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An Experimental Analysis of Higher-Order Stimulus Control in Humans

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AN EXPERIMENTAL ANALYSIS OF HIGHER-ORDER STIMULUS CONTROL IN HUMANS

by

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Michael B. Gatch

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ABSTRACT

An Experimental Analysis of Higher-Order
Stimulus Control in Humans

by

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This dissertation explored some effects of context on the development of stimulus classes and the transfer of stimulus functions to novel stimuli. The research was also intended to demonstrate the utility of current behavioral theories for prediction and control of contextual effects on class formation. In Experiment 1A, contextual control of stimulus classes was established successfully in all six college-student subjects. Matching-to-sample training successfully transferred the function of the contextual stimuli to four novel stimuli, which resulted in the formation of two three-member classes of contextual stimuli. The first portion of Experiment 1B replicated Experiment 1A with three additional subjects. In the second portion, matching-to-sample training resulted in the establishment of two six-member contextual classes. In Experiment 2, three of four subjects learned a matching-to-sample task in which the role of the contextual stimuli was controlled by a pair of "higher-order" contextual stimuli. Two of the subjects received matching-to-sample training in which the function of the higher-order contextual stimuli was transferred to four novel stimuli, which resulted in the development of two three-member, higher-order contextual classes. Experiments 3A, 3B, and 3C demonstrated that some groupings of stimuli are more difficult to learn than other groupings. The experiments found that overlapping roles of stimuli tended to confuse subjects and that subjects, when confused, would respond based on "familiarity" to stimuli rather than on the conditional relations. Experiments 4A and 4B demonstrated that types of matching performance (identity, oddity, and arbitrary) can be controlled by the presence of contextual stimuli. The experiments also provided evidence supporting the idea that generalized identity (reflexivity) and generalized oddity performances are closely related to, if not prerequisites for, successful arbitrary matching and the development of stimulus classes.

(205 pages)

INTRODUCTION

Concept formation and language are central topics in the study of human behavior and have been studied extensively, especially by cognitive psychologists. Behavioral psychology has only begun to examine these two topics in any depth because of the methodological difficulties involved in testing the very complex array of behaviors, many of which are covert. Much of cognitive psychology is devoted to devising analogies of what is done privately with information (discriminative stimuli) by the subjects. As behaviorists have traditionally resisted an appeal to unobservable variables, little attention was paid to covert behavior until recently, when pressure by nonbehaviorists and the development of new methodologies encouraged attention to language and concept formation.

Stimulus Equivalence

One of these new methodologies is loosely referred to as stimulus equivalence. Technically, stimulus equivalence is not a new experimental technique, since matching to sample (given a stimulus, choose from choices which one goes with it) is most often used in experiments on equivalence. Stimulus equivalence is an inference about behavior, in which subjects treat a group of stimuli as if they were the same. However, the term is also used loosely as the name for the theoretical account of how stimuli come to be treated the same, that is, become equivalent.[1] The theory is comprised of a group of axioms logically derived from set theory which have some empirical support: symmetry, reflexivity, and transitivity (Lazar, Davis-Lang, & Sanchez, 1984; Sidman, Rauzin, Lazar, Cunningham, Tailby, & Carrigan, 1982; Sidman & Tailby, 1982; Sidman, Willson-Morris, & Kirk, 1986; Wetherby, Karlan, & Spradlin, 1983). (The word "axiom" is chosen since some of those responsible for the theory regard them as logically self-evident and indisputable.) For the purposes of this paper, stimulus equivalence will refer to the behavior of classifying stimuli, equivalence training or equivalence procedures will refer to the experimental/training techniques which lead to the formation of stimulus classes, and equivalence theory will be used to refer to the various theoretical attempts to provide a framework for equivalence research that have been devised by Sidman and Tailby (1982); Fields, Verhave, and Fath (1984); Fields and Verhave (1987); and others.

According to equivalence theory, a stimulus class is established by training a subject to "group together" a set of topographically different stimuli. Doing so is usually accomplished by reinforcing the behavior of selecting one of the stimuli in the presence of another,

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[1] This terminological difficulty is a result of the assumption made by behaviorists that if one can produce the behavior, one has at least one explanation of it. Hence, terms referring to a behavior or a technique become theoretical in nature. Matching to sample was originally used to name a training technique. Recently, matching to sample has been used to indicate an inferred performance when a subject relates any stimulus to itself without prior exposure or training, which is what subjects were supposed to learn from the matching-to-sample task (when based on identity). This behavior has also been termed generalized identity matching, or reflexivity, and has a number of theoretical implications discussed below under reflexivity.

