12/12 0/12
Preference Test		9.(2)	0-A(N11, N12) 12/12 0/12	0-D(N11, N12) 12/12 0/12	0-B(N13, N14) 2/12 10/12	0-C(N13, N14) 1/12 11/12
Potential Transitive Relations	65%	10.(2)	0-A(D , N11) 8/12 4/12	0-D(A , N11) 7/12 5/12	0-B(C , N14) 8/12 4/12	0-C(B , N14) 8/12 4/12
Control Test for Familiarity	60%	11.(2)	X-A(D , N12) 9/12 3/12	Y-D(A , N12) 6/12 6/12	X-B(C , N13) 6/12 6/12	Y-C(B , N13) 8/12 4/12

Table 8

Number of Responses to each Stimulus Array, Percent Correct, and Number of Sessions Run per Test for Subject 3

Test Description	Percent Correct	Test #/ (# of sessions)	Test Arrays and # Responses/Total			
Preference Test		1.(2)	X-A(N1, N2) 6/6 0/6	X-D(N1, N2) 1/6 5/6	Y-A(N1, N2) 2/6 6/6	Y-D(N1, N2) 6/6 0/6
			X-C(N3, N4) 6/6 0/6	X-B(N3, N4) 1/6 5/6	Y-B(N3, N4) 1/6 5/6	Y-C(N3, N4) 1/6 5/6
Control by Matching Stimuli	88%	2.(2)	X-A(C , N1) 6/6 0/6	X-D(B , N2) 6/6 0/6	Y-A(B , N2) 6/6 0/6	Y-D(C , N1) 6/6 0/6
			X-C(A , N3) 0/6 6/6	X-B(D , N4) 6/6 0/6	Y-B(B , N4) 6/6 0/6	Y-C(D , N4) 6/6 0/6
Preference Test		1.(2)	X-A(N1, N2) 2/6 4/6	X-D(N1, N2) 5/6 1/6	Y-A(N1, N2) 5/6 1/6	Y-D(N1, N2) 2/6 4/6
			X-C(N3, N4) 6/6 0/6	X-B(N3, N4) 1/6 5/6	Y-B(N3, N4) 4/6 2/6	Y-C(N3, N4) 2/6 4/6
Control by Matching Stimuli	100%	2.(2)	X-A(C , N2) 6/6 0/6	X-D(B , N1) 6/6 0/6	Y-A(B , N1) 6/6 0/6	Y-D(C , N2) 6/6 0/6
			X-C(A , N4) 6/6 0/6	X-B(D , N3) 6/6 0/6	Y-B(B , N4) 6/6 0/6	Y-C(D , N3) 6/6 0/6
Preference Test		3.(2)	X-A(N5, N6) 0/6 6/6	X-D(N5, N6) 6/6 0/6	Y-A(N5, N6) 6/6 0/6	Y-D(N5, N6) 0/6 6/6
			X-C(N7, N8) 6/6 0/6	X-B(N7, N8) 2/6 4/6	Y-B(N7, N8) 2/6 4/6	Y-C(N7, N8) 2/6 4/6
Control by Non-Matching Stimuli	100%	4.(2)	X-A(N6, B) 6/6 0/6	X-D(N6, C) 6/6 0/6	Y-A(N6, C) 6/6 0/6	Y-D(N5, B) 6/6 0/6
			X-C(N8, B) 6/6 0/6	X-B(N7, C) 6/6 0/6	Y-B(N8, C) 6/6 0/6	Y-C(N7, B) 6/6 0/6

(Table 8 continued)

Preference Test		3.(2)	X-A(N5, N6)	X-D(N5, N6)	Y-A(N5, N6)	Y-D(N5, N6)
			6/6 0/6	0/6 6/6	0/6 6/6	6/6 0/6
			X-C(N7, N8)	X-B(N7, N8)	Y-B(N7, N8)	Y-C(N7, N8)
			5/6 1/6	0/6 6/6	6/6 0/6	0/6 6/6
Control by Non-Matching Stimuli	98%	4.(2)	X-A(N5, B)	X-D(N5, C)	Y-A(N5, C)	Y-D(N6, B)
			6/6 0/6	6/6 0/6	6/6 0/6	6/6 0/6
			X-C(N7 B)	X-B(N8, C)	Y-B(N7, C)	Y-C(N8, B)
			5/6 1/6	6/6 0/6	6/6 0/6	6/6 0/6
Potential Competing Relations		5.(1)	0-A(B , C)	0-D(B , C)		
			10/12 2/12	12/12 0/12		
Preference Test		6.(1)	0-A(N9, N10)	0-D(N9, N10)		
			0/12 12/12	0/12 12/12		
Control by Sample without Sec. Ord. Stimulus (error in 4th configuration)	79%	7.(1)	0-A(B , N10)	0-A(C , N10)	0-D(B , N10)	0-D(C , X)
			6/6 0/6	5/6 1/6	6/6 0/6	2/6 4/6
Control by Sample without Sec. Ord. Stimulus	92%	7.(2)	0-A(B , N10)	0-A(C , N10)	0-D(B , N10)	0-D(C , N10)
			11/12 1/12	12/12 0/12	12/12 0/12	9/12 3/12
Preference Test		6.(1)	0-A(N9, N10)	0-D(N9, N10)		
			10/12 2/12	4/12 8/12		
Control by Sample without Sec. Ord. Stimulus	56%	7.(2)	0-A(B , N9)	0-A(C , N9)	0-D(B , N10)	0-D(C , N10)
			9/12 3/12	9/12 3/12	7/12 5/12	2/12 10/12
Control with appropriate Sec. Ord. Stimulus	100%	8.(2)	Y-A(B , N9)	X-A(C , N9)	X-D(B , N9)	Y-D(C , N9)
			12/12 0/12	12/12 0/12	12/12 0/12	12/12 0/12
Preference Test		9.(2)	0-A(N11, N12)	0-D(N11, N12)	0-B(N13, N14)	0-C(N13, N14)
			12/12 0/12	0/12 12/12	11/12 1/12	0/12 12/12
Potential Transitive Relations	0%	10.(2)	0-A(D , N11)	0-D(A , N12)	0-B(C , N13)	0-C(B , N14)
			0/12 12/12	0/12 12/12	0/12 12/12	0/12 12/12
Preference Test		9.(2)	0-A(N11, N12)	0-D(N11, N12)	0-B(N13, N14)	0-C(N13, N14)
			12/12 0/12	1/12 11/12	12/12 0/12	0/12 12/12
Potential Transitive Relations	0%	10.(2)	0-A(D , N11)	0-D(A , N12)	0-B(C , N13)	0-C(B , N14)
			0/12 12/12	0/12 12/12	0/12 12/12	0/12 12/12
Control Test for Familiarity	10%	11.(2)	X-A(D , N12)	Y-D(A , N11)	X-B(C , N14)	Y-C(B , N13)
			1/12 11/12	4/12 8/12	0/12 12/12	0/12 12/12

responding to the baseline, review trials for any subject fall below 90%.

Control by matching stimuli with most-preferred novel comparisons: Tests 1 and 2. During the first sessions of Test 1 probes, Subjects 1 and 3 did not distribute responses evenly between the novel comparisons within Test 1 configurations. Subjects 1 and 3 demonstrated a preference for one of the novel stimuli in most of the eight trial-types. However, Subject 2 demonstrated a preference only during presentation of the first two trial-types shown in Table 7. No strong preferences were evident from the remaining configurations.

Test 2 probes were designed to test for control by positive stimulus relations between the second-order, standard, and correct comparison stimuli with a most-preferred novel comparison stimulus replacing the incorrect comparison. During the two sessions of the first presentation of Test 2, all subjects demonstrated high percentages of correct responding. However, for one particular probe type, X-C(A N3) (see Table 8), Subject 3 made every response to the novel comparison. It is not known why this occurred although it did not occur during the replication of Test 2. The high percentages of correct responding were also demonstrated by all subjects upon replication of the Test 1 and 2 sequence.

Subjects 2 and 3 each responded with 100% accuracy during the replication of Test 2 probes while Subject 1 missed only a single response.

Control by nonmatching stimuli with least preferred novel stimuli: Tests 3 and 4. This test assessed potential control by negative stimulus relations. The two comparisons in these probes were: (1) a familiar, but incorrect comparison; and (2) a least-preferred, novel comparison. As shown in Tables 6, 7, and 8, Subjects 1 and 3 continued to show stronger preferences for particular novel stimuli during the first presentation of Test 3 preference probes than did Subject 2. As shown by the percent correct responding to Test 4 probes, each subject responded with 98% or greater accuracy to the least-preferred, novel comparisons during the first set of Test 4 probes. This result was replicated during the second presentation of Test 4 probes. These results provide evidence for control by negative stimulus relations under a five-term contingency.

The remaining probes in this experiment were designed to test for the existence of four-term contingency relations that would result from the removal of the second-order stimulus.

Test for potential competing relations: Test 5. In Test 5, the second-order stimulus was not presented during probe trial-types. Thus, the comparisons B and C were presented with either A or D as the sample (see Test 5 of Tables 6, 7, and 8). Given training and baseline trials where both B and C were correct in the presence of A and D (as determined by X or Y), it was not expected that differential responding to either B or C would obtain. As shown in Test 5 of Tables 6 and 7, Subjects 1 and 2 distributed responses between B and C in the presence of either A or D. However, as shown in Test 5 of Table 8, S3 chose stimulus B whether A or D was the sample. Logically, during this probe test, no sample-comparison combination should have expected more or less control than any other. In the case of Subject 3, for example, one could not infer A-B and D-B relations on the basis of a high degree of responding to B without questioning why A-C or D-C relations should not also have been demonstrated. Thus, for Subject 3, responding can best be described as a preference for stimulus B under these probe conditions.

There are two separate and competing explanations for why Test 5 trial-types were not adequate demonstrations of four-term stimulus control. First, given the training and baseline trials, four-term contingencies control responding in the absence of the second-order stimulus. If this is the case, then A would control responding to B and C equally as would stimulus D. Thus, subjects would respond to such probes by either distributing their responses across the two comparisons (as did S1 and S2) or resort to a simple preference (as did S3). Second, however, these same results could have been obtained if no four-term stimulus control was present in the absence of the second-order stimulus. Specifically, if neither A nor D controlled responding to B and C, and because subjects were required to respond in order to get the next trial, S1 and S2 could have distributed responses across B and C on the basis of no control by A or D. In addition, S3's resort to a preference could also be a function of no control by A or D. Test 7 attempted to separate these two explanations.

Control by sample without second-order stimulus: Tests 6 and 7. Test 7 probes were designed to provide evidence for whether or not four-term contingency stimulus control existed in the absence of the second-order stimulus. Since stimuli B and C could not appear together as comparisons, the four-term relations AB, AC, DB, and DC were tested separately with a most-preferred novel stimulus as one of the comparisons.

The results of the first set of Test 7 probes (see Tables 6, 7, and 8) show that Subjects 1 and 2 distributed their responses between the familiar comparision and the most-preferred novel comparison stimuli. This resulted in percent correct responding of 46 and 50 for Subjects 1 and 2, respectively. Subject 3, however, responded correctly to the familiar stimuli with exception of the fourth, incorrectly presented configuration during the first session of Test 7. (As shown in Table 8, the stimulus, X, was inadvertently presented as a comparison stimulus in the trial-type, O-D(C, X). This experimental error was corrected in subsequent presentations of Test 7 probe trial-types.) Subject 3 responded to the subsequent set of two sessions of Test 7 probes with 92% accuracy. Thus, for Subjects 1 and 2, no evidence was present that four-term stimulus control existed in the absence of the second-order stimulus. For Subject 3, however, four-term contingency stimulus control did appear to exist.

These same results were not obtained when the Test 6 and 7 sequence was replicated. While Subject 1 continued to distribute responding across the comparisons, Subject 2 demonstated a high degree of correct responding (92%) to the familiar stimuli suggesting four-term stimulus control. Subject 3, however, no longer demonstrated four-term stimulus control. Percent correct responding decreased to 56% during the replication of Test 7. Thus, at this point, only Subject 2 demonstrated four-term stimulus control.

Control with appropriate second-order stimuli - Test 8. During Test 8 probes, subjects were presented with the same stimulus configurations as in Test 7 except that the appropriate second-order stimulus was present in each stimulus array. Under these conditions, all subjects made every response to the correct comparison regardless of their performance on the most recently presented Test 7 probes (see Test 8 in Tables 6, 7, and 8). Thus, all subjects demonstrated second-order stimulus control on these probes.

Potential transitive relations without second-order stimulus: Tests 9 and 10. These probes were designed to test for potential transitive relations among the four-term contingency stimuli. For example, if a subject showed AB, AC, DB, and DC matching in Test 7, then all these stimuli should be transitively "linked" (as demonstrated by the emergence of the relations, BC, CB, AD, and DA) in the absence of the second-order stimulus. Recall that Subject 2 demonstrated the underlying four-term relations during the final presentation of Test 7 probes. It follows that only Subject 2 should demonstrate the transitive relations.

As shown in the first set of Test 10 probes (see Tables 6, 7, and 8) Subject 2 was in fact the only subject that demonstrated transitive relations among the four-term contingency stimuli. Subjects 1 and 3 chose the most-preferred novel stimulus in each array of Test 10 almost exclusively. However, upon replication of Test 10, transitive control of responding in S2's performance deteriorated while S1 and S3 continued to respond to the novel stimulus exclusively.

Control test for familiarity: Test 11. This test was designed to accomplish two objectives. First, it was designed as a control for responding to Test 10 probes only on the basis of familiarity (i.e., away from the novel stimuli): it would not be appropriate to continue responding to the familiar stimuli in the presence of the second-order stimuli used in these probes. Second, if subjects are responding transitively during Test 10 probes, then the addition of the second-order stimuli in Test 11 should disrupt transitive responding thereby demonstrating that the transitive relations only occur in the absence of the second-order stimuli. However, since no transitive relations were demonstrated during the replication of Test 10, the addition of second-order stimuli in Test 11 probes was not expected to change responding from that demonstrated by the subjects during Test 10 probes. As shown in Test 11 in Tables 6, 7, and 8, the percentages of correct responding changed little between the final set of Test 10 probes and Test 11 probes.

General Discussion: Experiment 1-A

Subjects 1 and 3 responded to the baseline training task at 90% or greater by the second session of training while Subject 2 did not meet the criterion until the 12th session. Despite this discrepancy in aquisition, all subjects responded to the eight baseline trial-types at greater than 90% correct throughout the experiment.

All subjects demonstrated performance that suggested control by positive and negative stimulus relations under the five-term contingency. The use of novel stimuli as comparisons may have confounded the results from the probes for positive relations. For example, when all subjects had completed the initial and replicating probe tests for positive relations, no responses to novel stimuli had been scored as correct up to that point. Thus, it could be hypothesized that the results of tests for positive relations were a function of only responding to the familiar stimulus (in this case the correct comparison). However, there are two arguments against this hypothesis. The first argument is that the novel comparison in each stimulus array was the most-preferred novel stimulus in the presence of the given second-order and sample stimuli as determined by previous preference tests. Thus, a hypothesis based only on familiarity of a given comparison must also take into account the presumed stimulus control of the empirically demonstrated, most-preferred stimulus. However, it should be noted that strong preferences were not noted in all stimulus arrays (see Test 1 results in Tables 6, 7, and 8). A second, and stronger case against a familiarity hypothesis would be evidenced by strong responding _to_ novel comparisons. From the subsequent tests for negative stimulus relations, such evidence was present, i.e., subjects responded away from incorrect comparisons _to_ novel comparisons.

The results suggesting control of responding by positive and negative stimulus relations are consistent with Stromer and Osborne's (1982) findings that positive and negative relations between samples and comparisons can be inferred when humans perform arbitrary matching-to-sample tasks. The present experiment extends these findings by demonstrating that positive and negative relations are present even when the choice of a comparison is ultimately under fifth-term control.

This experiment also demonstrated that, given the present five-term contingency training, the demonstration of underlying, four-term relations in the absence of the second-order stimulus varies across subjects, and should be described, at best, as weak. Subject 1 never demonstrated such relations; Subject 3 did so, but not upon replication; and Subject 2 demonstrated four-term relations only upon replication.

Subsequent tests for transitive relations among the four-term stimuli were logically consistent with the results from probes for the underlying, four-term relations. Subjects 1 and 3 who did not demonstrate the four-term relations, also did not (and would not be expected to) demonstrate transitive relations. Subject 2 did not demonstrate the underlying four-term relations initially, but did so upon replication of the probe tests for these relations. During the subsequent tests for transitive relations, Subject 2 did demonstrate transitive relations, but not upon replication. Perhaps the lack of Subject 2's demonstration of the underlying, four-term relations during the initial tests as well as replication was a factor in why the transitive relations were only briefly demonstrated. It should be noted that in Experiment 1-A feedback was never directly provided for any of the underlying four-term relations in the absence of the second-order stimulus. This may also have been a factor in the present findings. Functional analyses that more closely examined the underlying, four-term relations were performed in Experiment 1-B.

EXPERIMENT 1-B

Experiment 1-B was designed to provide the subjects from Experiment 1-A with direct feedback on trials of the underlying, four-term relations in the absence of the second-order stimulus from Experiment 1-A. The experimental question was whether such training would increase the likelihood that subsequent tests identical to those of Experiment 1-A for transitive relations would yield positive results.

Method

Subjects

Subjects 1, 2, and 3 from Experiment 1-A served.

Apparatus and Stimuli

All apparatus and stimuli used in Experiment 1-B were identical to those used in Experiment 1-A.

Procedures

Training. Figure 10 shows the four-term contingency training that each subject received. Each of the underlying stimulus pairs was unidirectionally matched: AB, AC, DB, and DC. In addition, arrays containing formerly novel stimuli were matched so that stimuli A, B, C, & D would appear equally often as a correct and incorrect comparison. The criterion for

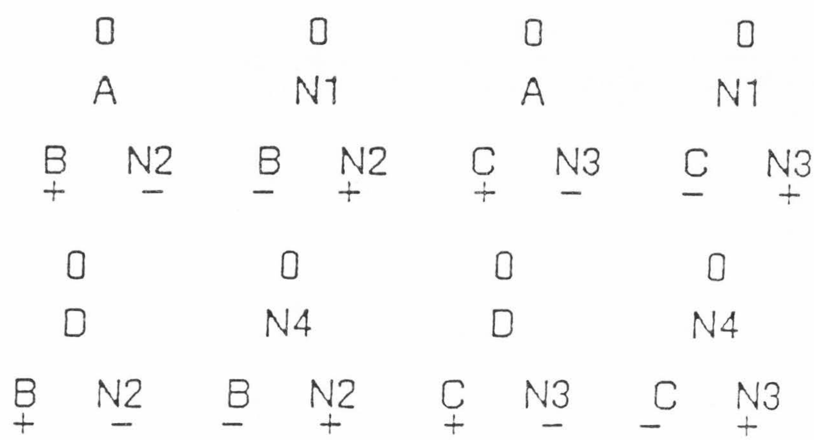


Figure 10. Four-term contingency training for each subject in Experiment 1-B.

learning the Experiment 1-B training was two consecutive sessions with 90% or greater accuracy.

Probes. The subjects were presented with a probe test series for transitive relations similar to that presented in Experiment 1-A. The series consisted of tests for preference of novel stimuli (Test 9), tests for potential transitive relations (Test 10), and a control test for responding on the basis of familiarity (Test 11). The baseline trials into which the probes were inserted were identical to the baseline trials in Experiment 1-A. Based on their performances, some additional functional analysis in presenting probes and training was necessary. These will be explained as the separate results for each subject's performance are presented.

Results and Discussion

Training

S2 met the training criterion in two sessions and S1 and S3 met the training criterion in three sessions.

Probe Tests: Subject S1

The results of probe tests for Subject 1 are shown in Table 9. (The test numbers are the same as those used in Experiment 1-A.) Subject 1 did not demonstrate strong preferences for novel stimuli in Test 9.

Table 9

Number of Responses to Each Stimulus Array, Percent Correct, and Number of Sessions Run per Test for Subject 1 in Experiment 1-B

Probe Test	Percent Correct	(number of sessions)	Test Arrays and # Responses/Total			
9. Preference Test		(2)	0-A(N11, N12) 5/12 7/12	0-D(N11, N12) 5/12 7/12	0-B(N13, N14) 7/12 5/12	0-C(N13, N14) 5/12 7/12
10. Potential Transitive Relations	98%	(2)	0-A(D , N12) 11/12 1/12	0-D(A , N12) 12/12 0/12	0-B(C , N13) 12/12 0/12	0-C(B , N14) 12/12 0/12
9. Preference Test		(2)	0-A(N11, N12) 7/12 5/12	0-D(N11, N12) 4/12 8/12	0-B(N13, N14) 12/12 0/12	0-C(N13, N14) 1/12 11/12
10. Potential Transitive Relations	96%	(2)	0-A(D , N11) 12/12 0/12	0-D(A , N12) 12/12 0/12	0-B(C , N13) 11/12 1/12	0-C(B , N14) 11/12 1/12
11. Control Test for Familiarity	58%	(2)	X-A(D , N12) 7/12 5/12	Y-D(A , N11) 5/12 7/12	X-B(C , N14) 11/12 1/12	Y-C(B , N13) 5/12 7/12

However, as shown in the first set of Test 10 probes, almost every response was made to the familiar comparison stimuli which resulted in 98% correct responding. During the replication of Test 9 and 10, Subject 1 showed stronger preferences for given novel stimuli in Test 9. As shown in the second set of Test 10 probes, Subject 1 responded with 96% accuracy.