using a matching-to-sample task (given this stimulus, which of the following stimuli, or comparisons, "go with it?"). Sidman (1971) found that all the possible combinations of stimulus pairings do not have to be trained, and the necessary and sufficient prerequisites for the establishment of a stimulus class have been identified (Sidman & Tailby, 1982). These prerequisites correspond to the three axioms mentioned above. First, reflexivity must be present; that is, the subject must be able, in the presence of any stimulus, to choose the identical stimulus from an array of comparisons. This indicates that the subject can treat any stimulus as equivalent to itself, which is necessary before a subject can treat topographically different stimuli as equivalent. Second, symmetry must be present; that is, the subject must be able to, without training, relate stimulus B to stimulus A if trained to relate A to B. This means that the subject can use two topographically different stimuli interchangeably or, in other words, treat the stimuli as if they had the same meaning. Thirdly, transitivity must be present; that is, the subject, if trained A=B and B=C, will relate A to C without training. This means a subject is able to generalize the function of a stimulus without direct training and explains why all possible stimulus combinations need not be trained. If all three conditions set by the axioms are met, then the stimuli may be said to be equivalent. The three axioms not only indicate the prerequisites for classing but also suggest three empirical tests to assess whether stimuli are related and to investigate at a fine-grain level why particular stimuli may not be related.

Two important points must be made about the limits of equivalence theory. First, equivalence is intended to refer only to the case where stimuli are equal to each other, not greater than or less than. Second, (using set theory terms) equivalence does not deal with intersection, only union. However, intersection can be dealt with using the higher-order methods discussed in the following section.

Higher-Order Control of Stimulus Classes

Sidman (1986) postulated that one could place the classification of stimuli under conditional control; for example, in Situation 1, place stimuli A, B, and C together and D, E, and F together, but in Situation 2, place stimuli A, E, and F together and D, B, and C together. A single stimulus can be used as a cue to signal how classes go together in different situations. This allows for an analysis of the effects of context on stimulus classification and for an account of the intersection of classes which occurs in everyday human behavior. The establishment of stimulus classes by a conditional stimulus is called contextual control. In a sense, a hierarchy of stimulus control is established in which a contextual stimulus controls responding to a sample stimulus, which controls responding to a comparison stimulus. The three-term operant contingency (S-R-->CSQ) can be placed under the control of the presence of the sample, or fourth-term, stimulus (S-S-R-->Csq), which can be placed under the control of the contextual, or fifth-term, stimulus (S-S-S-R-->Csq), which can in turn be placed under the control of a sixth-term stimulus (S-S-S-S-R-->Csq). Each term provides a cue to how to resolve the remainder of the contingency.

The hierarchy is meant to be a theoretical tool by which to analyze the effects of higher-order stimulus control. There is no implication that some natural hierarchy exists in either the stimuli or the mind.

Control of Class Membership

Higher-order (contextual) stimuli may play a number of roles in the formation of stimulus classes. First, in situations in which a stimulus belongs to more than one class, higher-order stimuli may be used to indicate which of the classes is relevant at the present and can prevent the development of spurious relations. For example, mercury is both a metal and a liquid. At various times, mercury could be correctly related to both iron and milk, yet a response that iron and milk are members of the same set is generally considered incorrect. The word metal, then, can serve as a contextual cue that iron and mercury are both class members, while milk is not, and the word liquid can indicate that milk and mercury are both class members, while iron is not.

Contextual control is then not only of interest for studying the formation of hierarchical classes but for determining how classes may intersect. Language classes used in natural settings are not usually simple, mutually exclusive groups of stimuli but tend to overlap or "intersect." That is, stimuli are in one class in one context and in another class in some unrelated context, as is the word mercury in the example above. In such a case, a word could be synonymous with other words in one contextual situation, yet those synonyms could be seriously incorrect in other contexts. Homonyms such as the word "leaves" may indicate that one is going away or be the plural of the word leaf. The correct interpretation depends on the context, which may be the preceding paragraph or a single word. Synonyms such as "animal" and "beast" rarely overlap completely in meaning. Both refer to nonplant organisms, but "beast" is usually used to refer to wild or dangerous animals. A wolf would be labelled an animal and a beast, but a cow likely would not be considered a beast. There are many contextual cues in language, including the antecedents for case, gender, or pronouns, as well as syntax. Knowledge of how contexts can serve to divide classes in such ways would be beneficial to the teaching of language and concepts.

Hierarchies of Context

Groups of stimuli often have a label which serves to set the context, and hierarchies of contexts can be formed via equivalence procedures. Such hierarchies of contexts can be used to explain various hierarchies of classes, such as Linnaeus's system of biological classification. The Linnaean classification system has seven levels of context: Kingdom-Phylum-Class-Order-Family-Genus-Species. Each level has conditional control over the next level. Assignment to the Class Mammalia is incorrect if the organism has no spinal chord, or is not an animal.

An everyday example of the contextual control of classification with multiple levels of context is that of finding one's way in a large city. People often classify the streets into those which go north and south and those which go east and west. However, some of these are one-way, and in some cities, whether a street is one-way or even which direction traffic must run is determined by the time of day. For the confused traveler, a hierarchy of contexts exists here. The street is the stimulus to be classed, the desired direction the first context, whether one-way the second, and time-of-day the third. Further examples of extended contingencies such as this may be provided by flow charts of problem-solving techniques or if-then statements in computer programs.

Other stimuli which are not specified by an experimenter can also serve as contexts for classifying stimuli. Incorrect comparisons in a matching-to-sample task provide such cues (McIlvane, Withstandley, & Stoddard, 1984; Sidman, 1987; Stromer & Osborne, 1982). Other indirect and nondiscrete cues can affect performance. Serna (1987) reported difficulty in establishing fifth-term control of classes. Part of the difficulty was probably due to using a two-choice task rather than a three-choice task (Sidman, 1987), but part of the difficulty may also have been due to the exposure of the subjects to an identity-matching task before the experiment began. Steele and Hayes (1988) reported that subjects failed to respond correctly on an identity matching task after being exposed to a series of arbitrary-matching tasks, which is a further indication that even history can serve as a contextual cue for classification.

Statement of the Problem

The purpose of this dissertation research is to demonstrate a number of features of stimulus classes under the control of contextual stimuli (Sidman, 1986) at a variety of levels, with a variety of stimulus class arrangements, in order to provide empirical tests of the procedures and predictions of equivalence theory. In particular, how contextual stimuli affect the formation of stimulus classes is investigated. Contextual control is defined by Sidman (1986) as the control by a stimulus of a set of conditional relations, correct responses to which are dependent upon the nature of the stimulus. Research has demonstrated that a stimulus can serve as a contextual cue in the stimulus equivalence paradigm (Bush, Sidman, & deRose, 1989; Fucini, 1982; Kennedy & Laitinen, 1988; Serna, 1987). The research in this dissertation is also intended to provide a procedural framework to suggest methods of instruction, diagnosis, and remediation for concept learning (e.g., vocabulary acquisition).

The experiments will examine a number of specific issues: (1) whether stimulus equivalence techniques will work at contextual levels, both fifth-term and sixth-term; (2) transfer of contextual function via equivalence; (3) establishment of higher-order contextual control; that is, sixth-term control; (4) establishment of contextual control by superimposition of fifth-term and/or sixth-term control over existing conditional relations versus training fifth-term and/or sixth-term conditional relations in toto; (5) generalization to large stimulus classes (6-member classes rather than 3-member classes); (6) limits on how classes can be intersected via contextual control; and (7) mechanisms of class formation in terms of how contextual stimuli may control classification. The following paragraphs will provide a description of how each experiment contributes to these issues.

Experiment 1A is a replication of the earlier research on the formation of contextual control of two subordinate three-member classes, using arbitrary stimuli. Experiment 1A fulfills three purposes: (1) it replicates earlier contextual control work which demonstrates that higher-order stimuli can control stimulus class formation; (2) it demonstrates empirically that stimulus equivalence techniques function at the upper levels of Sidman's theoretical hierarchy; that is, stimuli can become equivalent to contextual stimuli; and (3) it demonstrates that transfer of contextual function can be effected via equivalence techniques.

Experiment 1B is an extension of Experiment 1A, and tests whether the rapid expansion of stimulus classes shown to be possible at the fourth-term level (Sidman, Kirk, & Willson-Morris, 1985) takes place at the contextual level. Such rapid expansion is very useful for training large classes, and is a useful explanatory tool for how people can generalize among synonyms with very little training. Since a word such as "animal" can act as a contextual stimulus controlling a myriad of animal names, ease of creating a contextual class (such as beast, brute, creature, fauna, flesh, carnal, corporeal) without training each of the thousands of relations between each new context and each animal name would be of great teaching value.

Experiment 2 replicates and extends Experiment 1 to sixth-term control, that is, stimulus control of context. Sidman (1986) has discussed the possibility of such control, but as yet there has been no empirical demonstration of it. Experiment 2 also serves to test the limits of the practicability of Sidman's theoretical hierarchy of control, and its ability to explain higher-order real world situations in which contexts are conditionally controlled such as the Linnaean system of classification.