Test 11 was identical to Test 10 except that second-order stimuli were present and the novel comparisons were the least-preferred. As shown in Table 9 responses were distributed across the comparison stimuli for three of the four arrays. Eleven of twelve responses were made to the familiar stimulus in the third array. With the exception of this array, however, responding was much different on Test 11 than on Test 10 probes: while correct responding was greater than 96%, responding to the familiar stimuli during Test 11 sessions was only 58%.

Subject S3

Table 10 shows the results of probe tests for Subject 3. Subject 3 was given a set of probe tests similar to Subject 1. Subject 3 demonstrated strong preferences for novel stimuli during Test 9 probe sessions in both sets. As did Subject 1, Subject 3 demonstrated transitive relations in both the first presentation of Test 10 probes (94%) correct and the

Table 10

Number of Responses to Each Stimulus Array, Percent Correct, and Number of Sessions Run per Test for Subject 3 in Experiment 1-B

Probe Test	Percent Correct	(number of sessions)	Test Arrays and # Responses/Total			
9. Preference Test		(2)	0-A(N11, N12) 12/12 0/12	0-D(N11, N12) 0/12 12/12	0-B(N13, N14) 2/12 10/12	0-C(N13, N14) 12/12 0/12
10. Potential Transitive Relations	94%	(2)	0-A(D , N11) 11/12 1/12	0-D(A , N12) 12/12 0/12	0-B(C , N14) 10/12 2/12	0-C(B , N13) 12/12 2/12
9. Preference Test		(2)	0-A(N11, N12) 10/12 2/12	0-D(N11, N12) 0/12 12/12	0-B(N13, N14) 0/12 12/12	0-C(N13, N14) 12/12 0/12
10. Potential Transitive Relations	100%	(2)	0-A(D , N11) 12/12 0/12	0-D(A , N12) 10/12 2/12	0-B(C , N14) 12/12 0/12	0-C(B , N13) 12/12 0/12
11. Control Test for Familiarity (Novel Stim. Least Preferred)	100%	(2)	X-A(D , N12) 12/12 0/12	Y-D(A , N11) 12/12 0/12	X-B(C , N13) 12/12 0/12	Y-C(B , N14) 12/12 0/12
11. Control Test for Familiarity (Novel Stim. Most Preferred)	100%	(1)	X-A(D , N11) 6/6 0/6	Y-D(A , N12) 6/6 0/6	X-B(C , N14) 6/6 0/6	Y-C(B , N13) 6/6 0/6

replication of Test 10 Probes (100%).

However, unlike Subject 1, Subject 3 showed no difference in responding between Test 10 and Test 11. All responses were made to the familiar comparisons during the first two sessions of Test 11 as well as during the third session of Test 11 where most- rather than least-preferred novel stimuli were used as comparisons. In order to better understand the results of Test 11 for Subject 3, a functional analysis was conducted that consisted of new probe conditions. Subject 3 could have been responding to the familiar stimuli in Test 11 for two different reasons. First, the subject may have responded only on the basis of familiarity. If this was the case, it could be assumed that the subject was responding only on the basis of familiarity on Test 10 probes as well. Second, the subject may have been responding transitively to Test 10 probes, but the addition of second-order stimuli in Test 11 did nothing to disrupt these relations; i.e., no five-term control existed during these probes. Either or both of these explanations could account for Subject 3's performance on Test 11 probes. One way of examining these accounts would be to present five-term contingency probes during which correct (but with no feedback) responding would necessarily depend upon fifth-term control <u>and</u> would result in responding to both novel and familiar stimuli. If, upon re-presentation of Test 11 probes, the subject continued to respond to the familiar stimuli only, then it could be suggested that responding to Test 10 probes was only a function of familiarity. If the subject did not respond to the familiar stimuli during re-presentation of Test 11 probes, then it could be inferred that Test 10 responding was indeed transitive and that fifth-term stimulus control during probe trials had been restored.

For Subject 3, this functional analysis was accomplished by combining probes for positive relations and negative relations from Experiment 1-A into a single probe test. Test 12 consisted of the unidirectional configurations for positive and negative relations from Tests 2 and 4 of Experiment 1-A while Test 13 consisted of the symmetric configurations from Tests 2 and 4 of Experiment 1-A.

Table 11 shows the results of the above functional analysis. The first test, Test 3, determined preferences in the presence of the various second-order, sample stimulus combinations. The next test, Test 12, contained trial-types that tested for positive relations and trial-types that tested for negative relations as in Experiment 1-A. Thus, if the subject responded correctly, the subject would respond to the familar comparisons in the first four arrays of Test 12 in Table 11 (positive relation probes) and to the novel

Table 11

Number of Responses to Each Stimulus Array, Percent Correct, and Number of Sessions Run per Test during Functional Analysis for Subject 3 in Experiment 1-B

Probe Test	Percent Correct	(number of sessions)	Test Arrays and # Responses/Total			
3. Preference Test		(2)	X-A(N5, N6)	X-D(N5, N6)	Y-A(N5, N6)	Y-D(N5, N6)
			0/6 6/6	3/6 3/6	6/6 0/6	0/6 6/6
			X-C(N7, N8)	X-B(N7, N8)	Y-B(N7, N8)	Y-C(N7, N8)
			6/6 0/6	6/6 0/6	0/6 6/6	5/6 1/6
12. Combined Pos. and Neg. Probes - Unidirectional (<u>Error in Novels</u>)	67%	(1)	X-A(C , N6)	X-D(B , N7)	Y-A(B , N5)	Y-D(C , N7)
			3/3 0/3	3/3 0/3	3/3 0/3	3/3 0/3
			X-A(N7, B)	X-D(N6, C)	Y-A(N7, C)	Y-D(N6, B)
			1/3 2/3	2/3 1/3	0/3 3/3	1/3 2/3
12. Combined Pos. and Neg. Probes - Unidirectional	50%	(1)	X-A(C , N6)	X-D(B , N5)	Y-A(B , N5)	Y-D(C , N6)
			3/3 0/3	3/3 0/3	3/3 0/3	3/3 0/3
			X-A(N5, B)	X-D(N6, C)	Y-A(N6, C)	Y-D(N5, B)
			0/3 3/3	0/3 3/3	0/3 3/3	0/3 3/3
13. Combined Pos. and Neg. Probes - Symmetric	100%	(1)	X-C(A , N7)	X-B(D , N7)	Y-B(B , N8)	Y-C(D , N7)
			3/3 0/3	3/3 0/3	3/3 0/3	3/3 0/3
			X-C(N8, B)	X-B(N8, C)	Y-B(N7, C)	Y-C(N8, B)
			3/3 0/3	3/3 0/3	3/3 0/3	3/3 0/3
12. Combined Pos. and Neg. Probes - Unidirectional	100%	(1)	X-A(C , N6)	X-D(B , N5)	Y-A(B , N5)	Y-D(C , N6)
			3/3 0/3	3/3 0/3	3/3 0/3	3/3 0/3
			X-A(N5, B)	X-D(N6, C)	Y-A(N6, C)	Y-D(N5, B)
			3/3 0/3	3/3 0/3	3/3 0/3	3/3 0/3
13. Combined Pos. and Neg. Probes - Symmetric	100%	(1)	X-C(A , N7)	X-B(D , N7)	Y-B(B , N8)	Y-C(D , N7)
			3/3 0/3	3/3 0/3	3/3 0/3	3/3 0/3
			X-C(N8, B)	X-B(N8, C)	Y-B(N7, C)	Y-C(N8, B)
			3/3 0/3	3/3 0/3	3/3 0/3	3/3 0/3
11. Control Test for Familiarity	0%	(2)	X-A(D , N5)	Y-D(A , N5)	X-B(C , N8)	Y-C(B , N8)
			0/12 12/12	0/12 12/12	0/12 12/12	0/12 12/12

comparisons in the next four arrays of Test 12 (negative relation probes), all within the same session.

During the first presentation of Test 12, an error was inadvertently made in presenting the novel stimuli of the second, fourth, sixth, and eighth arrays: all other stimuli were correctly presented. Nevertheless, the majority of responses were made to the familiar stimuli resulting in responding at only 67%. The same result occurred during the next, correctly presented, set of Test 12 probes (50% correct). Test 13 consisted of the symmetrical arrays of Test 12. During these probes, the subject responded with 100% accuracy, i.e., both positive and negative relations were demonstrated. It was decided that Test 12 probes would again be presented. During this presentation, the subject responded with 100% accuracy. The same result was obtained upon replication of the Test 13 probes. When Test 11 probes were again presented, the subject did <u>not</u> respond to the familiar comparisons as in first presentation of Test 11 probes during the present experiment. Rather, Subject 3 made every response to the novel comparisons. Thus, with the second-order stimuli present, fifth-term control was restored and responding to the underlying four-term contingency relations did not occur.

Subject S2

The results of Experiment 1-B for S2 are shown in Table 12. Following the four-term contingency training, S2 was also tested for transitive relations. Three series of tests for transitive relations were conducted because of the difficulty of obtaining transitive responding during the initial tests with this subject. Within each series are training procedures designed to increase the likelihood that the subject would demonstrate the transitive relations. The results are discussed separately for each series.

Series 1. In Series 1, the subject was first given a test for preferences of novel stimuli in the presence of the sample stimuli (Test 9). The results of the following Test 10 show that the majority of responses occurred to the familiar (transitive) stimuli though the total percent correct was only 75%. In an attempt to strengthen the underlying four-term relations, it was decided that the subject should receive one session of the Experiment 1-B training, but at 25% correct feedback. Subject 2 responded to this session with 100% accuracy. During the next session of Test 10, however, the subject responded only to the novel stimuli.

Series 2 In Series 2, Subject 2 was again presented with the Experiment 1-B training, but at 100% correct feedback. Subject 2 responded to the training

Table 12

<u>Number of Responses to Each Stimulus Array, Percent Correct, and Number of Sessions Run per Test for Subject 2 in Experiment 1-B</u>

Probe Test	Percent Correct	(number of sessions)	Test Arrays and # Responses/Total			
			Series 1			
9. Preference Test		(2)	0-A(N11, N12)	0-D(N11, N12)	0-B(N13, N14)	0-C(N13, N14)
			3/12 9/12	12/12 0/12	10/12 2/12	0/12 12/12
10. Potential Transitive Relations	75%	(2)	0-A(D , N12)	0-D(A , N11)	0-B(C , N13)	0-C(B , N14)
			10/12 2/12	9/12 3/12	9/12 3/12	8/12 4/12
Four-Term Training 25% Feedback	100%	(1)				
			0-A(D , N12)	0-D(A , N11)	0-B(C , N13)	0-C(B , N14)
10. Potential Transitive Relations	0%	(1)	0/6 6/6	0/6 6/6	0/6 6/6	0/6 6/6
			Series 2			
Four-Term Training 100% Feedback	100%	(1)				
9. Preference Test		(2)	0-A(N11, N12)	0-D(N11, N12)	0-B(N13, N14)	0-C(N13, N14)
			0/12 12/12	12/12 0/12	12/12 0/12	0/12 12/12
10. Potential Transitive Relations	21%	(2)	0-A(D , N12)	0-D(A , N11)	0-B(C , N13)	0-C(B , N14)
			1/12 11/12	3/12 9/12	3/12 9/12	3/12 9/12
9. Preference Test		(2)	0-A(N11, N12)	0-D(N11, N12)	0-B(N13, N14)	0-C(N13, N14)
			12/12 0/12	0/12 12/12	1/12 11/12	12/12 0/12
10. Potential Transitive Relations	0%	(2)	0-A(D , N11)	0-D(A , N12)	0-B(C , N14)	0-C(B , N13)
			0/12 12/12	0/12 12/12	0/12 12/12	0/12 12/12

(Table 12 continued)

Series 3

9. Preference Test		(2)	0-A(N11, N12)	0-D(N11, N12)	0-B(N13, N14)	0-C(N13, N14)
			11/12 1/12	0/12 12/12	0/12 12/12	12/12 0/12
10.[a]Potential Transitive Relations	63%	(1)	0-A(Da, N11)	0-D(A , N12)	0-B(C , N14)	0-C(B , N13)
			4/6 2/6	5/6 1/6	2/6 4/6	4/6 2/6
10. Potential Transitive Relations	96%	(2)	0-A(D , N11)	0-D(A , N12)	0-B(C , N14)	0-C(B , N13)
			11/12 1/12	12/12 0/12	11/12 1/12	12/12 0/12
9. Preference Test		(2)	0-A(N11, N12)	0-D(N11, N12)	0-B(N13, N14)	0-C(N13, N14)
			11/12 1/12	0/12 12/12	0/12 12/12	12/12 0/12
10. Potential Transitive Relations	0%	(1)	0-A(D , N11)	0-D(A , N12)	0-B(C , N14)	0-C(B , N13)
			0/6 6/6	0/6 6/6	0/6 6/6	0/6 6/6
10.[a]Potential Transitive Relations	96%	(1)	0-A(Da, N11)	0-D(A , N12)	0-B(C , N14)	0-C(B , N13)
			5/6 1/6	6/6 0/6	6/6 0/6	6/6 0/6
10. Potential Transitive Relations	63%	(1)	0-A(D , N11)	0-D(A , N12)	0-B(C , N14)	0-C(B , N13)
			4/6 2/6	5/6 1/6	2/6 4/6	4/6 2/6
10. Potential Transitive Relations	96%	(2)	0-A(D , N11)	0-D(A , N12)	0-B(C , N14)	0-C(B , N13)
			11/12 1/12	12/12 0/12	12/12 0/12	11/12 1/12
11. Control Test for Familiarity	0%	(2)	X-A(D , N12)	Y-D(A , N11)	X-B(C , N13)	Y-C(B , N14)
			0/12 12/12	0/12 12/12	0/12 12/12	0/12 12/12

Note. [a]indicates probes during which a correct response to the 0-A(D,Nmp) array was presented with correct feedback; incorrect responses to this array resulted in the trial being presented again.

with 100% accuracy. Following this was the standard presentation of the Test 9 and 10 probes and a replication. Again, transitive relations were not shown in either of the Test 10 presentations. The Test 10 results were 21% and 0%, respectively.

Series 3. The subject began Series 3 as usual with the preference test for novel comparisons. However, during the next session of Test 10 probes, 100% correct feedback was given for each O-A(D, Nmp) trial, exclusively. Responses to the novel stimulus in this array resulted in the trial being presented over. Thus, for this array, a correction procedure was in effect. All other probes were presented as usual, i.e., no correction and no feedback. This procedure produced 63% correct responding for that session. This is contrasted with the results of the most recently presented Test 10 probes in Series 2 (0%).

The probe trials of the next sessions of Test 10 probes were presented as usual; i.e., no correction and no feedback. During this test, the subject made almost every response to the familiar stimuli, thus demonstrating the transitive relations.

Test 9 was again presented to determine preferences for novel stimuli before replicating Test 10 probes. During the next session of Test 10 probes, Subject 2 returned to the pattern of exclusively responding to the novel stimuli. One additional session of Test 10 probes with the correction and feedback procedure for each trial-type, O-A(D, Nmp) was conducted. This changed responding to the familiar stimuli within this test (96%) but the result did not hold during the next no-feedback, single session of Test 10 probes (63%). However, during the last two sessions of Test 10 probes, Subject 2 demonstrated 96% correct responding.

Control test for familiarity. The final two sessions consisted of Test 11 probes in which second-order stimuli were present. As shown in Table 12, the subject responded to the novel stimuli in every probe presented. Thus, after demonstrating the transitive relations in the final two sessions of Test 10, five-term stimulus control was reestablished in Test 11: The transitive relations were no longer demonstrated in the presence of the second-order stimuli.

General Discussion: Experiment 1-B

In Experiment 1-A, it was found that the five-term contingency training produced only weak demonstrations of the underlying four-term contingency relations in the absence of the second-order stimulus. Logically and empirically, then, transitive relations that would emerge from the underlying, four-term contingency relations were only evident for those subjects demonstrating the underlying, four-term relations.

In Experiment 1-B, the subjects from Experiment 1-A were given explicit feedback for the four-term relations in the absence of second-order stimuli. This was not provided in Experiment 1-A. The experimental question was whether this would facilitate the emergence of transitive relations in the absence of the second-order stimuli. All subjects demonstrated transitive relations in Experiment 1-B where the transitive relations did not appear or appeared weak in Experiment 1-A.

The results of Test 11 probes, in which second-order stimuli were present in trial-types resembling those used to test for transitive relations, provide important information for two issues. First, Test 11 probes functioned as a control test for responding to the transitive relations on the basis of familiarity only. For the trial-types from Test 11, responding to the familiar comparison could not be conceived as "correct" from the subjects' perspective in the presence of the second-order stimulus unless the subject ignored the second-order stimulus and continued to respond transitively as during Test 10 probes or unless the subject responded only on the basis of familiarity. During the final presentations of Test 11, none of the three subjects responded exclusively to the familiar stimuli. This can be taken as evidence that: (1)

responding on Test 10 probes was not made on the basis of familiarity only; and (2) the four-term contingency transitive relations occur only in the absence of the fifth-term stimulus.

EXPERIMENT 2

In Experiment 2, naive subjects were trained under the same, minimal second-order conditional discrimination procedures as in Experiment 1-A. In addition, new comparison stimuli were added for training bringing the total of trained relations from four to eight. The training and conceptualization of this experiment are shown in Figure 11. The upper part of Figure 11 shows the training necessary to produce four classes of equivalent stimuli of three members each under the separate control of second-order stimuli. The bottom part of Figure 11 shows the conceptualization of the stimulus classes after training. As shown in the upper portion of the figure, the first four (numbered) relations were identical to those trained in Experiment 1-A (see Figure 5 from Experiment 1-A). Relations five through eight were identical to relations one through four with regard to the second-order stimuli and the sample. However, new comparison stimuli (E and F) were added such that stimuli A and D were trained to be in a relation with two rather than one additional stimulus (within X and Y). To illustrate, consider relation 1 and 5. In Experiment 1, sample A was trained only with C in the presence of X. In Experiment 2, sample A was trained with C <u>and</u> E in the presence of X. The training of relations 1 and 5 resulted in the conceptual class as

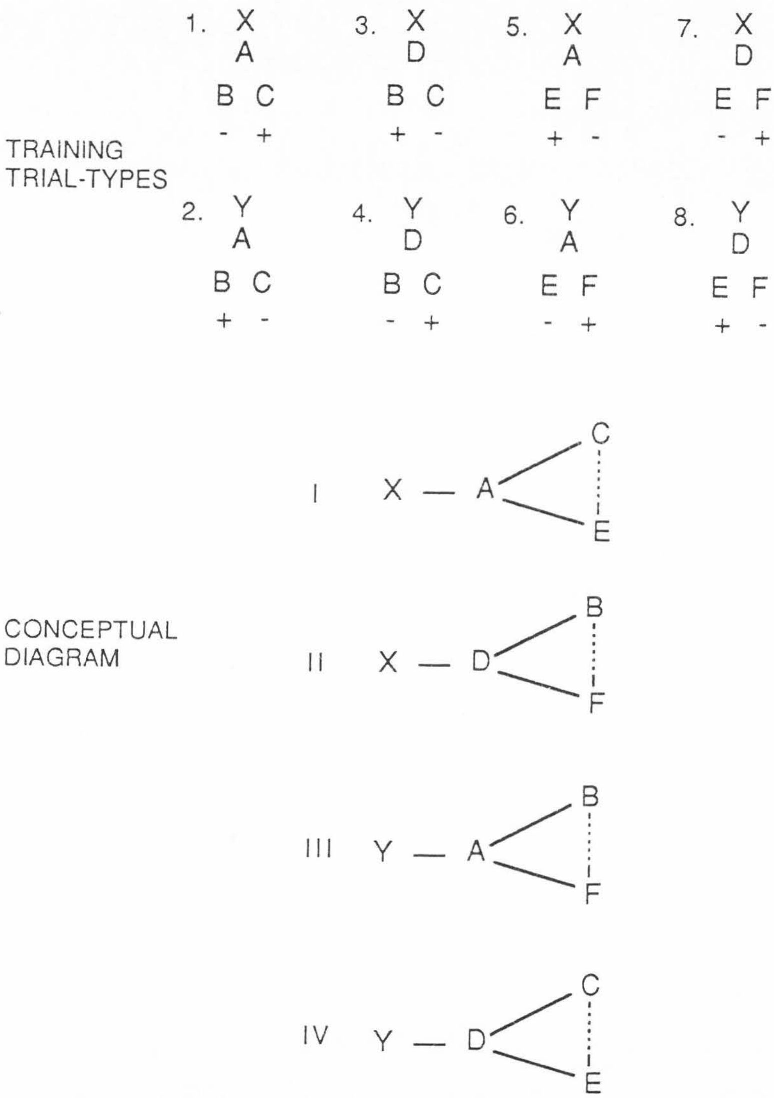


Figure 11. Trained relations (upper portion) and conceptual diagram (lower portion) for Experiment 2.

illustrated by I in the lower portion of the figure: the trained "legs" are X-AC and X-AE. The transitive (derived or untaught) relation would be X-CE. Under the second-order stimulus Y, A was trained to B (relation 2) and A was trained to F (relation 6). The conceptual result is shown in III in the lower portion of the figure. Note that while the stimulus classes conceptualized in I and III have stimulus A in common, the classes II and IV have stimulus D in common.