Experiments 3A, 3B, and 3C are a series of systematic replications intended to provide a functional analysis of problems related to contextual control of class membership. These experiments also examine the alternate procedure of successively introducing levels of control rather than presenting them from the start as in Experiments 1A, 1B, and 2. These experiments serve to test a number of procedural issues and begin an analysis of classification which is continued in Experiments 4A and 4B. Specifically, Experiments 3A, 3B, and 3C examine (1) whether establishing contextual control bottom-up creates different results than establishing control all at once as suggested by Kennedy & Laitinen (1988); (2) whether increasing class size creates difficulty in terms of classification (testing limits of class size); (3) whether classes can be combined without confusing the subject; and (4) how subjects respond when presented confusing sets of conditional relations. The findings related to issue (4) provide further data on how incorrect comparisons and the overall set of conditional discriminations affect how subjects class stimuli.

Experiments 4A and 4B involve establishing stimulus control of identity (reflexivity), oddity, and equivalence by establishing stimuli which signal when reflexive, and other behavior is appropriate (reinforced). While the logical demonstration of the necessity of reflexivity, symmetry, and transitivity to equivalence has been made (Sidman & Tailby, 1982), the empirical demonstration of reflexivity has been called into question (Steele & Hayes, 1988). There have been repeated demonstrations of the empirical necessity of symmetry to transitivity (e.g., Sidman et al., 1982), but reflexive performance has largely been taken for granted until the experiment by Steele & Hayes (1988). Experiments 4A and 4B demonstrate that classing and non-classing behaviors can be controlled by contextual cues, and need not be mutually exclusive as suggested by Steele and Hayes.

LITERATURE REVIEW

A systematic framework to describe the structure of stimulus classes has been formulated (Sidman, 1986). A framework is useful to help guide an understanding of the nature of the relations among groups of stimuli. This review will present the current state of the framework as well as some historical developments in order to provide background for the problems to be studied in this dissertation.

Fourth-Term Control

Sidman (1986) has established a theoretical base with which to analyze interrelations of conditional relations. First, he extended the operant three-term contingency (S-R-->CSQ) to four terms in order to analyze conditional discriminations. A fourth term (S-S-R-->CSQ) allows for description of the environmental control of a three-term contingency. The stimulus control task involving fourth-term control is called a conditional discrimination; for example, if stimulus A occurs then respond to stimulus B, but not stimulus C for reinforcement, and if stimulus D occurs, then respond to stimulus C and not stimulus B for reinforcement. A four-term contingency is illustrated in Table 1. The German word "Hund" is related to the English equivalent "dog" and the German word "Katze" is related to the English equivalent "cat". The conditional discrimination is the fundamental unit for the functional description of a stimulus class, since it describes the manner in which two stimuli become related.

The question arises of how humans can learn a number of conditional relations and then generalize from them to a stimulus class. Two behavioral approaches to concept formation have been developed (functional equivalence and stimulus equivalence), and have led to two different procedures for establishing stimulus classes. These two approaches and how they developed will be described, followed by a discussion of how the two approaches interact.

Table 1

Four-Term Contingency Example, in Which Subject Relates an English Word to the Corresponding German Word

```
                    (                        ( R1 (press) ---> C1 (point)
                    ( S1 ("Katze") ---- (
                    (                        ( R2 (other) -/-> C1 (point)
S3 ("Cat") ----- (                        ----------------------------
                    (                        ( R1 (press) -/-> C1 (point)
                    ( S2 ("Hund")  ---- (
                    (                        ( R2 (other) -/-> C1 (point)
                 ---------------------------------------------------------
                    (                        ( R1 (press) -/-> C1 (point)
                    ( S1 ("Katze") ---- (
                    (                        ( R2 (other) -/-> C2 (point)
S4 ("Dog") ----- (                        ----------------------------
                    (                        ( R1 (press) ---> C1 (point)
                    ( S2 ("Hund")  ---- (
                    (                        ( R2 (other) -/-> C2 (point)
```

Functional Equivalence and Mediated Transfer

In 1971, Sidman first reported the establishment of stimulus classes via equivalence. He taught a severely mentally retarded youth to form 20 four-member classes. The youth could relate pictures to a spoken word (A-B) and could name pictures (B-D). He was taught to relate printed words to the spoken word (A-C). Upon testing, the youth could then relate the picture to the printed word (C-B). The study demonstrated that a retarded youth could generalize stimulus relations without training.

Spradlin, Cotter, and Baxley (1973) suggested that the generalization of stimulus relations occurred because the stimuli came to control a common response. In three separate experiments, they taught nine subjects a number of conditional discriminations, and found that the subjects could then perform a new conditional discrimination without training. Over the course of the experiments, they found that only two conditional discriminations need be trained to produce a new conditional discrimination via equivalence, as long as one stimulus is common to both trained conditional discriminations.