Experiment 2 was designed to answer the following questions: First, does the training outlined above result in four classes of equivalent stimuli under the separate control of the second-order stimuli as shown in the lower portion of Figure 11? This was tested by presenting subjects with the potentially transitive relations in probe tests. Second, what would be the effect of reversing the second-order stimuli if a subject demonstrated the equivalence classes? It was hypothesized that correct responding to probes would be disrupted given an incorrectly presented second-order stimulus; this is a result of presenting X where Y should be and Y where X should be. Third, what is the effect of removing the second-order stimuli from both probe trials that tested for transitive relations and probe trials that presented the trained trials? It was hypothesized that while the second-order stimuli were necessary for the establishment of the classes, the presence of the second-order stimuli would not be necessary for demonstration of the transitive relations since, for example, CE should result from training in both I and IV. However, it was hypothesized that without the "instructional value" of the second-order stimulus, correct responding to probes for the trained relations in the absence of the second-order stimuli should be disrupted.

Method

Subjects

Three adults who were not subjects in Experiments 1-A and 1-B served. Subjects were recruited as in Experiment 1-A. Subject 1 was a 19-year-old, female, freshman; Subject 2 was 24, female, and a freshman; and Subject 3 was 19, female, and a sophomore.

Apparatus and Stimuli

The apparatus in this experiment was the same as in Experiments 1-A and 1-B. Eight of the stimuli used in Experiments 1-A and 1-B were used in Experiment 2. These stimuli are shown in Figure 12.

Design

A probe design was used where subjects responded to probe trials designed to assess the effects of the preceding training. The cycle of training and testing

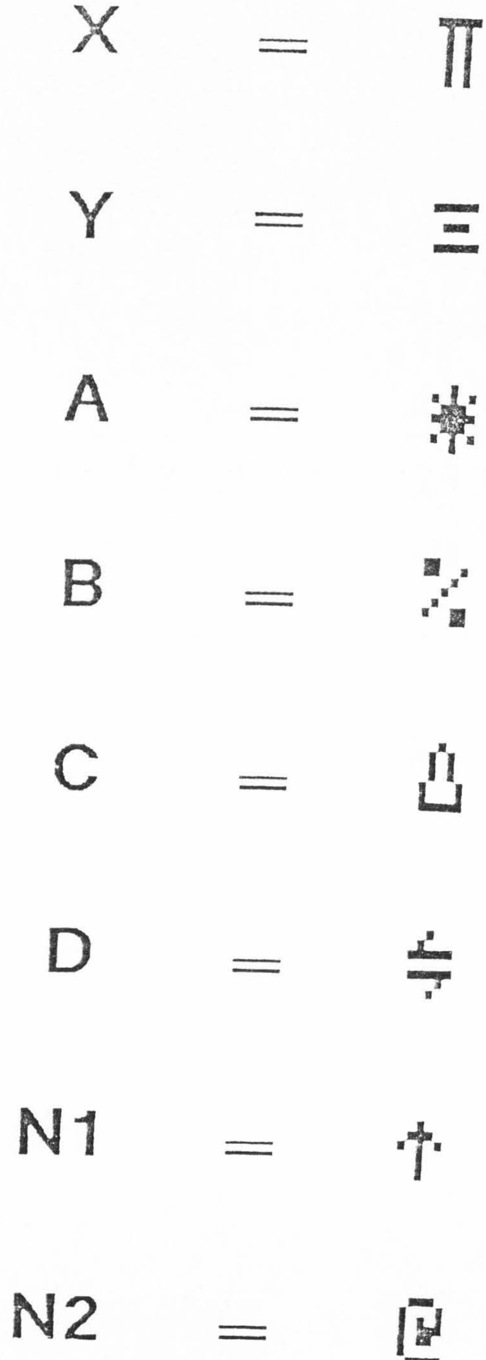


Figure 12. Stimuli used in Experiment 2.

varied with each subject depending upon their performances. This cycle is detailed in Table 13. Training and testing conditions are described below.

Training Procedures

All general procedures and pretraining in this experiment were identical to those used in Experiment 1-A. Specific training and probe conditions differed.

Initial training. Table 14 shows all of the trial-types that were trained. Training began for all subjects with the first four relations (X-AC, Y-AB, X-DB, and Y-DC) and their symmetrical counterparts for a total of eight trial-types. Subjects received correct feedback for each correct response. Ten trials of each of these trial-types were presented in each 80-trial session. To this point, the training was identical to training in Experiment 1-A.

Following two complete sessions of 90% correct responding or better, the remaining four relations in Table 14 and their symmetrical counterparts (eight trial-types) were trained separately in a manner identical to the first eight trial-types. When correct responding was 90% or greater for two consecutive sessions, the subjects were trained with new sessions consisting of all 16 trial-types. When correct responding was 90% or greater for two consecutive sessions, the frequency of feedback for correct

Table 13

Sequence of Conditions for Subjects in Experiment 2

S1	S2	S3
Train 1st eight (9) trial-types	Train 1st eight (2) trial-types	Train 1st eight (6) trial-types
Train 2nd eight (3) trial-types	Train 2nd eight (2) trial-types	Train 2nd eight (2) trial-types
Train sixteen (2) trial-types	Train sixteen (2) trial-types	Train sixteen (2) trial-types
Train (no symmetry) (2)	Train sixteen (2) trial-types (reduced feedback)	Train sixteen (2) trial-types (reduced feedback)
Train (no symmetry) (2) (reduced feedback)		
Test 2 (4) (no symm baseline)	Test 2 (5)	Test 2 (3)
	Test 3 (2)	Train (no symmetry) (2)
	Test 2 (1)	Train (no symmetry) (2) (reduced feedback)
	Test 3 (1)	Test 1 (2) (no symmetry in baseline)
	Test 4 (3)	

Note. Number of sessions shown in parentheses.

Table 14

Training Trial-types for Experiment 2

			Comparisons	
Relation	Sec-Order	Sample	Correct	Incorrect
X-AC	X	A	C	B
	X	C	A	B
Y-AB	Y	A	B	C
	Y	B	A	C
X-DB	X	D	B	C
	X	B	D	C
Y-DC	Y	D	C	B
	Y	C	D	B
X-AE	X	A	E	F
	X	E	A	F
Y-AF	Y	A	F	E
	Y	F	A	E
X-DF	X	D	F	E
	X	F	D	E
Y-DE	Y	D	E	F
	Y	E	D	F

responding was lowered to 25% of the correct trials in the 80-trial sessions. As in Experiment 1-A, the correction procedure was not in effect during reduced feedback.

Training with no symmetry trials. Subsequent to the initial training, Subject 1 and Subject 2 were given training trials that were identical to those described in the initial training except that they contained no symmetrical trial-types. This is illustrated by only the top lines of each of the eight relations shown in Table 14.

Probe Tests

As in Experiment 1-A and 1-B, each probe session consisted of twenty-four unreinforced probes randomly inserted into a baseline of all the training trial-types with feedback to the subject on 25% of correct trials. The correction procedure was never in effect during test sessions. The number of probe-test sessions varied for each subject. These are shown in Table 13.

Test 1. These probes were designed to test for symmetrical relations following training sessions that contained no symmetrical trial-types. Only Subject 3 was tested with these probes. Test 1 probe trial-types are shown in Table 15. These symmetrical probes differ from the symmetrical trial-types used in training.

Rather than simply reversing the sample and correct comparison--with all other stimuli remaining the same--to produce symmetrical trial-types, Test 1 probes consisted of the second-order stimulus, the original

Table 15

Probe Trial-Types for Test 1

1. X-C(A D)	5. X-E(A D)
2. Y-B(A D)	6. Y-F(A D)
3. X-B(D A)	7. X-F(D A)
4. Y-C(D A)	8. Y-E(D A)

sample and correct comparison reversed, and the remaining, unused sample as the incorrect comparison.

Test 2. These probes were designed to test for the emergence of the derived relations (see Figure 11) under the control of the second-order stimulus within each of the four, three-member stimulus classes. As shown in the upper portion of Table 16, each relation (e.g., X-CE) was tested with three different incorrect comparisons. In addition, each relation was tested for the symmetrical relation.

Test 3. Because of her performance on Test 2 probes, Subject 2 received sessions with Test 3 probes.

Table 16

Relations and Trial-Types for Test 2 and Test 3 Probes of Experiment 2

TEST 2 TRIAL-TYPES

Relation	Sec-Order		Sample	Comparisons	
X-CE	1.	X	C	E	D
	2.	X	E	C	D
	3.	X	C	E	B
	4.	X	E	C	B
	5.	X	C	E	F
	6.	X	E	C	F
Y-CE	1.	Y	C	E	A
	2.	Y	E	C	A
	3.	Y	C	E	B
	4.	Y	E	C	B
	5.	Y	C	E	F
	6.	Y	E	C	F
X-BF	1.	X	B	F	A
	2.	X	F	B	A
	3.	X	B	F	E
	4.	X	F	B	E
	5.	X	B	F	C
	6.	X	F	B	C
Y-BF	1.	Y	B	F	D
	2.	Y	F	B	D
	3.	Y	B	F	E
	4.	Y	F	B	E
	5.	Y	B	F	C
	6.	Y	F	B	C

TEST 3 TRIAL-TYPES

Y-CE	Y	C	E	D
	Y	E	C	D
X-CE	X	C	E	A
	X	E	C	A
Y-BF	Y	B	F	A
	Y	F	B	A
X-BF	X	B	F	D
	X	F	B	D

These probes were designed to test the potential disrupting effect of reversing the second-order stimulus. By reversing the second-order stimulus in some of the Test 2 configuations, new trial-types (Test 3) were produced where both comparisons were potentially related to the sample via the second-order stimulus. The trial-types probed in this set are shown in the bottom portion of Table 16. Each of the two trial-types for each relation in Test 3 were identical to the first two trial-types of each relation in Test 2 with the following exception: In each of the four relations in Test 3, the second-order stimulus has been reversed from the one in Test 2 probes. For example, in Test 2, the second-order stimulus, X, of the trial-type, X-C(E D), has been changed to Y, as in the trial-type, Y-C(E D) in Test 3.

Test 4. Because of her performance on Tests 2 and 3, Subject 2 was tested with probes from Test 4 (see Table 17). Test 4 probes were designed to test the effects of removing the second-order stimulus from transitivity probes and trials resembling training trials. Thus, as shown in Table 17, relations 0-CE and 0-BF were identical to Test 2 probes for transitivity except that the second-order stimulus was not presented. The remaining probe trial-types of Test 4 were identical to training trials except that the second-order stimulus

Table 17

Test 4 Probes for Experiment 2

Relation	Sec-Order	Sample	Comparisons	
0-CE	0	C	E	F
	0	E	C	F
	0	C	E	B
	0	E	C	B
0-BF	0	B	F	E
	0	F	B	E
	0	B	F	C
	0	F	B	C
0-AC	0	A	C	B
	0	C	A	B
0-AE	0	A	E	F
	0	E	A	F
0-DB	0	D	B	C
	0	B	D	C
0-DF	0	D	F	E
	0	F	D	E
0-AB	0	A	B	C
	0	B	A	C
0-AF	0	A	F	E
	0	F	A	E
0-DC	0	D	C	B
	0	C	D	B
0-DE	0	D	E	F
	0	E	D	F

was not presented. As in Experiment 1-A, on probes that contained no second-order stimulus in the trial-type, the first stimulus to appear was the sample.

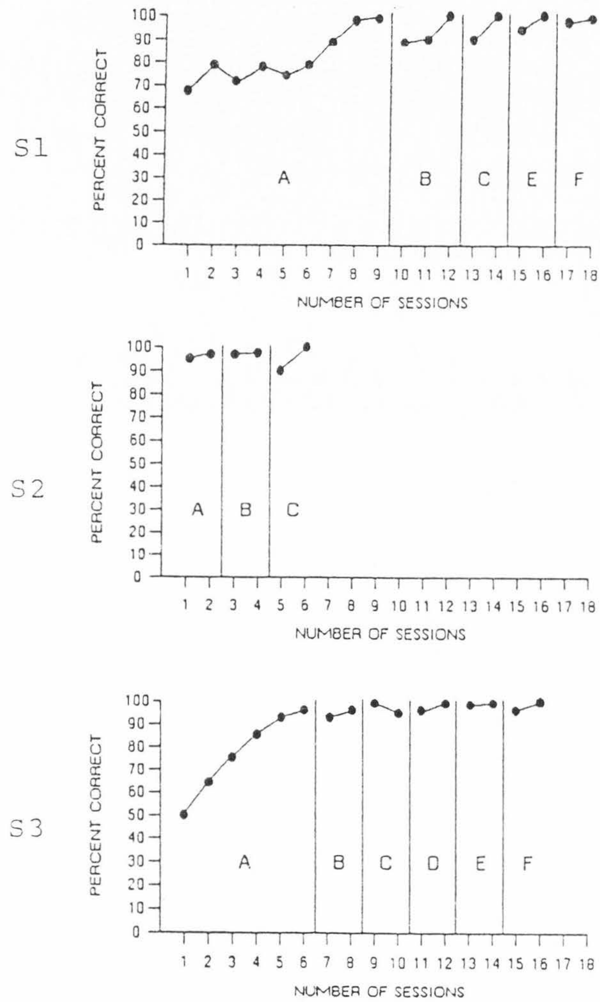
Results and Discussion

Training

Figure 13 shows the results of the Training sessions for Subjects 1, 2, and 3. As shown, the subjects varied greatly in the number of sessions to the training criterion with the first eight trial-types. Subject 2 learned the first eight trial-types (phase A) very quickly reaching criterion in two sessions. Subject 3 learned the first eight trial-types in six sessions while Subject 1 took nine sessions to reach criterion performance. All subjects learned the next eight trial-types within three sessions. All subjects met criterion with all 16 trial-types within the minimum two sessions. When the correct feedback was reduced, all subjects reached criterion responding within the minimum two sessions.

Subject 1 was given four additional sessions of training trials that contained no symmetrical trial-types before Test 2 probes were presented. Subject 1 reached the training criterion for both the 100% and 25% feedback conditions in the minimum number of sessions (2).

Each subject in Experiment 2 was tested with



<u>Figure 13</u>. Results of training conditions for Subjects 1, 2, and 3. A = first 8 trial-types; B = second 8 trial-types; C = all 16 trial-types; D = all 16 trial-types--reduced feedback; E = training with no symmetry trials; F = training with no symmetry trials--reduced feedback.

differing orders of probe tests and different numbers of sessions for each probe test as a function of individual training and probe performance. Hence, the results of the probe tests are presented separately for each subject.

Probe Tests: Subject 3

Test 2. The results of Test 2 probes for Subject 3 are shown in Table 18. The bottom line of the table shows the percent correct responding to probes for each session. During sessions one and two, responding to probes was at chance levels. During session 3, no correct responses were made.

A closer examination of Table 18 shows that no correct responses were made in any session when the second comparison was either D or A regardless of the relation being tested. If the means for correct responding to a session of Test 2 probes are calculated with all trial-types which contained D or A as the incorrect comparison removed, then the percentages would be 75%, 88%, and 0% for sessions 1, 2, and 3 respectively.

One reason that there may have been a greater tendency to respond to the D and A stimuli in Test 2 probes was the greater frequency with which they were reinforced during training. Table 19 shows the number of times in each session that each comparison appeared

Table 18

Results of Test 2 Probes in Experiment 2 for Subject 3

Relation	Trial-Type	Session 1	Session 2	Session 3
X-CE	X-C(E D)	0/1	0/1	0/1
	X-C(E B)	1/1	1/1	0/1
	X-C(E F)	1/1	0/1	0/1
X-EC	X-E(C D)	0/1	0/1	0/1
	X-E(C B)	0/1	1/1	0/1
	X-E(C F)	1/1	1/1	0/1
Y-CE	Y-C(E A)	0/1	0/1	0/1
	Y-C(E B)	1/1	1/1	0/1
	Y-C(E F)	0/1	1/1	0/1
Y-EC	Y-E(C A)	0/1	0/1	0/1
	Y-E(C B)	1/1	1/1	0/1
	Y-E(C F)	1/1	1/1	0/1
X-BF	X-B(F A)	0/1	0/1	0/1
	X-B(F E)	1/1	1/1	0/1
	X-B(F C)	1/1	1/1	0/1
X-FB	X-F(B A)	0/1	0/1	0/1
	X-F(B E)	1/1	1/1	0/1
	X-F(B C)	0/1	1/1	0/1
Y-BF	Y-B(F D)	0/1	0/1	0/1
	Y-B(F E)	1/1	1/1	0/1
	Y-B(F C)	1/1	0/1	0/1

(Table 18 continued)

Y-FB	Y-F(B D)	0/1	0/1	0/1
	Y-F(B E)	1/1	1/1	0/1
	Y-F(B C)	0/1	1/1	0/1
Mean Percent Correct per Session		50%	58%	00%

as correct and incorrect for each of the 16 trial-types used in training. Note that stimuli D and A were

Table 19

Frequency Per Session of Correct and Incorrect Stimuli for each Comparison Stimulus

Correct	Incorrect
A - 20	A - 0
B - 10	B - 20
C - 10	C - 20
D - 20	D - 0
E - 10	E - 20
F - 10	F - 20

correct 20 times each and did not appear at all as incorrect comparisons during training. A closer examination of the training trial-types (see Table 14) reveals that this was the result of the method used to set up the symmetrical trial-types: simply reversing the correct comparison and the sample to produce symmetry trial-types.

Test 1. Before Test 1 probes were presented, Subject 3 was given four additional sessions of training (two at 100% correct feedback and two at 25% correct feedback) that were identical to those in the initial training except that no symmetrical trials were present. Subject 3 met criteria in the minimum number of sessions. The trial-types from these training sessions were used as the baseline into which Test 1 probes were inserted.

The results from Test 1 probes with Subject 3 are shown in Table 20. These results indicate that Subject 3 did not demonstrate symmetrical relations.

Probe Tests: Subject 1

Subject 3 completed the probe tests from Experiment 2 before Subject 1 had completed the initial training. Because Subject 3 did not demonstrate transitivity, and because the original symmetrical trial-types in the initial training might have precluded such performance, Subject 1 was given additional training sessions with trials containing no symmetrical trial-types. The training criteron was met in the minimum number (2) of sessions.

Test 2. Subject 1 was presented with Test 2 probes that were identical to the Test 2 probes presented to Subject 3 except that the baseline into which the probes were inserted contained no symmetrical trials.

The results of Test 2 probes with Subject 1 are shown in Table 21. Across the four sessions of Test 2 probes, percent correct responding was below chance

Table 20

Results of Test 1 Probes in Experiment 2 for Subject 3

Trial-Type	Session	
	1	2
1. X-C(A D)	3/3	2/3
2. Y-B(A D)	3/3	3/3
3. X-B(D A)	0/3	2/3
4. Y-C(D A)	3/3	2/3
5. X-E(A D)	2/3	3/3
6. Y-F(A D)	2/3	3/3
7. X-F(D A)	0/3	1/3
8. Y-E(D A)	2/3	1/3
Mean Percent Correct per Session	63%	71%

Table 21

Results of Test 2 Probes for Subject 1

Relation	Trial-Type		Session			
			1	2	3	4
X-CE	1.	X-C(E D)	1/1	1/1	0/1	0/1
	2.	X-C(E B)	1/1	0/1	0/1	0/1
	3.	X-C(E F)	0/1	0/1	1/1	0/1
X-EC	1.	X-E(C D)	0/1	0/1	0/1	0/1
	2.	X-E(C B)	0/1	0/1	0/1	0/1
	3.	X-E(C F)	0/1	0/1	1/1	1/1
Y-CE	1.	Y-C(E A)	1/1	0/1	1/1	1/1
	2.	Y-C(E B)	0/1	0/1	0/1	0/1
	3.	Y-C(E F)	1/1	1/1	0/1	1/1
Y-EC	1.	Y-E(C A)	0/1	0/1	0/1	0/1
	2.	Y-E(C B)	0/1	0/1	0/1	0/1
	3.	Y-E(C F)	1/1	0/1	1/1	1/1
X-BF	1.	X-B(F A)	0/1	0/1	0/1	0/1
	2.	X-B(F E)	0/1	0/1	0/1	0/1
	3.	X-B(F C)	1/1	0/1	0/1	0/1
X-FB	1.	X-F(B A)	1/1	1/1	1/1	1/1
	2.	X-F(B E)	0/1	0/1	0/1	0/1
	3.	X-F(B C)	0/1	0/1	0/1	1/1
Y-BF	1.	Y-B(F D)	0/1	0/1	0/1	0/1
	2.	Y-B(F E)	0/1	0/1	0/1	0/1
	3.	Y-B(F C)	0/1	0/1	0/1	0/1

(Table 21 continued)

Y-FB	1.	Y-F(B D)	1/1	1/1	1/1	0/1
	2.	Y-F(B E)	0/1	0/1	0/1	0/1
	3.	Y-F(B C)	0/1	1/1	0/1	0/1
Mean Percent Correct per Session			30%	33%	25%	25%

levels (i.e., 50% correct) indicating the absence of the transitive relations. Unlike Subject 3, Subject 1 did not demontrate a strong tendency to respond to the A and D stimuli during probes. Of the 32 opportunities to do so, 20 responses were made to D or A when they appeared as comparison stimuli.

Probe Tests: Subject 2.

Subsequent to the initial training, Subject 2 was presented with Test 2 probes to test for transitivity. Because of Subject 2's performance, Test 2 probes were followed by Test 3 probes which assessed the results of reversing the second-order stimulus. These two probe tests were then replicated with a session each. Finally, Subject 2 was presented with Test 3 probes that were designed to assess the effects of removing the second-order stimulus from transitive and trained trials.

Test 2. The results of Test 2 probes are shown in Table 22. In the first session, Subject 2 only scored 38% correct. However, the percent correct per session increased until Subject 2 demonstrated 100% correct on the final session indicating the presence of the transitive relations.

Test 3. Because Subject 2 demonstrated the transitive relations via Test 2 probes, Test 3 probes,

Table 22

Results of Test 2 Probes for Subject 2

Relation	Trial-Type	Session			
		1	2	3	4
X-CE	1. X-C(E D)	0/1	1/1	0/1	1/1
	2. X-C(E B)	0/1	1/1	0/1	1/1
	3. X-C(E F)	0/1	0/1	1/1	1/1
X-EC	1. X-E(C D)	0/1	0/1	1/1	1/1
	2. X-E(C B)	0/1	0/1	1/1	1/1
	3. X-E(C F)	0/1	0/1	1/1	1/1
Y-CE	1. Y-C(E A)	0/1	0/1	1/1	1/1
	2. Y-C(E B)	0/1	0/1	1/1	1/1
	3. Y-C(E F)	0/1	0/1	1/1	1/1
Y-EC	1. Y-E(C A)	0/1	0/1	1/1	1/1
	2. Y-E(C B)	0/1	0/1	1/1	1/1
	3. Y-E(C F)	0/1	0/1	1/1	1/1
X-BF	1. X-B(F A)	0/1	0/1	1/1	1/1
	2. X-B(F E)	1/1	1/1	1/1	1/1
	3. X-B(F C)	1/1	1/1	1/1	1/1
X-FB	1. X-F(B A)	0/1	1/1	1/1	1/1
	2. X-F(B E)	1/1	1/1	1/1	1/1
	3. X-F(B C)	1/1	1/1	1/1	1/1
Y-BF	1. Y-B(F D)	0/1	1/1	1/1	1/1
	2. Y-B(F E)	1/1	1/1	1/1	1/1
	3. Y-B(F C)	1/1	1/1	1/1	1/1

(Table 22 continued)

Y-FB	1.	Y-F(B D)	1/1	1/1	0/1	1/1
	2.	Y-F(B E)	1/1	1/1	1/1	1/1
	3.	Y-F(B C)	1/1	1/1	1/1	1/1
Mean Percent Correct per Session			38%	58%	83%	100%

which reversed the second-order stimulus for trial-types from Test 2, were presented. The results of this probe test are shown in Table 23. Although neither comparison was "correct" --both comparisons potentially could be in a relation with the sample via the second-order stimulus-- choices to CE, EC, BF, or FB were scored as correct for purposes of calculating the percent correct for a given session. As shown in Table 23, the subject did not continue to respond to the transitive relations as she did during Test 2 probes. As shown by the percent "correct" scores of 21 and 25 for the first and second sessions, respectively, Subject 2 made a majority of responses away from the transitive comparison.

Test 2 and Test 3 replication. As shown in Table 24, the results of Test 2 and Test 3 probes were replicated with one session of each test. Test 2 probes remained at 100% correct responding while reversing the second-order stimulus in Test 3 probes again decreased the percentage of correct responses (13%).

Test 4. Because Subject 2 clearly demonstrated transitive relations, three sessions of Test 4 probes were presented. Within each session were probes designed to test the transitive relations in the absence of the second-order stimulus (see top portion of Table 25) as well as the trained relations in the absence of

Table 23

Results of Test 3 Probes for Subject 2

Relation	Trial-Type	Session 1	Session 2
Y-CE	Y-C(E D)	1/3	0/3
	Y-E(C D)	1/3	0/3
X-CE	X-C(E A)	0/3	0/3
	X-E(C A)	0/3	0/3
Y-BF	Y-B(F A)	0/3	2/3
	Y-F(B A)	1/3	1/3
X-BF	X-B(F D)	0/3	0/3
	X-F(B D)	2/3	2/3
Percent "Correct" per Session		21%	25%

Table 24

Results of Test 2 and Test 3 Replication Probes for Subject 2

Test 2			Test 3		
Relation	Trial-Type	Session 1	Relation	Trial-Type	Session 1
X-CE	1. X-C(E D)	1/1	Y-CE	1. Y-C(E D)	0/3
	2. X-C(E B)	1/1			
	3. X-C(E F)	1/1			
X-EC	1. X-E(C D)	1/1	Y-EC	1. Y-E(C D)	0/3
	2. X-E(C B)	1/1			
	3. X-E(C F)	1/1			
Y-CE	1. Y-C(E A)	1/1	X-CE	1. X-C(E A)	0/3
	2. Y-C(E B)	1/1			
	3. Y-C(E F)	1/1			
Y-EC	1. Y-E(C A)	1/1	X-EC	1. X-E(C A)	0/3
	2. Y-E(C B)	1/1			
	3. Y-E(C F)	1/1			
X-BF	1. X-B(F A)	1/1	Y-BF	1. Y-B(F A)	1/3
	2. X-B(F E)	1/1			
	3. X-B(F C)	1/1			
X-FB	1. X-F(B A)	1/1	Y-FB	1. Y-F(B A)	1/3
	2. X-F(B E)	1/1			
	3. X-F(B C)	1/1			

(Table 24 continued)

Y-BF	1.	Y-B(F D)	1/1	X-BF	1.	X-B(F D)	0/3
	2.	Y-B(F E)	1/1				
	3.	Y-B(F C)	1/1				
Y-FB	1.	Y-F(B D)	1/1	X-FB	1.	X-F(B D)	1/3
	2.	Y-F(B E)	1/1				
	3.	Y-F(B C)	1/1				
Mean Percent Correct per Session			100%				13%

Table 25

Results of Test 4 Probes for Subject 3

Relation	Trial-Type	Session 1	Session 2	Session 3
0-CE	0-C(E F)	1/1	1/1	1/1
	0-C(E B)	1/1	1/1	1/1
0-EC	0-E(C F)	1/1	1/1	1/1
	0-E(C B)	1/1	1/1	1/1
0-BF	0-B(F E)	1/1	1/1	1/1
	0-B(F C)	1/1	1/1	1/1
0-FB	0-F(B E)	1/1	1/1	1/1
	0-F(B C)	1/1	1/1	1/1
Percent Correct per Session		100%	100%	100%
0-AC	0-A(C B)	1/1	1/1	1/1
0-CA	0-C(A B)	1/1	1/1	1/1
0-AE	0-A(E F)	1/1	1/1	1/1
0-EA	0-E(A F)	1/1	1/1	1/1
0-DB	0-D(B C)	0/1	0/1	1/1
0-BD	0-B(D C)	1/1	1/1	1/1
0-DF	0-D(F E)	0/1	0/1	0/1
0-FD	0-F(D E)	1/1	1/1	1/1
0-AB	0-A(B C)	0/1	0/1	1/1
0-BA	0-B(A C)	1/1	1/1	1/1
0-AF	0-A(F E)	0/1	0/1	0/1

(Table 25 continued)

0-FA	0-F(A E)	1/1	1/1	1/1
0-DC	0-D(C B)	1/1	1/1	1/1
0-CD	0-C(D B)	1/1	1/1	1/1
0-DE	0-D(E F)	1/1	1/1	1/1
0-ED	0-E(D F)	1/1	1/1	1/1
Percent "Correct" per Session		63%	63%	88%

Note. A zero in place of the second-order stimulus denotes the absence of the second-order stimulus. The top portion of Table 25 represents the transitive probes in the absence of the second-order stimulus while the lower portion of Table 25 represents probes of the trained relations in the absence of the second-order stimulus. In the lower portion of the table, neither stimulus was "correct", though the left comparison was scored as such.

the second-order stimulus (see lower portion of Table 25) Subject 3 demonstrated transitive relations in the absence of the second-order stimulus with 100% accuracy throughout all three sessions of Test 4 probes.

As shown in the lower portion of Table 25, each of the 16 trained trial-types, minus the second-order stimulus, were also presented in Test 4 as probe trials. During training, the second-order stimulus instructed which comparison would be correct with the sample. Removing the second-order stimulus, and presenting these trial-types should result in something other than 100% performance since neither stimulus was "correct". The percent correct scores for these probes were 63, 63, and 88 for sessions one, two, and three, respectively.

General Discussion: Experiment 2

Of the three subjects in Experiment 2, only Subject 2 demonstrated the transitive relations. In doing so, only Subject 2 demonstrated four, functionally separate, equivalent classes of stimuli under second-order control.

If, during the formation of equivalence classes, it is found that a subject is not demonstrating one of the trained relations and, at the same time, not demonstrating equivalence relations, then, logically, training the deficient relation of the potential equivalence class should result in transitivity (cf.

Sidman & Tailby, 1982). This logic cannot be used to explain the absence of transitivity with Subjects 1 and 3 since responding to the trained relations in the baseline into which the tests were inserted, was, at all times, above 90% correct. Hence, factors other than that just described must have accounted for the results.

One possible source of control accounting for the absence of transitive relations with Subject 3 was the disproportionate number of times that stimuli A and D appeared as correct comparisons during training. Such valence (cf. Fields et al. 1984) may have produced a tendency to respond to the A and D stimuli during the probes. Since A and D were incorrect during probe trials, correct responding would be less than 100%. Also, the trial-types in which A and D stimuli appeared as incorrect were identical to other probe trial-types with the exception of a different incorrect comparison. Hence, it is possible that generalization of incorrect responding occurred. Evidence for this comes from the fact that correct responding decreased to 0% across the three Test 2 probe sessions for Subject 3.

It was thought that by removing the symmetry trials in training for Subject 1, the tendency to respond to A and D stimuli during Test 2 probes would be reduced, resulting in the transitive relations. The tendency to respond to A and D stimuli was not as strong as in

Subject 3 but the transitive relations did not emerge.

Another effect from the disproportionate number of A and D stimuli appearing as correct comparisons was the possibility that neither Subject 1 or 3 actually learned some of the trained relations. Since stimuli A and D only appeared as correct stimuli, the subject only needed to respond to A or D when they appeared as comparisons without attending to the rest of the trial-type. A similar result has been noted by Osborne and Barnard (1987). Thus, while baseline correct percentages remained high, the subjects may not have actually demonstrated the trained relations in the manner necessary for the emergence of the transitive ones. Some evidence for this comes from the symmetry probes presented to Subject 3. Symmetry was not demonstrated, and, thus, neither was a necessary property of equivalence relations.

Why Subject 2 did not demonstrate the same problems with transitivity as did Subjects 1 and 3 is unknown. Subject 2 performed all probe tests as expected. Once it was established that the transitive relations were present, the second-order stimuli were reversed in Test 3 probes. This resulted in the presentation of the second-order stimulus, the sample, and two comparisons--one of which was transitively related to the sample, and the other related to the sample through training.

As expected, for Subject 2, 100% correct responding to the transitive relations was disrupted by the reversal of the second-order stimuli. This effect was replicated by repeating Tests 2 and 3. In essence, these results showed that, as would logically be expected, having to choose two comparisons from the same class (as defined by the second-order stimulus) does not result in a consistent choice of one stimulus over another since both are related to the sample. However, if one comparison is from the same equivalence class as the sample, yet the other is from a different class (as in Test 2 probes), the subject will choose the stimulus from the same class. These results suggest further evidence that the training for Subject 2 resulted in four three-member stimulus classes that functioned separately even though some had stimuli in common.

As shown in Figure 11, the transitive relations, CE and BF should have resulted twice each in the four stimulus classes via different second-order stimuli and samples. These did in fact result with Subject 2. Once the classes were established, Test 4 probes demonstrated that the second-order stimulus was not necessary for correct responding to the transitive relations, CE/EC and BF/FB, but was necessary for responding to trained relations.

EXPERIMENT 3-A

In Experiment 2, only one of the three subjects demonstrated the transitive relations necessary for inferring conditional control of equivalence relations. It was found that the training trial-types used during symmetrical trials were a likely alternate source of control for subjects who did not demonstrate responding consistent with conditional control of equivalence relations.

In Experiment 3-A, two subjects from Experiment 2 were given additional training sessions similar to training in Experiment 2. The difference in training, however, was that each comparison stimulus appeared equally often as correct and incorrect. The experimental question was whether this training would result in demonstrations of transitive relations by Subjects 1 and 3.

Method

Subjects

The subjects of Experiment 3-A were Subjects 1 and 3 from Experiment 2.

Apparatus and Stimuli

The apparatus and stimuli used in this Experiment were the same as in Experiment 2.

Design

As in Experiment 2, a probe design was used. The cycle of training, testing and number of sessions varied with each subject. This cycle is detailed in Table 26. The training and testing conditions are described below.

Training Procedures

All general training procedures in this experiment, including correction and no correction procedures corresponding to different feedback conditions, were identical to those used in Experiment 2. Specific training and probe conditions differed.

Training trials. All subjects were given training sessions that contained the sixteen trial-types shown in Table 27. The first trial-types of each relation was identical to those used in Experiment 2. The symmetrical trial-types of each relation were also identical to those used in Experiment 2 with the exception of the incorrect comparison. In Experiment 2, symmetrical trial-types were formed by simply reversing the the sample and correct comparison leaving all other stimuli the same. For example, the trial-type for the relation X-AC was X-A(C* B) while the symmetrical counterpart was X-C(A* B). The symmetrical trial-types used in training in Experiment 3-A were formed by

Table 26

Sequence of Conditions for Subjects in Experiment 3-A

S1		S3	
Train sixteen trial-types	(3)	Train sixteen trial-types	(2)
Train sixteen trial-types (reduced feedback)	(3)	Train sixteen trial-types (reduced feedback)	(2)
Test 2	(2)	Test 2	(2)
Test 4 (reduced feedback)	(1)	Train sixteen trial-types	(1)
		Test 2	(2)

Note. The training and testing are listed in the order of occurrence for each subject. Tables 27, 28, and 29 list the stimulus arrays corresponding to the training and testing conditions for each subject. The number of sessions for each condition is shown in parentheses.

Table 27

Training Trial-Types for Experiment 3-A

			Comparisons	
Relation	Sec-Order	Sample	Correct	Incorrect
X-AC	X	A	C	B
	X	C	A	D
Y-AB	Y	A	B	C
	Y	B	A	D
X-DB	X	D	B	C
	X	B	D	A
Y-DC	Y	D	C	B
	Y	C	D	A
X-AE	X	A	E	F
	X	E	A	D
Y-AF	Y	A	F	E
	Y	F	A	D
X-DF	X	D	F	E
	X	F	D	A
Y-DE	Y	D	E	F
	Y	E	D	A

reversing the sample and correct comparison, but, in addition, inserting the remaining, unused sample as the incorrect comparison. Keeping the example used above, the trial-type for the relation X-AC was X-A(C* B) while the symmetrical counterpart was X-C(A* D) in the present experiment. Thus, just as C and B, and E and F always appear as comparisons together--and, therefore equally often as correct and incorrect comparisons--so do A and D always appear as comparisons together.

Probe Tests

As in Experiment 2, each probe session consisted of twenty-four unreinforced probes randomly inserted into a baseline of all the training trial-types with feedback to the subject at 25% of correct responses. The correction procedure was never in effect during test sessions. The number of probe-test sessions for each subject varied (see Table 26).

Test 2. As in Experiment 2, Test 2 probes from Experiment 3-A were designed to test for the emergence of the four transitive relations. Unlike Test 2 probes from Experiment 2, Test 2 probe trial-types from Experiment 3-A were not repeated with different incorrect comparisons. Rather, the comparisons reflected the pairing of stimulus E with F and C with B as used in training and probe baselines. Each trial-type is shown in Table 28. Since there were only eight

Table 28

Relations and Trial-Types for Test 2 Probes of Experiment 3-A

Relation	Sec-Order	Sample	Comparisons	
X-CE	X	C	E	F
X-EC	X	E	C	B
Y-CE	Y	C	E	F
Y-EC	Y	E	C	B
X-BF	X	B	F	E
X-FB	X	F	B	C
Y-BF	Y	B	F	E
Y-FB	Y	F	B	C

probe trial-types, each appeared three times during a probe session.

Test 4. Because of her performance on Test 2 probes, Subject 2 was given a session of Test 4 probes (see Table 29). As in Experiment 2, these probes were designed to assess the effect of removing the second-order stimulus from transitive and trained relations. These probes were identical to Test 2 probes with the second-order stimulus removed and to the training trial-types with the second-order stimulus removed.

Results and Discussion

Training

Both subjects were able to respond to the training sessions--100% and 25% feedback--to criteria within a few sessions (see Table 30).

Table 29

Test 4 Probes from Experiment 3-A

Relation	Sec-Order	Sample	Comparisons	
0-CE	0	C	E	F
	0	E	C	B
0-BF	0	B	F	E
	0	F	B	C
0-AC	0	A	C	B
	0	C	A	D
0-AE	0	A	E	F
	0	E	A	D
0-DB	0	D	B	C
	0	B	D	A
0-DF	0	D	F	E
	0	F	D	A
0-AB	0	A	B	C
	0	B	A	D
0-AF	0	A	F	E
	0	F	A	D
0-DC	0	D	C	B
	0	C	D	A
0-DE	0	D	E	F
	0	E	D	A

Note. Each line depicts a relation and probe trial-type. The "0" denotes the absence of the second-order stimulus. Within each relation, the symmetrical trial-type is also presented. The first two relations are the transitive relation probes and the second eight are the trained relation probes.

Table 30

Results of Training for Experiment 3-A

	Subject 1	Subject 2
Training	86%	98%
	94%	98%
	96%	
Training (Reduced feedback)	99%	100%
	100%	100%
	100%	

Probe Tests: Subject 1

Test 2. The results of Test 2 probes for Subject 1 are shown in Table 31. In the first Test 2 probe session, Subject 1 responded to probes with only 38% accuracy. However, in the second session, Subject 1 only missed a single probe trial-type, X-E(C B), thereby demonstrating the transitive relations.

Test 4. Because Subject 1 demonstrated transitivity on Test 2 probes, Test 4 probes were presented. Only a single session of Test 4 probes was presented to Subject 1. (Subject 1 terminated participation in the experiment entirely following this session.) As shown in the upper portion of Table 32, Subject 1 responded incorrectly once each to relations

Table 31

Results of Test 2 Probes for Subject 1

Relation	Trial-Type	Session	
		1	2
X-CE	X-C(E F)	1/3	3/3
X-EC	X-E(C B)	1/3	2/3
Y-CE	Y-C(E F)	1/3	3/3
Y-EC	Y-E(C B)	1/3	3/3
X-BF	X-B(F E)	0/3	3/3
X-FB	X-F(B C)	1/3	3/3
Y-BF	Y-B(F E)	2/3	3/3
Y-FB	Y-F(B C)	2/3	3/3
Percent Correct per Session		38%	96%

Table 32

Results of Test 4 Probes for Subject 1 during Experiment 3-A

Relation	Trial-Type	Session
0-CE	0-C(E F)	1/2
0-EC	0-E(C B)	1/2
0-BF	0-B(F E)	2/2
0-FB	0-F(B C)	2/2
Percent Correct per Session		75%
0-AC	0-A(C B)	2/2
0-CA	0-C(A D)	2/2
0-AE	0-A(E F)	0/2
0-EA	0-E(A D)	1/2
0-DB	0-D(B C)	0/2
0-BD	0-B(D A)	1/2
0-DF	0-D(F E)	1/2
0-FD	0-F(D A)	0/2
Percent Correct per Session		44%

Note. A zero in place of the second-order stimulus denotes the absence of the second-order stimulus. The top portion of Table 32 represents the transitive probes in the absence of the second-order stimulus while the lower portion of Table 32 represents probes of the trained relations in the absence of the second-order stimulus. In the lower portion of the table, neither stimulus was "correct", though the left comparison was scored as such.

0-CE and 0-EC. However, all responses to 0-BF and 0-FB were correct. As expected, no systematic responding occurred to the probes representing training trials minus the second-order stimulus (see lower portion of Table 32).

Probe Tests: Subject 3

Test 2. Table 33 shows the results of Test 2 probes for Subject 3. In the first session, Subject 3 only responded incorrectly to one trial-type, X-C(E F). Thus, Subject 3 demonstrated the transitive relations during the first session. However, during the second session of Test 2 probes, the percentage of correct responding decreased to 46%.

Subject 3 then received one session of trained trial-types alone at 100% feedback for correct responding. Although the baseline percent correct responding remained greater than 90, it was expected that reinforcing the trained relations would increase the likelihood of recovering the transitive relations.

However, as shown in Table 33, percent correct responding to the transitive probes during sessions 3 and 4 remained at chance levels. Thus, the additional reinforcement of the trained relations was not sufficient to recover the demonstration of the transitive relations.

Table 33

Results of Test 2 Probes for Subject 3 in Experiment 3-A

Relation	Trial-Type	Session 1	2	3	4	5
X-CE	X-C(E F)	2/3	3/3	3/3	2/3	2/3
X-EC	X-E(C B)	3/3	2/3	2/3	2/3	2/3
Y-CE	Y-C(E F)	3/3	1/3	1/3	1/3	1/3
Y-EC	Y-E(C B)	3/3	0/3	2/3	2/3	1/3
X-BF	X-B(F E)	3/3	0/3	1/3	0/3	2/3
X-FB	X-F(B C)	3/3	2/3	2/3	1/3	1/3
Y-BF	Y-B(F E)	3/3	1/3	0/3	3/3	2/3
Y-FB	Y-F(B C)	3/3	2/3	1/3	2/3	2/3
Percent Correct per Session		96%	46%	50%	54%	54%

Note. Between the second and third session, the subject received one session of training trials at 100% feedback for correct responses. See text for details.