The formation of a class of stimuli by relating them to a common response, or function, is called "functional equivalence" (Goldiamond, 1962, 1966). A common physical topography is not necessary to form a stimulus class, as stimuli which are physically dissimilar can come to have the same meaning. For example, a red light, a stop sign, or a child running into the street can all signal a driver to stop. Transfer of control would then account for the generalization of new conditional relations. If A-B and A-C are taught, then B-C could be performed, since the subject can mediate the new relation with the same response made to A-B or A-C. Naming can be such a mediating response.

Sidman, Cresson, and Willson-Morris (1974) demonstrated that naming is not necessary to form equivalence classes. In a systematic replication of the 1971 Sidman study, they taught two retarded adolescents 20 four-member classes by training A-B, B-D, and B-C (picture to word) rather than A-C. They also taught the subjects C-C matching. The subjects generalized A-C performance before they learned to name consistently, which rules out naming as a causal factor. The authors raised the question of what mediated the transfer of the stimulus equivalences, since the verbal naming apparently did not do so.

How the untrained relations develop without mediation became a puzzle. In 1977, Lazar demonstrated that classes could develop through functional equivalence. Three adults of normal intelligence were taught to order pairs of stimuli. Lazar found that two classes of stimuli resulted based on order. Those stimuli which were first became a class, and those stimuli which came second became a class. The subjects were then trained to relate new stimuli to a member of one or the other of the classes. Testing revealed that the subjects also ordered the new stimuli according to which class the new stimuli had been related. One subject did not transfer the sequence function. Further testing found that he was not able to perform symmetrically on the matching-to-sample task. The study demonstrated that matching to sample can transfer stimulus function. However, there was no common function to mediate the matching-to-sample task.

Stimulus Equivalence

Sidman and Tailby (1982) proposed that mediation is not necessary, and that stimulus classes are formed based on the three prerequisites of reflexivity, symmetry, and transitivity. Stimulus equivalence is different from functional equivalence in that the stimuli are directly related to each other, rather than via a common response. In a matching-to-sample task, the subject makes a selection based on stimulus-stimulus relations. A button pressing response is made regardless of stimulus class, and verbal mediation and other coding responses apparently are not necessary.

More recently, a series of studies by Dube and others have indicated that functional equivalence and stimulus equivalence seem to be governed by the same rules (reflexivity, symmetry, and transitivity) and that stimulus equivalence results in functional equivalence and functional equivalence results in stimulus equivalence. Dube, McIlvane, Mackay, and Stoddard (1987) found that reinforcers could become members of a stimulus class. They concluded that the results supported the notion of the four-term contingency because a simple discrimination between reinforcer type and a particular stimulus would have resulted in errors. They did note that fourth-term relations could be established without class formation occurring, and noted that they did not examine comprehensively for stimulus equivalence. However, they did conclude that the results were consistent with the acquisition of equivalence classes.

In a series of follow-up studies, when stimuli were related via matching to sample to stimuli which signalled reinforcement (S^D) or to stimuli which signalled absence of reinforcement (S^{Δ}), those stimuli acquired the same discriminative function (deRose, McIlvane, Dube, Galpin, & Stoddard, 1988; deRose, McIlvane, Dube, & Stoddard, 1988; Dube, McIlvane, Maguire, Mackay, & Stoddard, 1989). Dube et al. (1989) attributed their results to indirect relations of the new stimuli to differential consequences. Stimuli became S^D's when they were related to an S^D, and became S^{Δ}'s when related to an S^{Δ}. Due to inherent difficulties with the methodology, stimulus equivalence could not be tested directly. The authors then concluded that their results provide support for the definitions of stimulus equivalence (Sidman & Tailby, 1982) and functional equivalence (Goldiamond, 1966), but also suggest that the variables which affect the two types of equivalence may be the same.

However, the study by Lazar (1977) and a study by Sidman, Wynne, Maguire, & Barnes (1989) both reported that subjects acquired functional equivalence among a group of stimuli, but did not develop stimulus equivalence among those stimuli. Lazar (1977) attributed his results to the failure of the matching-to-sample task, but Sidman et al. (1989) suggested that while the two processes may be similar, and may coexist, they are not necessarily the same process. The relation between functional equivalence and stimulus equivalence is still unclear, and more research is necessary to clarify the roles of these two types of equivalence in the generalization of relational behaviors.

Transfer of Function

An area in which both types of equivalence overlap is that of transfer of function. An investigation of transfer may help clarify the roles of stimulus and functional equivalence, and is important in its own right for understanding how common properties of stimuli come to be shared among a stimulus class. As mentioned earlier, some of the early studies in equivalence attempted to account for the formation of new conditional relations by transfer of function (Spradlin et al., 1973; Spradlin & Dixon, 1976). Lazar (1977) demonstrated that one function of a stimulus, its order in a sequence, could be transferred via matching to sample. In 1986, Lazar and Kotlarchyk found that when a member of a stimulus class acquired a particular order in a sequence, the other members of that stimulus class were also ordered in the same way.