General Discussion: Experiment 3-A

Both subjects in Experiment 3-A demonstrated transitive relations under the control of the second-order stimulus. However, Subject 3 demonstrated transitive relations for only the first session of probe trials. Subsequent sessions that tested for transitive relations with Subject 3 resulted in chance performance.

It appears that the new training used in this experiment, in which comparison stimuli appeared equally often as correct and incorrect, was sufficient to produce five-term stimulus control of equivalence classes with Subject 1 and, at least for the first probe session, with Subject 3 where no such control was evident under the training initiated in Experiment 2 for these two subjects. These results suggest that simply reversing the sample and the correct comparison stimuli to produce symmetry trial-types (as in Experiment 2) may have produced unwanted and difficult to isolate sources of stimulus control. The remainder of the study utilized the training trials from Experiment 3-A during five-term contingency training and probe baselines unless otherwise noted.

EXPERIMENT 3-B

Experiment 3-B represented an attempt to functionally analyze the performance of Subject 3 and to recover the transitive relations demonstrated by Subject 3 in the first session of probes during Experiment 3-A. This was accomplished by removing the second-order stimuli thereby reducing the five-term contingency to the underlying four-term relations of which the five-term contingency was comprised.

Referring to the upper portion of Figure 11, the five-term contingency can be conceptualized as two sets of four-term relations, each under of the control of a different second-order stimulus. Considering the top row of trial-types only, if the X stimulus is removed, the remaining four-term relations are AC, DB, AE, and DF. Similarly, if the Y stimulus is removed from the bottom row of trial-types, the remaining four-term relations are AB, DC, AF, and DE. If only the first set of four-term relations were trained separately, the resulting transitive relations logically would be CE (via stimulus A) and BF (via stimulus D). If the second set of four-term relations were trained separately, the resulting transitive relations logically would be CE (via stimulus D) and BF (via stimulus A). Such a demonstration of transitive relations is essentially what comprises the stimulus classes shown in the lower portion of Figure 11. However, these two sets of four-term relations cannot be trained together without the second-order stimuli since, for example, the correct choice of comparison B or C in the presence of sample A depends upon the presence of X or Y.

Sidman (1986) has conceptualized the second-order stimulus as the stimulus controlling the unit of behavior comprised of the four-term contingency. Logically, then, the four-term units themselves must be intact for the five-term contingency to be functional. As shown in Experiment 1, five-term contingency training did not automatically result in trained, four-term relations once the second-order stimulus is removed. Perhaps the five-term training presented to Subject 3 in Experiments 2 and 3 did not result in the the four-term relations that comprise the second-order control of equivalence classes. The answer to this question is the intent of the present fuctional analysis.

The foregoing logic was used to analyze the behavior of Subject 3 and as a means of recovering the transitive relations demonstrated briefly under the five-term contingency. Specifically, Subject 3 was given training and testing sessions that resulted in separate demonstrations of the four-term stimulus classes described above. The equivalence classes were then tested for five-term control as in Experiments 2 and 3. The experimental question was whether such four-term relation training was sufficient to recover the transitive relations under the five-term contingency.

Method

Subject 3 served. The apparatus, stimuli, design, and general training procedures were the same as those used in Experiments 2 and 3.

Training and Testing Sequences

The sequences of training and testing for Subject 3, and the number of sessions for each, are shown in Table 34. Experiment 3-B was divided into two main sequences, each representing four-term contingency training prior to Test 2 probes for five-term contingency transitivity. Each condition of the sequences is described below.

Sequence 1. As shown in the left hand portion of Table 34, Sequence 1 contained thirteen separate training and testing conditions.

Condition 1 consisted of unidirectional training of the four-term relations experimentally associated with the second-order stimulus, X (i.e., AC, DB, AE, and DF). However, the second-order stimulus was not present during training. Condition 2 was identical to Condition 1 except that feedback was reduced to 25%.

In Condition 3, the symmetrical relations that

Table 34

Sequences of Training and Testing for Subject 3 during Experiment 3-B

Sequence 1		Sequence 2	
Condition	(# of sess.)	Condition	(# of sess.)
1. Train Four-Term associated with X	(1)	1. Five-Term Training: X Trials Only (reduced feedback)	(1)
2. Train Four-Term associated with X (reduced feedback)	(2)	2. Test 2: X Probes Only	(1)
3. Test Symmetrical Relations	(1)	3. Train Four-Term associated with X	(1)
4. Test Transitive Relations	(1)	4. Test Symmetrical Relations	(1)
5. Train Four-Term associated with X (reduced feedback)	(1)	5. Test Transitive Relations	(1)
6. Test Transitive Relations	(4)	6. Test Transitive Relations (rein. CE)	(1)
7. Train Four-Term associated with Y	(1)	7. Train Four-Term associated with X (rein. CE)	(1)
8. Train Four-Term associated with Y (reduced feedback)	(1)	8. Test Transitive Relations	(1)
9. Test Symmetrical Relations	(1)	9. Test 2: X Probes Only	(1)
10. Test Transitive Relations	(2)	10. Five-Term Training: Y Trials Only (reduced feedback)	(1)
11. Experiment 3 Five-Term Training	(2)	11. Test 2: Y Probes Only	(1)

(Table 34 continued)

12.	Experiment 3 Five-Term Training (reduced feedback)	(2)	12.	Train Four-Term associated with X (rein. CE)	(1)
13.	Test 2	(4)	13.	Train Four-Term associated with Y (rein. CE)	(1)
			14.	Test 2	(2)
			15.	Test 4	(3)

would derive from training in Conditions 1 and 2 were tested (i.e., CA, BD, EA, and FD). Condition 4 tested the transitive relations (i.e., CE, EC, BF, and FB). Condition 5 repeated reduced feedback training of the four-term relations associated with X while Condition 7 retested the transitive relations that would derive from the training.

In conditions 7 and 8, subjects were unidirectionally trained (at 100% and 25% correct feedback, respectively) on four-term relations previously associated with Y (i.e., AB, DC, AF, and DE). The second-order stimulus was not present. Conditions 9 and 10 tested the symmetrical (ie., BA, CD, FA, and ED) and transitive (i.e., CE, EC, BF and FB) relations that would derive from training four-term relations previously associated with Y.

Conditions 11 and 12 were identical to training from Experiment 3-A. Condition 13 was identical to Test 2 probes for transitivity from Experiment 3-A.

Sequence 2. Because of her performance on Test 2 probes in condition 13 of Sequence 1, Subject 3 required additional training and testing before Test 2 probes were again introduced. This training and testing consisted of 15 separate conditions.

Condition 1 was identical to Experiment 3-A, five-term contingency training at reduced feeback (see Table

27) except that only the trials containing an X as the second-order stimulus were presented. Condition 2 was identical to Experiment 3-A, Test 2 probes except that only Test 2 probes that contained an X as the second-order stimulus were presented (i.e., X-CE, X-EC, X-BF, and X-FB). The baseline for these probes consisted of Condition 1 trials.

In Condition 3 subjects were unidirectionally trained on the four-term relations previously associated with X (no second-order stimulus present) as in Sequence 1. Conditions 4 and 5 tested symmetrical and transitive relations that would derive from Condition 3 training.

Condition 6 was identical to Condition 5 transitive relation probes except that each time the probed relation CE appeared, an incorrect response resulted in the trial being presented over again. A correct response resulted in correct feedback plus one point.

Condition 7 was identical to four-term training in Condition 3 except that the relation CE was added to the trial-types trained. Thus, training consisted of relations AC, DB, AE, DF, and CE (the transitive relation derived from AC and AE). In Condition 8, test probes were presented for all transitive relations that would derive from Condition 7 training.

In Condition 9, Test 2 probes for five-term transitivity were again presented that consisted only of trial-types containing the second-order stimulus X.

Condition 10 was identical to Experiment 3-A training except that only training trials that contained Y as the second-order stimulus were used (Y-AB, Y-DC, Y-AF, and Y-DE). Condition 11 tested the transitive relations that would derive from Condition 10 training (i.e., Y-CE, Y-EC, Y-BF, and Y-FB).

In Condition 12, four-term relations previously associated with X were trained with the addition of the CE relation. In Condition 13, four-term relations previously associated with Y were trained with the addition of the CE relation.

In Condition 14, Test 2 probes for five-term transitivity were presented. As in Experiment 3-A, Condition 15 consisted of Test 4 probes designed to assess the effect of removing the second-order stimulus from the transitive relations and removing the second-order stimulus from the training trials.

Results and Discussion

Sequence 1

Four-term training and testing associated with X. Subject 3 performed at 100% accuracy on training trials designed to train the relations, AC, DB, AE, and DF, at both 100% feedback and 25% feedback (Conditions 1 and 2). The first test (Condition 3) was a test for the symmetrical relations, CA, BD, EA, and FD. Subject 3 responded to these probes with 100% accuracy. The next test (Conditions 4 and 6) tested for the four-term, transitive relations, CE, EC, BF, and FB. The results of this test are shown in Table 35. One session of

Table 35

Results of Transitive Relations Derived from AC, DB, AE, and DF Training

Relation	Trial-Type	Sessions			
		1	2	3	4
0-CE	0-C(E F)	0/3	1/3	3/3	3/3
0-EC	0-E(C B)	1/3	1/3	3/3	3/3
0-BF	0-B(F E)	0/3	2/3	3/3	3/3
0-FB	0-F(B C)	1/3	3/3	3/3	3/3
Mean Percent Correct per Session		17%	58%	100%	100%

four-term training, reduced feedback (Condition 5) was presented between the first and second probe sessions shown in Table 35. Subject 3 did not demonstrate transitive relations during the first and second probe sessions. However, Subject 3 performed with 100% accuracy during the third and fourth probe sessions.

Four-term training and testing associated with Y. Because Subject 3 demonstrated the four-term trained relations associated with X as well as the transitive relations deriving from the trained relations, she was then trained for two sessions (100% and 25% feedback for correct responding) with the four-term relations associated with Y, i.e., AB, DC, AF, and DE (Conditions 7 and 8). Subject 3 scored 99% and 100% for these two sessions, respectively.

The first test under four-term relations associated with Y (Condition 9) consisted of probes for the symmetrical relations BA, CD, FA, and ED. Subject 3 scored 100% on this test. The next two sessions (Condition 10) tested for the transitive relations, CE, EC, BF and FB that would derive from the trained relations. Subject 3 scored 100% on both of these probe sessions.

Five-term training and testing. Because Subject 3 had demonstrated all of the separate four-term relations including the transitive ones, she was then given Experiment 3-A training--all of the trained relations including stimuli X and Y that instructed which choice would be correct. Four sessions of Experiment 3-A training were conducted--two at 100% feedback and two at 25% feedback for correct responding (Conditions 11 and 12). Subject 3 scored above 99% on all training sessions.

In order to assess the effects of the four-term training on five-term transitive relations, Subject 3 was tested with Test 2 probes (Condition 13) from Experiment 3-A. The results of Test 2 probe sessions are shown in Table 36. This table shows that Subject 3 still did not demonstrate the transitive relations throughout the four probe sessions conducted. Performance appears to be at chance levels by the fourth session.

Although performance appears to be at chance levels, a closer inspection of Table 36 reveals a clear pattern of responding that emerged by the fourth session. Responding to the relations, CE, EC, BF and FB in the presence of X or Y during the last session of Test 2 probes is shown in Table 37. Subject 3 responded correctly to each transitive relation only when Y was present. However, when X was present, responses were only made to the incorrect comparison.

Table 37

Subject 3 Responses to Fourth Session of Test 2 Relations as a Function of X or Y

Relation	Second-Order Stimulus	
	X	Y
CE	0	3
EC	0	3
BF	0	3
FB	0	3

Table 36

Results of Test 2 Probes (Condition 13) for Subject 3 during Sequence 1 of Experiment 3-B

Relation	Trial-Type	Sessions			
		1	2	3	4
X-CE	X-C(E F)	1/3	0/3	1/3	0/3
X-EC	X-E(C B)	1/3	1/3	0/3	0/3
Y-CE	Y-C(E F)	3/3	1/3	2/3	3/3
Y-EC	Y-E(C B)	3/3	2/3	3/3	3/3
X-BF	X-B(F E)	2/3	1/3	0/3	0/3
X-FB	X-F(B C)	2/3	0/3	0/3	0/3
Y-BF	Y-B(F E)	3/3	3/3	3/3	3/3
Y-FB	Y-F(B C)	3/3	2/3	3/3	3/3
Mean Percent Correct per Session		75%	42%	50%	50%

Sequence 2

The objective of Sequence 1 probes was to provide four-term training and tests that potentially would result in the five-term transitive relations. The objective was not met. In fact, Subject 3 developed a systematic pattern of responding, albeit incorrect from the perspective of the study. Sequence 2 was undertaken to examine this pattern of incorrect responding and to attempt to correct it. Specifically, training and tests in Sequence 2 were designed to: (a) examine the X and Y Test 2 probes separately to determine if presenting the X and Y probes together controlled the pattern of responding to Test 2 probes in Sequence 1; (b) reexamine the four-term relations; and (c) explicitly train one, four-term transitive relation and then test for the five-term transitive relations.

Five-term X training and probes. Condition 1 of Sequence 2 consisted of one session of Experiment 3-A training but only with trials containing the second-order stimulus X at reduced feedback. Subject 3 scored 100% on this session. This was followed by one session of Test 2 probes (Condition 2) that contained only X probes. Subject 3 scored 0% on these probes. This result is consistent with the same performance on X probes during Test 2 probes of Sequence 1 (see Table 37).

<u>Reexamination of four-term relations</u>. Condition 2 revealed incorrect responding to transitive relations in the presence of X. Would the same results occur if X was removed? In order to test this, Subject 3 was first given one training session of four-term relations associated with X but in the absence of X, as in Condition 1 of Sequence 1. She scored 100%. Next, the symmetrical relations were tested in Condition 4 where Subject 3 also scored 100%. Finally, the transitive relations were tested in Condition 5. Subject 3 scored 0% during these probes indicating that the incorrect pattern of five-term transitivity responding demonstrated in Sequence 1 extended to the four-term transitive relations associated with X.

<u>Training a single "transitive" relation</u>. In Condition 6, the same probes for transitive relations were repeated except that now the "transitive" probe trial-type, O-C(E* F) was explicitly reinforced. This resulted in 2 of 3 correct responses for the CE relation, 2 of 3 for EC, 1 of 3 for BF, and 2 of 3 for FB. This performance represented a significant increase in correct responding over the results of Condition 5 probes in which 0% correct responding occurred. However, this procedure also resulted in a 73% accuracy during baseline. In fact, the subject had made every baseline response correct before the first instance of

the reinforced CE relation. Subsequent to the first instance of the CE relation, the subject responded to every baseline trial incorrectly. Hence, this procedure was not continued.

Rather than reinforce the CE relation through probes, the trial-type, 0-C(E* F) was added to the trained (and thus, reinforced) four-term relations associated with X: AC, DB, AE, and DF in Condition 7. Subject 3 scored 99% on Condition 7 training. Condition 8 assessed the effect of this training on the four-term transitive relations. Subject 3 scored 100% on the probes. Thus, reinforcing one "transitive" trial-type was sufficient for generalization of correct responding to the other transitive relations.

Reassessment of separate five-term transitivity probes. Test 2 probes (X only) were presented again in Condition 9. This time, Subject 3 scored 100% indicating that the four-term transitive relations demonstrated in Condition 8 were also exhibited when the second-order stimulus, X, was present.

Would Subject 3 still demonstrate correct responding to transitive relations in the presence of Y? Before testing the Y five-term transitive relations, Subject 3 was given one session of Experiment 3-A training but only with trials containing the second-order stimulus, Y at 25% correct feedback (Condition

10). Subject 3 scored 100% for this session. Next, one session of Test 2 probes with Y trials only (Condition 11), was presented. The results are shown in Table 38. Table 38 shows that Subject 3 responded to transitive probes in the presence of Y with only 13% accuracy. At the end of Sequence 1, Subject 3 was responding to transitive probes in the presence of Y with 100% accuracy but to transitive probes in the presence of X with 0% accuracy. Now the results were reversed.

Table 38

Subject 3 Responses to Condition 11 Probes during Sequence 2

Relation	Correct/Incorrect
Y-CE	0/6
Y-EC	0/6
Y-BF	0/6
Y-FB	3/6
Mean Percent Correct Per Session	13%

Retraining four-term CE relation associated with X and Y. Given that the training of four-term relations associated with X resulted in accurate performance of transitive relations in the presence of X but not in the presence of Y, Conditions 12 and 13 were designed to explicitly reinforce the CE relation within the four-term relations associated with both X and Y. The results of these two sessions were accuracy scores of 96% for training of four-term relations associated with X and 95% for training of four-term relations associated with Y.

Reassessment of Test 2 probes. Test 2 probes, with trial-types containing either the second-order stimulus, X or Y, were presented in two sessions (Condition 14). As shown in Table 39, Subject 3 now demonstrated the transitive relations in the presence of either second-order stimulus.

Test 4 probes. Because Subject 3 demonstrated transitive relations in the presence of the second-order stimluli, Test 4 probes from Experiment 3-A were presented. These probes were designed to assess the effect of removing the second-order stimuli from transitive relations and training trials while the baseline trials remained the same as in Experiment 3-A. The results of these probes are shown in Table 40. Subject 3 responded to the transitive probes correctly in the absence of the second-order stimulus. As shown in the lower portion of Table 40, Subject 3 responded to the left comparisons almost exclusively. Although neither comparison was "correct" in the absence of the second-order stimulus, choices to the left comparison shown in Table 40 would be correct if X was present

Table 39

Results of Test 2 Probes for Subject 3 during Sequence 2 of Experiment 3-B

Relation	Trial-Type	Sessions 1	Sessions 2
X-CE	X-C(E F)	3/3	3/3
X-EC	X-E(C B)	3/3	3/3
Y-CE	Y-C(E F)	3/3	3/3
Y-EC	Y-E(C B)	3/3	3/3
X-BF	X-B(F E)	2/3	3/3
X-FB	X-F(B C)	3/3	3/3
Y-BF	Y-B(F E)	3/3	3/3
Y-FB	Y-F(B C)	3/3	2/3
Percent Correct per Session		96%	100%

Table 40

Results of Test 4 Probes for Subject 3 during Sequence 2 of Experiment 3-B

Relation	Trial-Type	Sessions		
		1	2	3
0-CE	0-C(E F)	2/2	2/2	2/2
0-EC	0-E(C B)	2/2	2/2	2/2
0-BF	0-B(F E)	2/2	2/2	2/2
0-FB	0-F(B C)	2/2	2/2	2/2
Mean Percent Correct per Session		100%	100%	100%
0-AC	0-A(C B)	2/2	2/2	2/2
0-CA	0-C(A D)	2/2	2/2	2/2
0-AE	0-A(E F)	2/2	2/2	2/2
0-EA	0-E(A D)	2/2	2/2	2/2
0-DB	0-D(B C)	2/2	2/2	2/2
0-BD	0-B(D A)	2/2	2/2	2/2
0-DF	0-D(F E)	2/2	1/2	2/2
0-FD	0-F(D A)	2/2	2/2	2/2
Mean Percent Correct per Session		100%	94%	100%

Note. A zero in place of the second-order stimulus denotes the absence of the second-order stimulus. The top portion of Table 40 represents the transitive trial-types in the absence of the second-order stimulus while the lower portion of Table 40 represents probes of the trained relations in the absence of the second-order stimulus. In the lower portion of the table, neither stimulus was "correct", though the left comparison was scored as such.

while choices to the right comparison would be correct if Y was present. Thus, Subject 3 responded to the comparisons that would be correct if X was present.

General Discussion: Experiment 3-B

Experiment 3-B was designed to analyze the behavior of Subject 3 with regard to performance on probes for transitive relations in the presence of the second-order stimuli, X or Y. Subject 3 did not demonstrate these relations during the final probe session of Experiment 3-A. It was hypothesized that training the underlying, four-term relations that comprised the training for Experiment 3-A would result in transitive relations in the presence of X or Y. The logic for such training and testing was as follows: Prior to Experiment 3-B, Subject 3 demonstrated above-90% correct responding to training trials consisting of a second-order stimulus, sample, and two comparison stimuli. But did this responding actually represent second-order control of four-term relations, i.e., were four-term relations "intact" in the first place in order to be controlled by the second-order stimulus? If they were, then the transitive relations that would result from the trained four-term relations (via the second-order stimuli) would be demonstrated. If the four-term relations were not "intact", it would still be possible to respond correctly to the five-term trial-types, yet not demonstrate the transitive relations that should have resulted. Thus, explicit training of the four-term relations and subsequent demonstration of the four-term transitive relations in the absence of the second-order stimuli, followed by the correct responding in the presence of the appropriate second-order stimuli, should have resulted in the demonstration of transitive relations and, thus, of equivalence classes under the control of second-order stimuli. This result did not obtain during Sequence 1, Test 2 probes but did obtain during the Test 2 probes presented in Sequence 2.

During the final condition of Sequence 1, four sessions of Test 2 probes were presented. By the final session, Subject 3 responded incorrectly to every trial in which the second-order stimulus, X, was present and correctly to every trial in which Y was present. Subject 3's history, as provided by the training and testing in Sequence 1, provides some information that would explain the incorrect response pattern found during Test 2 probes of Sequence 1. The underlying four-term relations experimentally associated with X or Y were trained separately: first the four-term relations associated with X, including tests for the transitive relations; then the four-term relations associated with

Y, including tests for the transitive relations. At this point, it could be stated that Subject 3 was able to demonstrate four separate stimulus classes provided that those two associated with X were tested separately from those associated with Y.

Subsequently, Experiment 3-A training was reintroduced. In essence, the two sets of four-term relations were combined. Now, however, X or Y instructed which stimulus would be correct in the presence of a given sample. During four-term training, the relations AC and AB could not be presented together because the trial-type for each relation would have to appear as 0-A(B C): both choices would be correct. But with the second-order stimuli present, B would be correct in Y-A(B C), and C would be correct in X-A(B C).

One way to view the function of the second-order stimulus would be to invoke a rule that states: if Y, choose one comparison in the presence of a four-term trial-type, and if X, choose the <u>other</u> comparison in the presence of the same four-term trial-type. Recall, though, that the same comparison within a given pair of comparisons is correct during five-term transitive probes regardless of whether X or Y is present. Even though Subject 3 demonstrated the four-term transitive relations separately for classes associated with X and Y, it seems reasonable that after four sessions of Experiment 3-A training, the same rule regarding choice based on X or Y was invoked during the Test 2 probes of Sequence 1. That is, during Test 2 probes, Subject 3 may have been capable of performing the transitive relations (and, in fact, did so in the presence of Y), but invoked the rule: if Y, choose the comparison most likely to be correct, and if X, choose the <u>other</u> comparison. This behavior pattern would be consistent with the rule stated above, and it was in fact consistent with the results of Test 2 probes at the end of Sequence 2.

In Sequence 2, it was hypothesized that probing Test 2 trials that contained X or Y separately may have resulted in correct performance. However, testing for transitive relations in the presence of X only revealed that the pattern of incorrect responding was still present. In fact, the incorrect responses had generalized to the four-term transitive relations associated with X.

Further evidence for the rule stated above comes from the reversal of the incorrect pattern found during Sequence 2. The four-term relation, CE, was explicitly reinforced resulting in correct responding to the transitive relations associated with X. Probing only Test 2 trials that contained X as the second-order stimulus also showed correct responding. However, probing only Test 2 trials that contained Y showed incorrect responding. This pattern, correct with X and incorrect with Y, is the opposite of the pattern that occurred before the four-term, CE relation associated with X was explicitly reinforced. Thus, Subject 3 again invoked the rule, if X, respond to the correct stimulus, and if Y, respond to the other stimulus. It was not until the CE relation was explicitly reinforced, first with four-term relations associated with X and then with those associated with Y, that the subject was able to respond correctly to all transitive relations in the presence of X or Y.

Test 4 probes revealed that, in the absence of X or Y, Subject 3 responded correctly to the transitive relations. However, while Subjects 1 and 2 from Experiment 3-A did not respond systematically during Test 4 probes designed to test trained relations in the absence of the second-order stimuli, Subject 3 did. She chose those comparisons that would be correct if the second-order stimulus, X, was present. Which pattern of choices would be chosen during these probes could not be predicted although the fact that a pattern associated exclusively with one second-order stimulus would be expected given the extensive history of presenting the four-term relations alone.

EXPERIMENT 4

In Experiment 2, only Subject 2 demonstrated transitive relations in the presence of the second-order stimuli. In Experiments 3-A and 3-B, both Subjects 1 and 3 demonstrated transitive relations. The results of Experiments 2, 3-A, and 3-B demonstrated the conditional control of equivalance relations. Four three-member classes, some of which had stimuli in common, emerged.

Both Subjects 1 and 3 demonstrated conditional equivalance relations under the new training (characterized by comparison stimuli that appeared equally often as correct and incorrect) instituted in Experiments 3-A and 3-B where they did not with the old training (i.e., the "imbalance" of comparison stimuli described earlier) from Experiment 2. For these subjects, however, the new training was instituted in Experiment 3-A after they had already learned the old training to criterion. For Subject 2, the new training was never instituted because her performance met expectations.

Experiment 4 was designed to provide Subjects 2 and 3 with the same training used in Experiment 3-A except that all new stimuli were used. Hence, they would have to learn an all new task. (Subject 1 was not included in this experiment because she terminated her participation in the study.) The experimental question for this experiment was whether Subjects 2 and 3 would demonstrate conditional control of equivalence relations with the Experiment 3-A training used with new stimuli. In addition, would the results of the additional training provided to Subject 3 during Experiment 3-B generalize to the new stimuli presented in Experiment 4?

Method

All training and testing procedures used in Experiment 4 were identical to those used in Experiment 3-A except that all stimuli were changed. Unlike Experiment 2, all sixteen trial-types were presented during training. The stimuli used for Experiment 4 are shown in Figure 14.

Results and Discussion

Training

The results of training are shown in Table 41. Subject 3 learned the training task to criterion under 100% feedback for correct responding in six sessions, while Subject 2 learned the training task to criterion under 100% feedback for correct responding in 3 sessions. Both subjects met criterion under 25% feedback in the minuimum number of sessions.

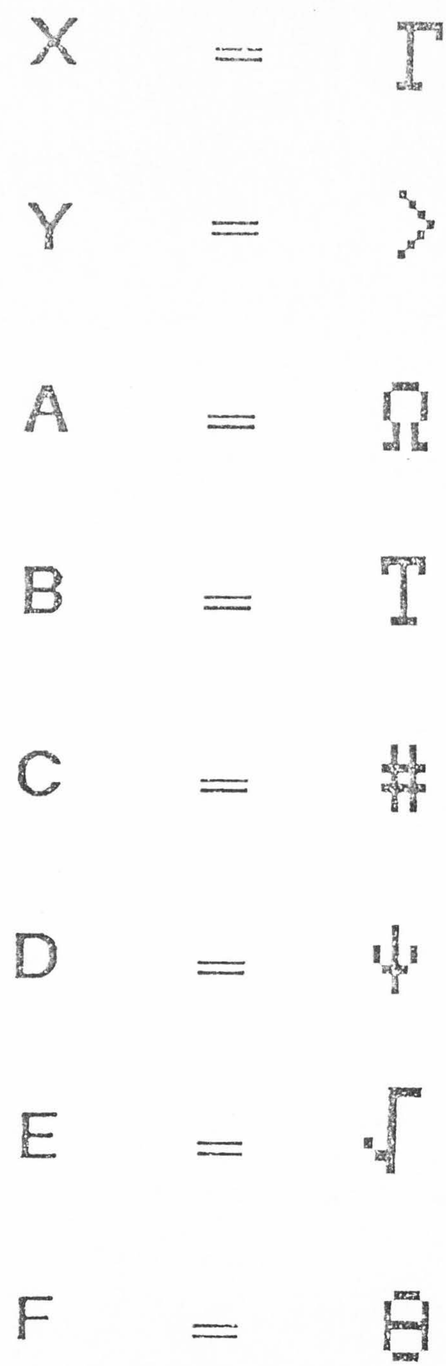


Figure 14. Stimuli used in Experiment 4.

Table 41

Percent Correct per Training Session for Subject 1 and 3 during Experiment 4

Training	Subjects	
	2	3
100% feedback	85%	63%
	96%	59%
	100%	80%
		75%
		91%
		99%
25% feedback	100%	99%
	100%	96%

Probe Tests: Subject 2

Test 2. Subject 2 was given 2 sessions of Test 2 probes. These probes were designed to assess the potential demonstration of transitive relations in the presence of the second-order stimuli. As shown in Table 42, Subject 2 responded correctly to every probe trial-type across the two sessions.

Test 4. Subject 2 was given 3 sessions of Test 4 probes. These probes assessed the effect of removing the second-order stimulus from the transitive relations as well as from probes resembling training trials (see

Table 42

Results of Test 2 Probes for Subject 2 during Experiment 4

Relation	Trial-Type	Sessions	
		1	2
X-CE	X-C(E F)	3/3	3/3
X-EC	X-E(C B)	3/3	3/3
Y-CE	Y-C(E F)	3/3	3/3
Y-EC	Y-E(C B)	3/3	3/3
X-BF	X-B(F E)	3/3	3/3
X-FB	X-F(B C)	3/3	3/3
Y-BF	Y-B(F E)	3/3	3/3
Y-FB	Y-F(B C)	3/3	3/3
Percent Correct per Session		100%	100%

Table 29). The results of Test 4 probes are shown in Table 43. Subject 2 continued to demonstrate the transitive relations in the absence of the second-order stimuli. With regard to the trained relations in the absence of the second-order stimuli, Subject 2 did not greatly favor one set of four-term relations associated with a second-order stimulus, though many more responses were made to those choices that would be correct if the second-order stimulus, Y, was present.

Probe Tests: Subject 3

Test 2. As shown in Table 44, Subject 3 did not demonstrate correct responding to all of the transitive trial-types. However, as occurred in Sequence 1 of Experiment 3-B, Subject 3 developed a systematic, albeit incorrect, pattern of responding by the fourth session: Subject 3 responded correctly in the presence of Y but incorrectly in the presence of X.

Test 4. Even though Subject 3 did not respond correctly to Test 2 probes, Test 4 probes were administered in an attempt to gain further information as to the controlling variables involved in the pattern of behavior exhibited during Test 2 probes. As shown in Table 45, Subject 3 responded correctly to the transitive relations. The lower portion of Table 45 shows that Subject 3 responded exclusively to those

Table 43

Results of Test 4 Probes for Subject 2 during Experiment 4

Relation	Trial-Type	Sessions		
		1	2	3
0-CE	0-C(E F)	2/2	2/2	2/2
0-EC	0-E(C B)	2/2	2/2	2/2
0-BF	0-B(F E)	2/2	2/2	2/2
0-FB	0-F(B C)	2/2	2/2	2/2
Mean Percent Correct per Session		100%	100%	100%
0-AC	0-A(C B)	0/2	1/2	0/2
0-CA	0-C(A D)	0/2	2/2	1/2
0-AE	0-A(E F)	0/2	0/2	0/2
0-EA	0-E(A D)	0/2	1/2	0/2
0-DB	0-D(B C)	1/2	1/2	1/2
0-BD	0-B(D A)	0/2	0/2	1/2
0-DF	0-D(F E)	0/2	0/2	0/2
0-FD	0-F(D A)	1/2	0/2	0/2
Mean Percent Correct per Session		13%	31%	19%

Note. A zero in place of the second-order stimulus denotes the absence of the second-order stimulus. The top portion of Table 43 represents the transitive relations in the absence of the second-order stimulus while the lower portion of Table 43 represents probes of the trained relations in the absence of the second-order stimulus. In the lower portion of the table, neither stimulus was "correct", though the left comparison was scored as such.

Table 44

Results of Test 2 Probes for Subject 3 during Experiment 4

Relation	Trial-Type	Sessions 1	2	3	4
X-CE	X-C(E F)	0/3	1/3	0/3	0/3
X-EC	X-E(C B)	0/3	0/3	0/3	0/3
Y-CE	Y-C(E F)	3/3	3/3	3/3	3/3
Y-EC	Y-E(C B)	3/3	3/3	3/3	3/3
X-BF	X-B(F E)	0/3	0/3	1/3	0/3
X-FB	X-F(B C)	2/3	0/3	1/3	0/3
Y-BF	Y-B(F E)	3/3	3/3	3/3	3/3
Y-FB	Y-F(B C)	3/3	3/3	3/3	3/3
Percent Correct per Session		58%	54%	58%	50%

Table 45

Results of Test 4 Probes for Subject 3 during Experiment 4

Relation	Trial-Type	Sessions 1	2	3
0-CE	0-C(E F)	2/2	2/2	2/2
0-EC	0-E(C B)	2/2	2/2	2/2
0-BF	0-B(F E)	2/2	2/2	2/2
0-FB	0-F(B C)	2/2	2/2	2/2
Mean Percent Correct per Session		100%	100%	100%
0-AC	0-A(C B)	0/2	0/2	0/2
0-CA	0-C(A D)	0/2	0/2	0/2
0-AE	0-A(E F)	0/2	0/2	0/2
0-EA	0-E(A D)	0/2	0/2	0/2
0-DB	0-D(B C)	0/2	0/2	0/2
0-BD	0-B(D A)	0/2	0/2	0/2
0-DF	0-D(F E)	0/2	0/2	0/2
0-FD	0-F(D A)	0/2	0/2	0/2
Mean Percent Correct per Session		0%	0%	0%

Note. A zero in place of the second-order stimulus denotes the absence of the second-order stimulus. The top portion of Table 45 represents the transitive relations in the absence of the second-order stimulus while the lower portion of Table 45 represents probes of the trained relations in the absence of the second-order stimulus. In the lower portion of the table, neither stimulus was "correct", though the left comparison was scored as such.

comparisons that would be correct if the second-order stimulus, Y, was present.

General Discussion: Experiment 4

Subject 2 demonstrated conditional control of equivalence relations just as she did in Experiment 2. Thus, Subject 2 demonstrated conditional control of equivalence relations under both the initial training from Experiment 2 and the Experiment 3-A training with all new stimuli.

Subject 3, however, did not demonstrate conditional control of equivalence relations. Nevertheless, the results of Test 2 probes suggest that the control responsible for the systematic, incorrect pattern of responding on these probes was probably the same as in Sequence 1 of Experiment 3-B. Specifically, the rule, if Y, respond to the transitive relation, and if X, respond to the other stimulus, is consistent with Experiment 4 results for Subject 3. In Experiment 4, the four-term relation CE was not trained as it was in Experiment 3-B. This may be why Subject 3 carried the incorrect pattern of responding into Experiment 4.

Further evidence of this pattern being controlled by the rule described above comes from Test 4 probes for Subject 3. Specifically, the rule can only work if X or Y is present. In the absence of X and Y, as in Test 4 probes, Subject 3 responded correctly. This suggests that it was the presence of X and Y in Test 2 probes that interfered with correct performance.

EXPERIMENT 5-A

In Experiment 4, Subject 2 demonstrated conditional control of equivalence relations under new stimuli and new (to Subject 2) training. Subject 3 generalized to Experiment 4 an incorrect pattern of responding to transitivity probes in the presence of second-order stimuli that she had demonstrated during Experiment 3-B. By Experiment 4, both subjects had had a history of learning five-term conditional discriminations and equivalence relations with different stimuli and different training procedures.

The purpose of Experiments 5-A and 5-B was to present naive subjects with the training and testing procedures used in Experiment 4. Experiments 5-A and 5-B represent attempts to replicate conditional control of equivalence relations with subjects who have had no previous history of five-term conditional discrimination training.

The primary purpose of Experiment 5-A was to test a training procedure that differed from that given to naive subjects in Experiment 2. In Experiment 2, subjects learned two sets of eight trial-types separately before all 16 were combined. Besides using the new training procedures introduced in Experiment 3-A and the new stimuli introduced in Experiment 4, the training procedure for Experiment 5-A consisted of beginning the training with all 16 trial-types. This was done to minimize any potential bias from learning one set of trial-types first.

Method

Subject

The subject in Experiment 5-A, Subject 4, was a 19-year-old, female, sophomore at Utah State University. She was recruited as in Experiment 1. Subject 4 was only available as a subject until the end of the academic quarter in which she began the study. Thus, the last session conducted with Subject 4 represents the last session in which she was able to participate.

Apparatus and Stimuli

The apparatus used in this experiment was the same as in Experiments 1-4. The stimuli used were identical to those used in Experiment 4.

Training and Testing

All training and testing procedures used in Experiment 5-A were identical to those used in Experiment 4. All sixteen trial-types were presented during initial training (see Table 27).

Results and Discussion

Training

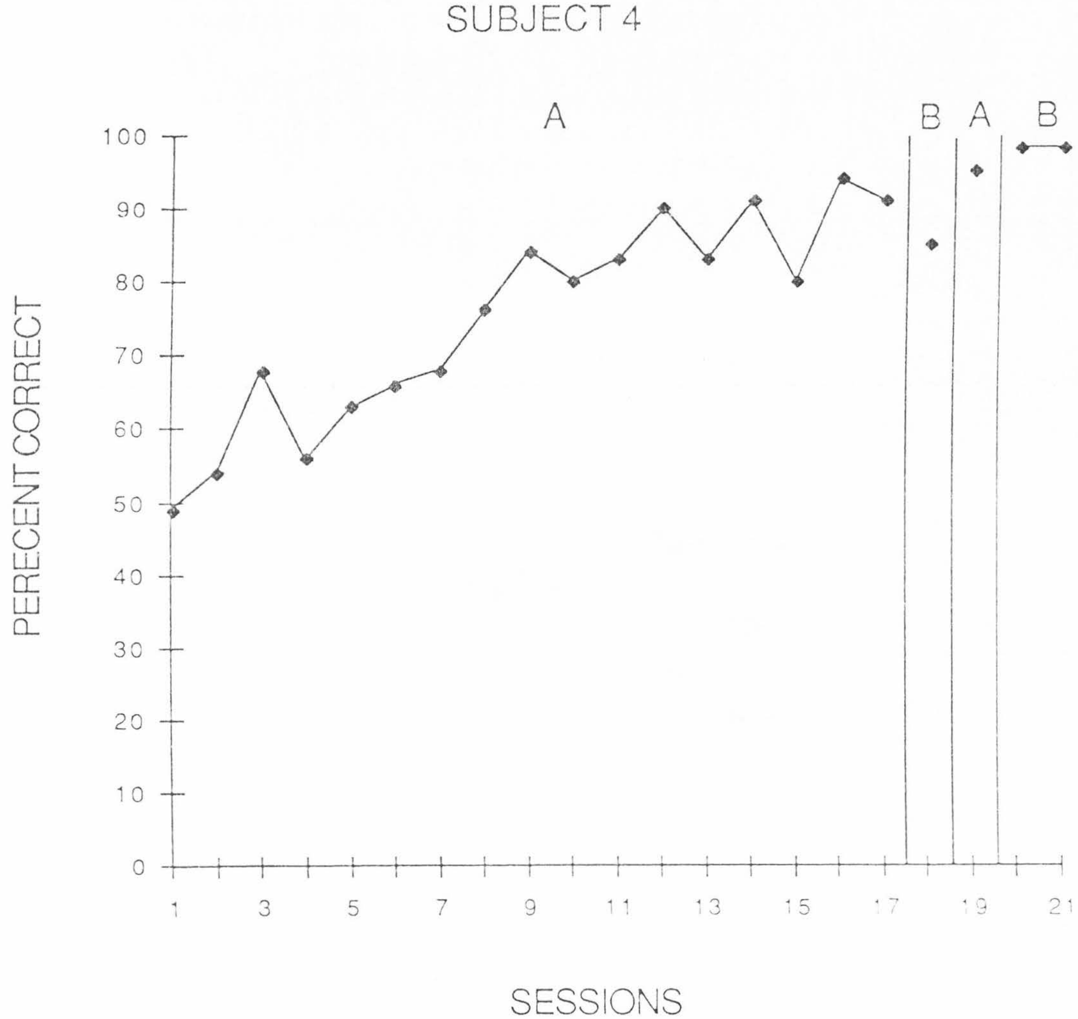
The results of training for Subject 4 are shown in

Figure 15. The portions labeled "A" denote conditions where 100% feedback for correct responding was delivered while "B" denotes reduced (25%) feedback conditions. Subject 4 required 21 sessions before criterion was met. During her first session of reduced feedback, subject 4 only scored 85%. For this reason, an additional session of training at 100% feedback was introduced. This session was sufficient to produce criterion responding during the next two sessions of training at 25% feedback.

<u>Probe Tests</u>

<u>Test 2</u>. Subject 4 received seven sessions of Test 2 probes. One session of training trials was inserted between the sixth and seventh session of Test 2 probes. This was done because the baseline of the sixth session dropped to 85%. The baseline for all other probe sessions was greater than 90%.

As shown in Figure 16, Subject 4 did not demonstrate all of the transitive relations in any of the seven sessions. Unlike Subject 3 from Experiments 3-B and 4, Subject 4 did not demonstrate a systematic pattern of incorrect responding. In general, Subject 4's performance was not consistent across sessions: i.e., no stable performance developed with the exception of the relations, X-EC, X-BF, and X-FB.



<u>Figure 15</u>. Results of Training for Subject 4 in Experiment 5-A.