Since then, a number of studies have demonstrated transfer of function. Wulfert and Hayes (1988) replicated the prior work on sequence classes, and Dougher, Greenway, and Wulfert (1988) demonstrated transfer of a conditioned response function via equivalence. Two studies have demonstrated transfer of the conditioned reinforcement function via equivalence (Greenway, Dougher, & Wulfert, 1988; Hayes, Devaney, Kohlenberg, Brownstein, & Shelby, in press). The last two studies overlap those of Dube and others on reinforcement as a mediating stimulus in functional equivalence, but add a comprehensive demonstration of the existence of equivalence classes among the stimuli.

The role of transfer of function in functional and stimulus equivalence has been recognized as an important one. Although the precise relations between functional equivalence and stimulus equivalence are not known, an understanding that the two types of equivalence are closely related and interact closely has developed. An understanding of how they work and how they are related is of importance for increasing the understanding of the development of novel repertoires via equivalence and transfer of function and for the understanding of the bases of stimulus class formation.

Fifth-Term Control

Sidman (1986) further added a fifth term in order to explain stimulus control on a hierarchical or contextual level (S-S-S-R-Csq). With a fifth term, a set of conditional discriminations can be placed under stimulus control, for example, Table 2. The items can be classed together on the basis of whether they are plants or animals, or whether they are edible or inedible. The fifth-term stimuli (S5 and S6) function as contexts that indicate which basis for classification is to be used. In fact, Sidman (1986) defines contextual control as the control by a stimulus of a set of conditional relations, correct responses to which are dependent upon the nature of the stimulus. The hierarchical structure of the five-term contingency allows various stimuli that occur in a variety of contexts to be understood in each specific situation.

Demonstrations of Contextual Control

A number of studies (Bush et al., 1989; Fucini, 1982; Hayes et al., in press; Kennedy & Laitinen, 1988; Lazar & Kotlarchyk, 1986; Serna, 1987; Wulfert & Hayes, 1988) have investigated fifth-term control of classes with humans. Fucini investigated how such stimulus classes as in the above example intersect, and what conditions are necessary in order for such classes to intersect without becoming one large class. To return to the Mercury example, if two small classes such as Iron, Mercury, and Copper, and Water, Milk, and Mercury are linked by one member, one large class is formed (Fucini, 1982; Sidman et al., 1985). However, the grouping of Iron and Copper with Water and

Table 2

Five-Term Contingency in Which the WordsGourd and Dow are Related to the Words Cord and Skunk Based on Whether One is Classifying According to Plant Versus Animal or Whether They Are Good to Eat

S5 (Plant/ Animal)	S3 (corn)	S1 (gourd)	R1 (press) ---> C1 (point)
			R2 (other) -/-> C1 (point)
		S2 (cow)	R1 (press) -/-> C1 (point)
			R2 (other) -/-> C1 (point)
	S4 (skunk)	S1 (gourd)	R1 (press) -/-> C1 (point)
			R2 (other) -/-> C2 (point)
		S2 (cow)	R1 (press) ---> C1 (point)
			R2 (other) -/-> C2 (point)
S6 (Edible/ Inedible)	S3 (corn)	S1 (gourd)	R1 (press) -/-> C1 (point)
			R2 (other) -/-> C1 (point)
		S2 (cow)	R1 (press) ---> C1 (point)
			R2 (other) -/-> C1 (point)
	S4 (skunk)	S1 (gourd)	R1 (press) ---> C1 (point)
			R2 (other) -/-> C2 (point)
		S2 (cow)	R1 (press) -/-> C1 (point)
			R2 (other) -/-> C2 (point)

Milk may be undesirable behavior in particular circumstances. Ideally, classification of Mercury as both a metal and a liquid should be possible without combining all elements of the classes metal and liquid together. Fucini (1982) found that training with a contextual stimulus would prevent the merging of the intersecting classes, and would break up existing intersecting classes. For example, the subject would be taught to relate Mercury to Water and Milk when the contextual stimulus Liquid was present, and to relate Mercury to Iron and Copper when the contextual stimulus Metal was present.

Lazar and Kotlarchyk (1986) investigated the use of contextual control to establish stimulus classes which were related with specific temporal sequences. Subjects were taught to select comparisons from one set of four Greek letters when the sample was red, and to select comparisons from another set of Greek letters when the sample was green. In another task which was concerned with performing in correct temporal sequences, the subjects were trained to press red first and then green when presented with one tone and to press green first and then red when a different tone was presented. Testing established that the subjects were then able to respond in the correct sequence when presented the tones with the Greek letters as comparisons.

Two separate studies set out to deliberately establish contextually controlled stimulus classes via stimulus equivalence (Bush et al., 1989; Serna, 1987). Each study demonstrated the development of contextually controlled stimulus relations in a majority of subjects, but both reported difficulty in establishing fifth-term control. Kennedy and Laitinen (1988) also reported difficulties when training five-term contingencies. However, they reported that when they trained subjects on a fourth-term task, and then attempted to establish contextual control over the four-term contingencies, the subjects were more successful. These studies demonstrate that fifth-term control is feasible, but report that establishment of fifth-term control is difficult and unreliable.

Wulfert and Hayes (1988) reported that subjects learned conditional control over a sequential ordering task similar to that of Lazar and Kotlarchyk (1986). Their subjects demonstrated all possible derived relations with little difficulty. Their study demonstrates that contextual control can be established without great difficulty, but the question remains of how to reliably and consistently establish such control. If fifth-term control as an explanatory and educational tool is to be effective, teaching five-term contingencies must become more effective.

Contextual Factors and Class Formation

Of further value, the study of contextual control and its influence on division of response classes may shed light on the development of equivalence. Sidman et al. (1985) suggest that contextual cues may affect how transitivity and symmetry form, or perhaps are even primarily responsible. Steele and Hayes (1988) failed to obtain reflexivity upon testing and claimed that reflexivity was not a prerequisite for equivalence. However, the construction of their experiment biased responding away from generalized identity matching (reflexivity). The subjects were probably able to respond reflexively, but did not in response to the contextual demand characteristics of the experimental situation. A demonstration that reflexive responding can be turned on and off without affecting transitive relations would provide evidence for this hypothesis. Others have used experimental preparations that involved conditional control of matching and mis-matching (Sherman, Saunders, & Brigham, 1970; Zimmerman & Baydan, 1963). Zimmerman and Baydan (1963) were concerned with other effects such as the effect of time-out on S^{Δ} responding, and not the conditional control itself, and Sherman et al. (1970) did no work with equivalence and class formation. However, the results of these studies indicate that human subjects can easily switch back and forth between these tasks.

Generalized identity matching is of interest in terms of how it relates to arbitrary matching, since it is a prerequisite for stimulus equivalence (Sidman & Tailby, 1982). Repeated studies have demonstrated that both positive and negative stimulus relations control identity (Dixon & Dixon, 1978; Dixon, Dixon, & Spradlin, 1983, Stromer & Stromer, 1989), which suggests that oddity and identity matching are closely interrelated. In addition, Stromer and Osborne (1982) found that both positive and negative stimulus relations control arbitrary matching and stimulus class formation. Stromer and Stromer (1989) suggest that generalized oddity and identity may have some sort of role in class formation. How they may be related is important for clarifying the role of reflexivity as a prerequisite of equivalence.

Sixth-Term Control

A further logical step is to postulate sixth-term control. The framework developed by Sidman (1986) does not address sixth-term control, but it is logically possible. That sixth-term and higher hierarchical control is possible can be argued logically by reference to the example of Linnaeus' hierarchical system of biological classification which consists of seven levels (or ninth-term control). Assignment of an organism to a class is conditional upon satisfying the requirement of each level.

In a review of Sidman's article on the framework of equivalence and context (1986), Delprato (1987) criticized Sidman on the grounds that hierarchical control could be taken to an infinite regress. Delprado's criticism may be logically valid, but the question is actually an empirical one. Behavior analysts are interested in what is functionally possible, and therefore research on what the actual limits of this type of conditioning is needed.

EXPERIMENT 1A

The first purpose of Experiment 1A[2] was to extend the analysis of stimulus classes and class interactions by examining whether equivalence classes of contextual stimuli could be formed. A contextual stimulus is a stimulus which controls responses to a conditional discrimination (Sidman, 1986). The second purpose was to determine whether the derived contextual stimuli within the classes of equivalent contextual stimuli would function in the same way as the stimuli originally trained as contextual stimuli. Specifically, subjects were trained to arrange six stimuli into groups of three based upon which of two contextual stimuli was present. When this task was mastered, novel stimuli were related to the two contextual stimuli to form two classes of three contextual stimuli. A test was then conducted to establish whether the derived contextual stimuli functioned as the original contextual stimuli.