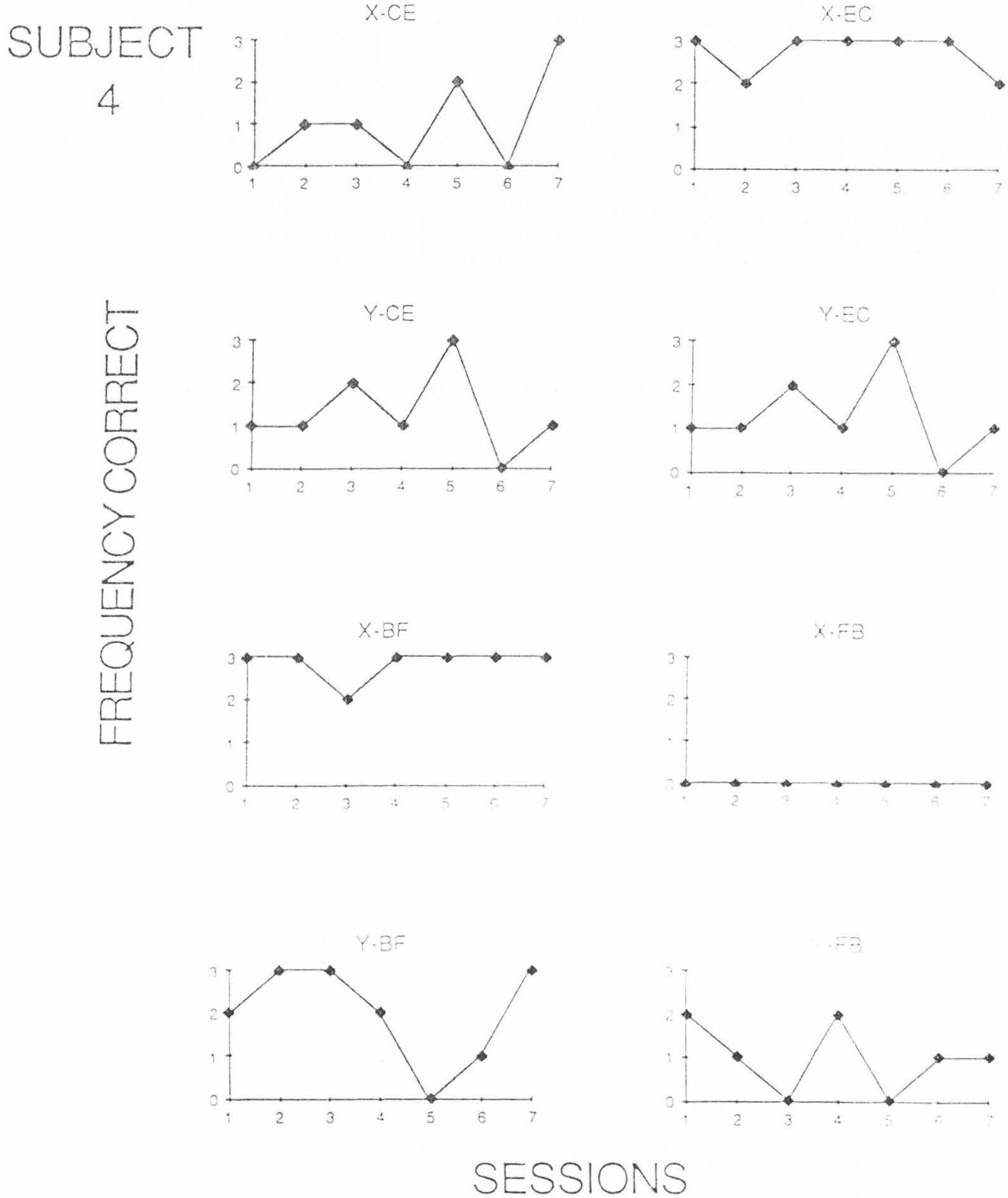


Figure 16. Frequency of correct responses for each relation probed in Test 2 for Subject 4 in Experiment 5-A.

Test 4. Even though Subject 4 did not demonstrate transitive relations in Test 2 probes, three sessions of Test 4 probes were run to check for the possibility that the transitive relations were present in the absence of the second-order stimulus. As shown in upper portion of Table 46, no systematic responding occurred to the transitive relations. However, as shown in the lower portion of Table 46, the majority of the comparisons chosen by Subject 4 were those that would be correct if the second-order stimulus Y was present.

General Discussion: Experiment 5-A

Subject 4 did not demonstrate conditional equivalence relations. Unlike Subject 3 during Experiment 3-A and 4, Subject 4 did not demonstrate a consistent pattern that could be described by a rule involving the second-order stimuli. Additional evidence for this is provided by Test 4 probes in which the transitive relations were not present.

The number of sessions needed to learn this task could have influenced, or at least been indicative of factors prohibiting the development of equivalence relations. Subject 4 had more difficulty learning the task than any other in previous experiments. Even after learning the initial task at 100% feedback, this subject was not immmediately able to perform the training at 25% feedback for two sessions in a row at greater than 90%.

Table 46

Results of Test 4 Probes for Subject 4 during Experiment 5-A

Relation	Trial-Type	Sessions		
		1	2	3
0-CE	0-C(E F)	1/2	0/2	0/2
0-EC	0-E(C B)	2/2	2/2	2/2
0-BF	0-B(F E)	1/2	1/2	1/2
0-FB	0-F(B C)	2/2	1/2	2/2
Percent Correct per Session		75%	50%	63%
0-AC	0-A(C B)	0/2	0/2	0/2
0-CA	0-C(A D)	1/2	0/2	0/2
0-AE	0-A(E F)	0/2	0/2	0/2
0-EA	0-E(A D)	0/2	0/2	0/2
0-DB	0-D(B C)	0/2	0/2	1/2
0-BD	0-B(D A)	0/2	0/2	0/2
0-DF	0-D(F E)	0/2	0/2	0/2
0-FD	0-F(D A)	0/2	0/2	0/2
Percent Correct per Session		6%	0%	6%

Note. A zero in place of the second-order stimulus denotes the absence of the second-order stimulus. The top portion of Table 46 represents the transitive probes in the absence of the second-order stimulus while the lower portion of Table 46 represents probes of the trained relations in the absence of the second-order stimulus. In the lower portion of the table, neither stimulus was "correct", though the left comparison was scored as such.

Given sixteen trial-types to learn at once as opposed to eight, it is possible that Subject 4 learned sixteen separate trial-types rather than using efficient rules that would facilitate learning. For example, even though the training was bidirectional, the use of the rule of symmetry would certainly facilitate learning: e.g., X-AC is the same as X-CA. Subject 4 may have treated these two trial-types as two separate relations rather than more efficiently as one. This may have increased the number of sessions to criterion.

Manipulations specific to Subject 4's performance that would examine the above possibility were not conducted during this research. However, evidence that bidirectional training did not produce symmetrical relations in this case comes from the performance of Subject 3 during Experiment 2. After learning the task--bidirectionally trained--to criterion, the symmetrical trials were removed for a number of sessions of training. When they were reintroduced as probes, Subject 3 did not demonstrate the symmetrical relations.

If the above hypothesis is correct and the symmetry relation was not present during training for Subject 4, then the absence of the transitive relations might be attributed to the lack of symmetry in the trained relations. This may have been the result of too many training trial-types to learn at once. This was the only subject who did not demonstrate the conditional equivalence relations. However, as noted, no specific manipulations were conducted that would functionally analyze this possibility, because of Subject 4's limited availability.

EXPERIMENT 5-B

The purpose of Experiment 5-B was to replicate the training and testing procedures of Experiment 5-A, except that a naive subject was trained first with eight trial-types rather than sixteen.

Method

Subjects

The subject, Subject 6, in Experiment 5-B was an 18-year-old, female, freshman at Utah State University. She was recruited as in Experiment 1-A.

Apparatus and Stimuli

The apparatus used in this experiment was the same as in Experiments 1-4. The stimuli used were identical to those used in Experiments 4 and 5-A.

Training and Testing Procedures

Training. Training trials were identical to those used in Experiment 5-A (see Table 27). The training procedure was similar to that used in Experiment 2 in that training began for Subject 6 with the first four relations and their symmetrical counterparts for a total of eight trial-types. Ten trials of each of these trial-types were presented in each 80-trial session. Following two complete sessions of 90% correct responding or better, the remaining four relations in

Table 27 and their symmetrical counterparts (eight trial-types) were trained separately in a manner identical to the first eight trial types. When correct responding was 90% or greater for two consecutive sessions, Subject 6 was presented with new sessions consisting of all 16 trial-types (relations 1-8). When correct responding was 90% or greater for two consecutive sessions, the frequency of correct responding was lowered to 25% of the correct trials in the 80-trial sessions. As in Experiment 1, the correction procedure was not in effect during reduced feedback.

Probe tests. The initial probe tests, Tests 2 and 4, were identical to those used in Experiment 5-A. The initial training combined with the initial probe tests is designated Series 1. Because of Subject 6's performance, additional series of training and testing similar to that presented to Subject 3 during Experiment 3-B were presented to Subject 6. Because the composition of each condition in this series was dependent upon the results of the previous one, each training and testing condition will be described in the Results section.

Results and Discussion

Training

The results of training for Subject 6 are shown in Figure 17. The training sessions were grouped into four parts: (A) first eight trial types; (B) second eight trial-types; (C) all sixteen trial-types; and (D) all sixteen trial-types with reduced feedback (25%).

Subject 6 learned the first eight trial-types (A) to criterion in seven sessions. The next eight trial-types (B) were learned to criterion in only four sessions. Subject 6 met criterion in the minimum number of sessions during the training of all sixteen trial-types at both 100% and 25% feedback.

Probe Tests: Series 1

Test 2. The results of the first eight sessions of Test 2 probes are shown in the portion of Figure 18 marked "A". Each relation is graphed separately. During the first session of Test 2 probes, Subject 6 responded correctly to six of the eight relations tested. Only four probe trials were incorrect: two during X-CE probes and two during Y-FB probes. However, throughout the eight sessions, responding to many of the relations became unstable. By the eighth session of Test 2 probes in Series 1, responding became more stable but only relations, Y-CE, Y-EC, X-FB, and Y-BF were correct.

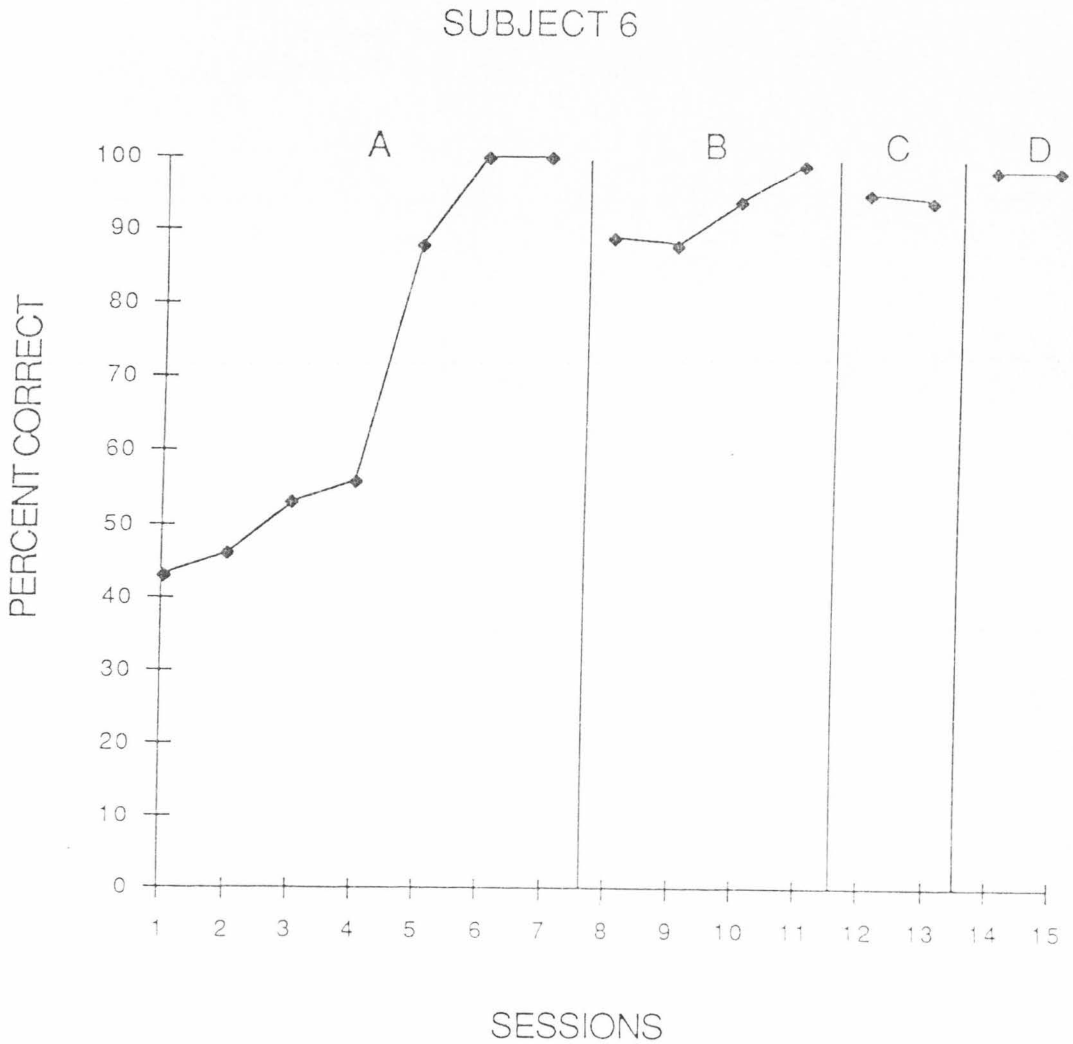


Figure 17. Percent of correct responses across training sessions during different conditions of feedback for Subject 6 in Experiment 5-B.

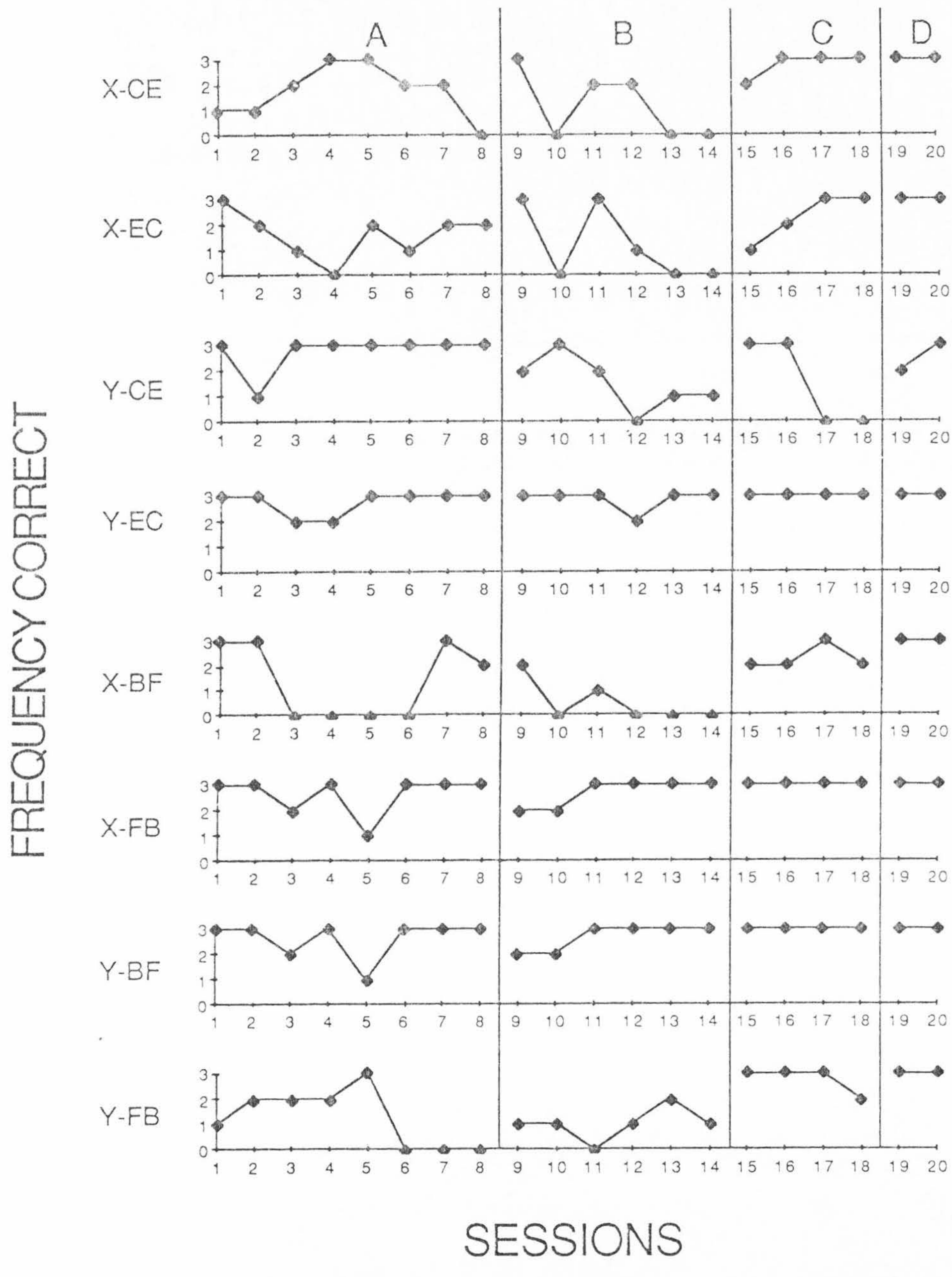


Figure 18. Frequency of correct responses for each relation probed in Test 2 for Subject 6 across different phases of Experiment 5-B.

Test 4. Even though subject 3 did not demonstrate transitive relations across all of the relations in Test 2 probes, two sessions of Test 4 probes that tested for the transitive and trained relations in the absence of the second-order stimulus were administered. As shown in Table 47, during the first session of Test 4 probes, Subject 6 only missed a single trial of transitive relation trials. However, during the second session, Subject 6 responded at chance levels to the transitivity probes. As expected, during both sessions, responses to trials resembling training trials without the second-order stimulus varied within and across the two sessions.

Series 2

Because Subject 6 did not demonstrate consistent performance with regard to transitive relations in the presence or absence of the second-order stimulus, factors which may have contributed to her performance were functionally analyzed. Before examining the underlying, four-term relations (see Series 3), the present series of sessions examined the possibility that removing all feedback from training and testing sessions might improve performance. It was hypothesized that adventitious reinforcement from the intermittently presented feedback for correct responding may have been

Table 47

Results of Test 4 Probes for Subject 6 during Experiment 5-B, Series 1

Relation	Trial-Type	Sessions 1	Sessions 2
0-CE	0-C(E F)	2/2	1/2
0-EC	0-E(C B)	2/2	1/2
0-BF	0-B(F E)	2/2	1/2
0-FB	0-F(B C)	1/2	1/2
Mean Percent Correct per Session		88%	50%
0-AC	0-A(C B)	1/2	0/2
0-CA	0-C(A D)	0/2	2/2
0-AE	0-A(E F)	0/2	1/2
0-EA	0-E(A D)	0/2	1/2
0-DB	0-D(B C)	2/2	1/2
0-BD	0-B(D A)	1/2	0/2
0-DF	0-D(F E)	0/2	0/2
0-FD	0-F(D A)	1/2	0/2
Mean Percent Correct per Session		44%	31%

Note. A zero in place of the second-order stimulus denotes the absence of the second-order stimulus. The top portion of Table 47 represents the transitive relations in the absence of the second-order stimulus while the lower portion of Table 47 represents probes of the trained relations in the absence of the second-order stimulus. In the lower portion of the table, neither stimulus was "correct", though the left comparison was scored as such.

a factor in maintaining incorrect patterns of response. Removing the feedback reduced the likelihood of this possibility.

As shown in Table 48, Subject 6 was given three sequences of training with and without correct feeback, and Test 2 probes. In all, six sessions of Test 2 probes were run during this series. These are shown in Figure 18 as sessions 9 through 14 under "B". In general, the series of training with and without feedback did not result in substantial changes to Subject 6's performance with regard to Test probes for transitive relations.

Table 48

Sequence of Training and Testing for Subject 6 during Series 2 of Experiment 5-B

Condition			# of Sessions
I.	1.	Training (100% feedback)	1
	2.	Training (no feedback)	4
	3.	Test 2 (no feedback in baseline)	1
II.	1.	Training (100% feedback)	1
	2.	Training (no feedback)	4
	3.	Test 2 (no feedback in baseline)	1
	1.	Training (100% feedback)	1
	2.	Training (no feedback)	4
III.	3.	Test 2 (no feedback in baseline)	4

Series 3

In Series 3, Subject 6 was exposed to a sequence of training and testing conditions similar to that presented to Subject 3 during Experiment 3-A. This sequence of conditions is shown in Table 49. This sequence of conditions was designed to examine the underlying, four-term relations that comprise the relations trained in the presence of the second-order stimulus.

Four-term relations associated with X. In Conditions 1 and 2 of Series 3 (see Table 49), the four-term relations (AC, DB, AE, DF) experimentally associated with the second-order stimulus, X, were trained unidirectionally with 100% feedback in Condition 1 and with no feedback in Condition 2. Subject 6 responded with 100% and 99% accuracy, respectively, during these two sessions. However, during the subsequent Condition 3, during which the transitive relations were tested, Subject 6 performed the baseline trials at 0%. Without feedback, the subject was not able to discriminate which four-term relation was correct. Thus, all subsequent test conditions utilized baselines in which 25% feedback for correct responding was presented.

In Condition 4, 20 trials of the four-term relations associated with X were presented at 100%

Table 49

Sequence of Training and Testing Conditions for Subject 6 during Experiment 5-B, Series 3

Condition		Number of Sessions
1.	Train Four-Term associated with X (100% feedback)	1
2.	Train Four-Term associated with X (no feedback)	1
3.	Test Transitive Relations (no feedback)	1
4.	Train Four-Term associated with X (20 trials only 100% feedback)	1
5.	Test Symmetrical Relations	1
6.	Test Transitive Relations	3
7.	Train Four-Term associated with X (rein. CE)	1
8.	Test Transitive Relations	2
9.	Train Four-Term associated with Y	1
10.	Test Transitive Relations	1
11.	Train Four-Term associated with X (20 trials only 100% feedback)	1
12.	Test Transitive Relations	1
13.	Test 2 Probes	4

feedback. Of those 20 trials, Subject 6 missed only the first. Next, the symmetrical relations were probed in Condition 5. Subject 6 responded with 100% accuracy to these probes. In the next 3 sessions, the transitive relations (CE, EC, BF, and FB) that would derive from the four-term relations associated with X were tested. The results of these probes are shown in Table 50. As shown in Table 50, Subject 6 demonstrated the transitive relations during the first probe test session. However, the accuracy of responding to probe trials dropped to 0% during the second session and increased only to 8% during the third. Nevertheless, the baseline trials for all three sessions were greater than 96% correct.

Table 50

Results of Transitive Relations Derived from AC, DB, AE, and DF Training for Subject 6 during Condition 6 of Series 3

Relation	Trial-Type	Sessions		
		1	2	3
0-CE	0-C(E F)	3/3	0/3	0/3
0-EC	0-E(C B)	3/3	0/3	0/3
0-BF	0-B(F E)	3/3	0/3	0/3
0-FB	0-F(B C)	2/3	0/3	1/3
Mean Percent Correct per Session		92%	0%	8%

In Condition 7, the four-term relations associated with X were again presented in training but with the addition of the "transitive relation", CE. One hundred percent feedback for correct responding was presented during this condition. Subject 6 responded with 98% accuracy. In the next condition (8), two sessions of probe tests for the transitive relations were presented. During these 2 sessions, Subject 3 responded to probe trials with 92% and 100% accuracy, respectively.

Four-term relations associated with Y. In Condition 9, the four-term relations, AB, DC, AF, and DE, that were associated with the second-order stimulus, Y, were trained for one session at 100% correct feedback. Subject 6 responded with 99% accuracy to this session. In the next session (Condition 10), the transitive relations CE, EC, BF, and FB that would derive from the four-term relations associated with Y were tested. Subject 6 responded with 100% accuracy to these probes.

Transitive relations associated with X. Because Subject 6 demonstrated transitive relations associated with Y in Condition 10, the transitive relations associated with X were retested in Condition 12. This was done to assess any potential interference with the transitive relations associated with X that may have been caused by the emergence of the transitive relations associated with Y. (Such an effect occurred with Subject 3 during Experiment 3-B.)

Before the transitive relations associated with X could be tested, the contingency in effect, i.e., the four-term relations associated X, was established with the presentation of 20 trials in Condition 11. Subject 6 was correct on every trial. Of the 12 probe trials for transitive relations presented to Subject 6 during Condition 12, two were missed: one trial of CE and one trial of FB. This session demonstrated that the performance of transitive relations associated with Y did not greatly disrupt the transitive relations associated with X.

Test 2. Four sessions of Test 2 probes, i.e., transitive relations in the presence of the second-order stimuli, were presented in Condition 13 of this series. The results of these probes are shown in the portion of Figure 18 labeled "C" (sessions 15-18). As shown, by the third session (17) of this series, all but one (Y-CE) of the transitive relations were demonstrated. This pattern of response continued during Session 18 although one correct response was made to Y-FB and X-BF.

Series 4

Because Subject 6 demonstrated all but one of the transitive relations (Y-CE) in the presence of the second-order stimulus, an additional session of training with four-term relations associated with Y was presented at 100% feedback. This session included trials with the four-term "transitive relation", CE. Thus, the four-term relation, CE, in the absence of the second-order stimulus, was explicitly reinforced. Would reinforcing the four-term relation, CE, result in increases in accuracy of the five-term relation, Y-CE?

Test 2. This question was answered with two additional sessions of Test 2 probes. The results of these sessions are shown in the portion of Figure 18 labeled "D" (sessions 19 and 20). In Session 19, of the three trials of Y-CE presented, Subject 6 responded to two of them correctly. Responses to all other probe trial-types were correct. In Session 20, Subject 6 responded correctly to all three of the Y-CE trials presented as well as to all other probe trial-types.

Test 4. Because Subject 6 demonstrated transitive relations in the presence of the second-order stimuli in the immediately preceding Test 2 probes, three additional sessions were run where Test 4 probes were presented. These probes were identical to the Test 4 probes used in Series 1. As shown in Table 51, Subject 6 responded with 100% accuracy to trials that tested the transitive relations in the absence of the second-order

Table 51

Results of Test 4 Probes for Subject 6 during Experiment 5-B, Series 4

Relation	Trial-Type	Sessions 1	Sessions 2	Sessions 3
0-CE	0-C(E F)	2/2	2/2	2/2
0-EC	0-E(C B)	2/2	2/2	2/2
0-BF	0-B(F E)	2/2	2/2	2/2
0-FB	0-F(B C)	2/2	2/2	2/2
Mean Percent Correct per Session		100%	100%	100%
0-AC	0-A(C B)	0/2	1/2	1/2
0-CA	0-C(A D)	1/2	0/2	0/2
0-AE	0-A(E F)	2/2	0/2	0/2
0-EA	0-E(A D)	1/2	1/2	0/2
0-DB	0-D(B C)	2/2	1/2	1/2
0-BD	0-B(D A)	0/2	0/2	0/2
0-DF	0-D(F E)	2/2	1/2	2/2
0-FD	0-F(D A)	1/2	1/2	1/2
Mean Percent Correct per Session		56%	31%	31%

Note. A zero in place of the second-order stimulus denotes the absence of the second-order stimulus. The top portion of Table 51 represents the transitive relations in the absence of the second-order stimulus while the lower portion of Table 51 represents probes of the trained relations in the absence of the second-order stimulus. In the lower portion of the table, neither stimulus was "correct", though the left comparison was scored as such.

stimulus. During the last two sessions of the probes for the trained trials in the absence of the second-order stimulus, Subject 6 made a majority of responses to the comparison that would be correct if the second-order stimulus, Y, were present.

General Discussion: Experiment 5-B

Experiment 5-B was designed to replicate the results of subjects in Experiments 2, 3, and 4 who demonstrated conditional equivalence relations. Experiment 5-B used a naive subject who received training that was balanced in terms of the frequency with which stimuli appeared as correct and incorrect comparisons. Experiment 5-B was also designed to systematically replicate the procedures of Experiment 5-A by training the subject by dividing the sixteen trial-types into two separate training conditions of eight trial-types.

The results of the training procedures used in Experiment 5-B showed that the task was learned to criterion in 15 sessions rather than the 21 it took Subject 4 from Experiment 5-A. This suggests that learning the first eight of 16 then the second eight trial-types is more efficient than attempting to learn 16 trial-types at once. The fact that Subject 6 also demonstrated transitive relations immediately after initial training where Subject 4 never did suggests the possibility that dividing the 16 trial-types into two training conditions of eight each promotes symmetrical relations which may facilitate the emergence of transitive relations. However, specific manipulations that would analyze this hypothesis were not conducted.

The results of this experiment also replicated the results of previous experiments in which conditional equivalence classes were demonstrated. However, the subject of this Experiment required similar training and testing of the underlying four-term relations as did Subject 3 in Experiment 3-B. As did Subject 3, Subject 6 demonstrated almost all of the five-term transitive relations during the first probe test for such relations, but this performance deteriorated across repeated testing sessions. Although Subject 6 did not demonstrate the same incorrect pattern of response to these probes that was demonstrated by Subject 3, there is some evidence that a similar rule, involving the second-order stimuli, operated to disrupt responding. This is provided by the results of testing for four-term transitive relations. Subject 6 generally responded to these probes as either all correct or all incorrect. This suggests that, while the transitive relations may have been present, the contingency (associated with X or with Y) into which probes were inserted may have controlled whether to respond transitively or "to the other" comparison. It was not until Subject 6 was explicitly trained on one of the four-term transitive relations from those that would derive from the four-term relations associated with X or with Y that consistent, correct performance on Test 2 probes for transitive relations in the presence of the second-order stimuli was obtained.

The results of this experiment, in combination with the results of Experiment 3-B, suggest that the nature of the task involved with second-order conditional discrimination training may, for some subjects, produce rules that have a disruptive effect on the demonstration of the transitive relations as they would derive with two-choice, five-term conditional discrimination training.

CONCLUSIONS AND GENERAL DISCUSSION

The Five-Term Contingency

Positive and Negative Stimulus Relations

Experiment 1-A was designed to answer three questions. First, can the subjects' responding be described as being controlled by positive and negative stimulus relations in a simultaneous five-term contingency arbitrary match-to-sample task? As shown in Experiment 1-A, such descriptions are accurate. During unreinforced probe trials, all subjects reponded to the correct comparison when a most-preferred, novel stimulus appeared as the incorrect comparison. This demonstrated control by positive stimulus relations. In addition, all subjects responded away from the incorrect comparison to the least-preferred novel stimulus when it appeared in place of the correct comparison. This demonstrated control by negative stimulus relations. Similar findings have been demonstrated by Stromer and Osborne (1982) in a four-term, arbitrary match-to-sample task with children.

While the present research clearly demonstrated control by positive and negative stimulus relations, the relationship of this control to the five-term contingency cannot be precisely determined. Specifically, what role, if any, did the second-order stimulus play in determining positive and negative stimulus relations? Were the positive and negative relations demonstrated merely relations between the sample and comparisons within the four-term unit, or did the second-order stimuli control responding away from the incorrect sample-comparison combination and toward the correct sample-comparison combination? Although direct tests of these questions were not performed in the present research, indirect evidence from responding throughout this research suggests that positive and negative relations can be inferred as having been controlled separately by the sample under some conditions and the second-order stimuli under other conditions. For example, some subjects responded correctly to the presentation of the four-term relations in the absence of the second-order stimuli in Experiment 1-A. Such correct responding must have been controlled by a positive relation between the sample and the correct comparison since the second-order stimulus was not present. However, no such opportunity for correct responding away from the incorrect comparison and in the absence of the second-order stimuli existed.

With regard to the control of positive and negative stimulus relations by the second-order stimuli, responding during probes for transitive relations for Subject 3 in Experiment 3-A seemed to follow a rule that states: if Y, then choose one comparison given C(E F) and if X, choose the other comparison (see Discussion, EXPERIMENT 3-A). In this situation, given that E was the correct comparison in C(E F) regardless of whether X or Y was the second-order stimulus present, and Subject 3 responded to E when Y was present and to F when X was present, the four-term unit CE seemed to be treated as a positive unit in the presence of Y and, in the presence of X, was treated as a negative unit. Such an interpretation is not valid until further research on the nature of the control by the second-order stimulus is conducted. Such research should be aimed at the use of novel stimuli replacing entire four-term units rather than simply replacing comparison stimuli as in the present research.

Four-Term Relations within the Five-Term Contingency

The second experimental question of Experiment 1-A asked whether the underlying four-term relations remain "intact" when the second-order stimulus is removed. The answer is a conditional no. The existence of four-term relations in the absence of the second-order stimulus was weakly demonstrated in Experiment 1-A. However, the same subjects did demonstrate such relations in Experiment 1-B.

While Sidman (1986) first formally introduced the notion of the five-term contingency, how the training of such a contingency was to be executed remained an implicit issue to be explored. The findings from Experiments 1-A and 1-B suggest that training the entire five-term contingency at once (as in Experiment 1-A) may have been the reason that subjects did not uniformly respond correctly when presented with four-term relations until Experiment 1-B. It cannot be assumed that the five-term contingency training used in Experiment 1-A will automatically lead to intact four-term relations. The present research demonstrated that direct training of the four-term relations was effective in bringing about second-order control of the four-term relations (i.e., five-term control). Evidence for this comes from the fact that no consistent transitive relations (resulting from the four-term relations under the control of X and Y) were evident in Experiment 1-A. However, subsequent to direct training of the four-term relations in Experiment 1-B, all subjects demonstrated transitive relations during test trials.

Given the above findings, the question should be raised as to why intact four-term relations are necessary for the emergence of transitive relations. (Recall that subjects in other portions of the present research required explicit training of the four-term relations, as well, before transitive relations emerged.) When confronted with the lack of emergent transitive relations, an appropriate functional analysis would examine the prerequisites (reflexivity and symmetry). For example, when a subject in Sidman and Tailby (1982) did not demonstrate an emergent four-member class of stimuli, the experimenters traced the problem to a deficient trained relation within the class. Specifically, they demonstrated that the symmetrical relation was not present in that trained relation. Retraining of that relation resulted in the emergence of the four-member class. When, as in the present research, the entire five-term contingency is trained all at once, the likelihood of a situation such as that observed in Sidman and Tailby (1982) may be increased. Even though the "symmetrical" relations between the sample and correct comparisons were explicitly trained in the present research, the presence of the second-order stimulus may have complicated the task such that, from the subjects' point of view, there were 16 separate positive relations to learn (eight original and eight sample-correct comparison symmetric configurations) rather than as eight separate relations which included the eight emergent symmetrical relations as well. Evidence for this comes from probe tests for Subject 3 in which she failed to demonstrate symmetry (see Experiment 2).

Other than the symmetry probes tested with Subject 3, the search for the lack of symmetry was not possible in any of the present experiments given that the nominally symmetrical configurations were already part of the training. However, it seems likely that directly training the underlying four-term relations first in the absence of the second-order stimulus may remove some of the complexity of the original task, thereby presenting the subject with the time-honored method (cf. Cumming & Berryman, 1965) of establishing a conditional discrimination and symmetrical relations--a major prerequisite to emergent transitive relations. The second-order stimuli can then be added after successful training of the four-term relations. Preliminary data from a recent study conducted after the present research (Feniello, Sidman, & DeRose, 1986) showed that when subjects were trained on an entire five-term contingency, emergent transitive relations were extremely difficult to obtain. However, in Lazar and Kotlarchyk (in press), training the four-term relations first proved quite successful.

Conditional Control of Equivalence Relations

Taking the results of all five experiments together, there emerged two distinct ways in which the composition of equivalence classes could be controlled conditionally. First, Experiments 1-A and 1-B showed that, following training with a second-order conditional discrimination (the five-term contingency training), the removal of the second-order stimulus resulted in the merging of all underlying four-term stimuli.

Whether such a result would obtain was a question raised by Sidman (1986) and answered (following four-term training in Experiment 1-B) in the affirmative by the present research: without an explicit second-order stimulus, each stimulus in the four-term unit was transitively related. When the second-order stimulus was again presented, these same transitive relations were no longer obtained.

The second way in which the composition of the equivalence classes was controlled was demonstrated in Experiments 2-5. Specifically, four separate three-member classes of stimuli were controlled by the second-order stimuli, X and Y. Some of the classes had one and two stimuli in common. As shown by Fucini (1982), the training of classes of equivalent stimuli with members in commmon will result in the merging of those classes unless second-order conditioning procedures are used.

Recall that Fucini (1982) used the context in which the comparisons appeared to establish second-order control of the equivalence relations in her study. In her discussion, Fucini (1982) raised the question as to the possibility of second-order control using an explicit second-order stimulus. The present research demonstrated second-order control with an explicit second-order stimulus in two ways: (a) in Experiments 1-A and 1-B, transitive relations resulted from the absence of the second-order stimulus, and (b) in Experiments 2-5, equivalence classes were controlled by the presence of one or another explicit second-order stimulus.

The differences between the second-order procedures of Fucini (1982) and the present research may have implications for the ease with which equivalence classes can be controlled. In Experiment 3, Fucini (1982) introduced her second-order conditional discrimination procedures with subjects that had already merged two three-member classes of stimuli. These procedures were mostly successful in separating the merged classes with three children but not successful in separating the classes with the adult subject. While Fucini did not attempt to return the subjects to the responding demonstrated before the second-order training, it seems reasonable to assume that this would have proven quite difficult: some manner of retraining with extinction and/or new trial-types would likely have been necessary. Using an explicit second-order stimulus in either of the manners described above in the present research allows the composition of equivalence classes to be quickly controlled merely with the presence of one or another second-order stimulus (as in Experiments 3-5) or its presence vs absence (as in Experiments 1-A and 1-B).

Another issue regarding the use of the explicit second-order stimuli is the modality from which it is derived. In suggesting the second-order control of five-term contingency relations (Sidman, 1986) and equivalence relations (Fucini, 1982) by explicit stimuli, the use of different tones has been the most common example. Indeed, Lazar and Kotlarchyk (in press) used tones to control second-order sequencing behavior. The present experiment represents the first to demonstrate that second-order control of equivalence relations can be established completely through visual stimuli.

Contiguity vs Conditionality

As discussed earlier, Green (1985) trained subjects to respond to either an identity match of colors or shapes or an arbitrary match of within-dimension colors or shapes. A superordinate, "contextual" stimulus--printed words of either the instance (e.g., BLUE) or concept (e.g., COLOR) being matched--was presented contiguously with the sample. During training, the presence of the superordinate stimulus was not <u>necessary</u> to make a correct response. The experimental question was whether the superordinate stimuli, by virtue of their contiguity with the sample stimuli, would become associated with the correct comparisons. Probe tests that presented the superordinate stimuli in the absence of the samples revealed that only one of the five subjects responded correctly above chance levels. Thus, for most of the subjects, the contiguity of the superordinate stimuli and the sample stimulus was not sufficient to establish a contextual control. Nevertheless, all subjects did learn the underlying, four-term relations being trained.

In the present research, the use of a "contextual" stimulus (the second-order stimulus) was necessary during training in order to make a correct response. For example, the choice between the comparison stimulus B or C depended not only upon whether sample A or D was present, but also upon whether the second-order stimulus X or Y was present. Also, as demonstrated in the present research, this conditionality of the second-order stimuli led to "contextual" control during training and testing.

The present research suggests that it may be necessary for the second-order stimulus to be related conditionally to the relations being trained. However, neither the present research, or that reported by Green (1985) systematically investigated this question. One question that arises from the present discussion, is the possibility that the modality in which the contextual stimulus is presented has bearing on whether contiguity or conditionality is necessary for contextual control.

Note that Green (1985) used a visual, contextual stimulus as did the present research. As noted earlier, Lazar and Kotlarchyk (in press) used different tones to establish contextual responding. In their study, the tone was conditionally related to the underlying relations being trained. Would a contiguous yet not conditionally related auditory stimulus control responding? As yet, research examining this issue has not been completed.

Implications of the Present Research

The use of the stimulus equivalence paradigm (Sidman, 1971) has provided behavior analysts with an important tool for the experimental analysis of behavior most often classified as cognitive: conceptual and linguistic. To date, much of the current research in stimulus equivalence has taken the basic stimulus equivalence paradigm set forth by Sidman (1971) and attempted to determine ways in which membership in the class of equivalent stimuli can be expanded (e.g., Lazar et al., 1984; Sidman, et al., 1985; Sidman & Tailby, 1982). Without question, such research is important to determine controlling factors of linguistic and conceptual classes of stimuli. However, human verbal and conceptual behavior is far more complex than can be described within the <u>four-term contingency</u> study of stimulus equivalence. Much of human behavior is under instructional control (Baron & Galizio, 1983)--instructional control that is more complex than that provided by the sample in a match-to-sample task. Using an example from Feniello et al. (1986), linguistic stimuli such as Renoir, Constable, and Da Vinci can be considered one equivalence class (artists); Churchill, Mussolini, and Louis XIV would be considered another (heads of state); and Dante, Voltaire, and Byron another (writers). Thus, under the context of discipline, the above stimulus classes are appropriate. However, if the context were nationality, the same linguistic stimuli are grouped differently: Renoir, Voltaire, and Louis XIV (French); Dante, Mussolini, and Da Vinci (Italian); and Churchill, Constable, and Byron (British). Thus, stimuli are not immutable members of single classes; context determines membership for any given moment.

The present research extended the findings of stimulus equivalence research into this more complex level: the conditional control of equivalence relations. Using arbitrary visual stimuli, classes such as those described above were controlled in Experiments 2-5 of the present research. But what about the control of equivalence relations shown in Experiments 1-A and 1-B of the present research in which classes were equivalent in the absence of the second-order stimuli? Keeping the above analogy, if the contextual stimuli, discipline and nationality, were removed, the linguistic stimuli above would likely be treated as a single class--great figures in history. Such was the result of probe tests in Experiments 1-A and 1-B: removal of the second-order stimuli resulted in transitive relations among all stimuli. Thus, the present research provides a cornerstone for understanding complex human behavior--behavior traditionally viewed as cognitive.

While Sidman (1971) demonstrated that stimulus equivalence training could result in rudimentary reading skills, the present five-term contingency paradigm--after extensive research determining the optimal training conditions--could also prove valuable for the behavioral training of complex human behavior for low functioning individuals. The present research was conducted with college students. Would the five-term training task prove too difficult for children or low functioning individuals? Research into this question is necessary.

Before researchers plunge into investigations of the conditional control of equivalence relations, it might be wise to investigate the tool which will be most valuable: the five-term contingency. Many questions (discussed earlier) were raised by the present research concerning the stimulus control involved in such a contingency. It may be that answers to these questions will make the task of analyzing complex human behavior a little easier.

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APPENDICES

Verbal Instructions to Subjects

INSTRUCTIONS

(to be read to the subject)

Identity Matching

Your task is to choose the correct symbols. If you choose the correct one on the first try, you will see the word "CORRECT" on the screen and you will earn a point. If you do not choose the correct one, then the screen will go blank and the trial will be presented over. This time, if you get it correct, you will see the word "CORRECT" but you will not earn a point. Therefore, the greater number of times you make the correct choice on the first try, the more points on the screen you earn and the more money you make. Every four points is worth 1 penny. Begin when you see a symbol on the screen.

(DEMONSTRATE)

Training

Now we will begin a different task. The same basic procedure regarding the word "correct" and points and money will still apply. When the session is over, the screen will go blank for one or two minutes during which time you should relax. When you see a symbol on the screen, you are to begin again. Good luck and do your best.

Reduced Feedback and Probes

(This time) (Today) (Now), the word "CORRECT" will not appear every time that you get one correct and the ones you miss will not be presented over, but I still want you to do the very best that you can. Now the points are worth a penny each. Good luck and do your best.

VITA

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