Method

Subjects

Six undergraduate students enrolled in the introductory psychology course at Utah State University were recruited for the investigation over two academic quarters. Three of the subjects were females, and three were males. Their ages ranged from 18 to 23 years. Subjects were given class points for participating in the research with bonus points

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[2]This experiment has been published in "Transfer of contextual stimulus function via equivalence class development" by M. B. Gatch and J. G. Osborne, 1989, Journal of the Experimental Analysis of Behavior, 51, pp. 369-378.

given to those who completed the experiment. In this experiment, and throughout the remaining experiments, APA guidelines for the ethical treatment of human subjects were followed. The Human Subjects Committee approval is in Appendix A. Each subject signed an informed consent form prior to participation in the research, (Appendix A) and was debriefed following the experiment (Appendix C).

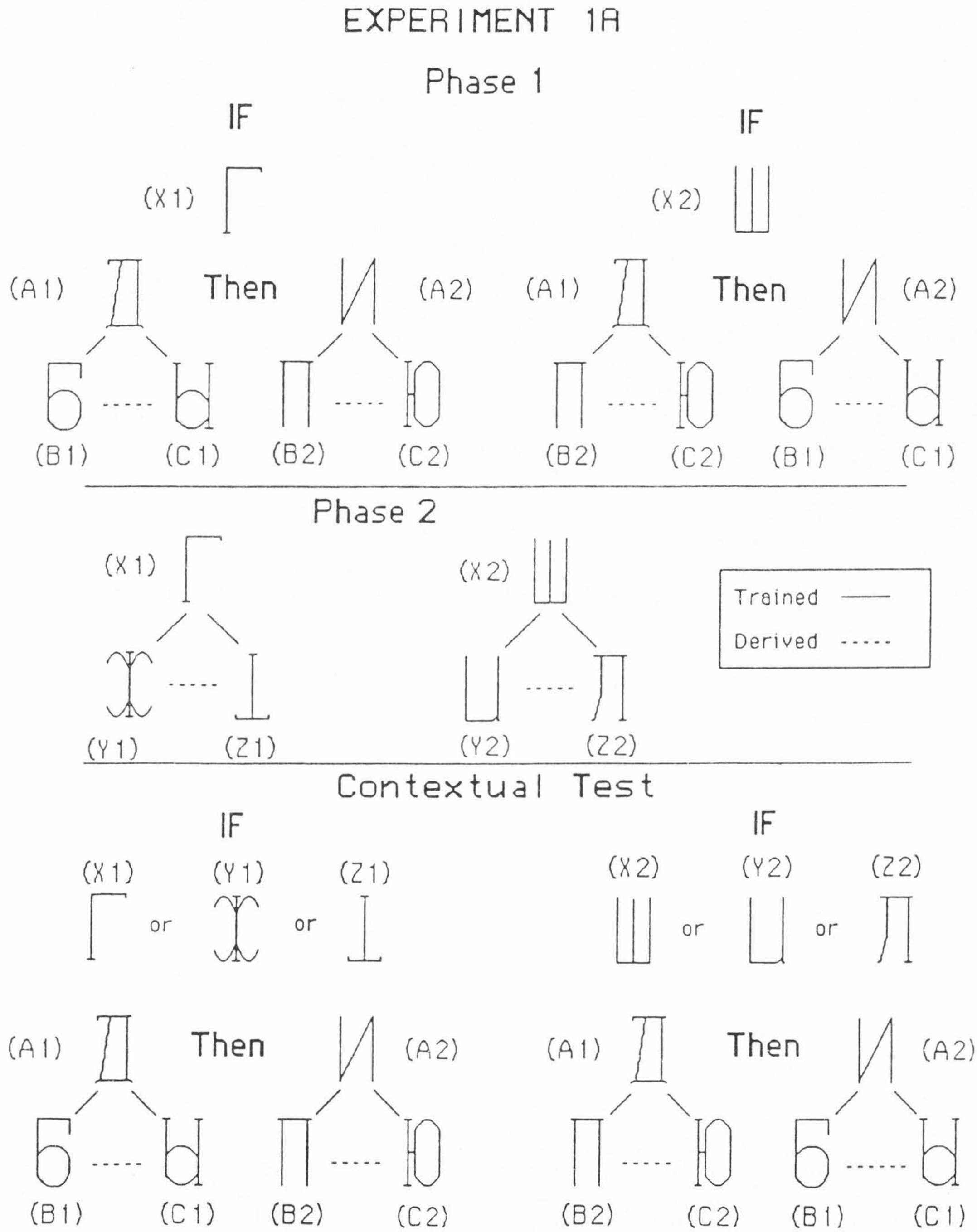
Apparatus

Subjects were seated in a small room at a table with an Apple II monitor and a joystick. An on-line Apple IIe microcomputer, located behind a partition, arranged events and recorded data. Single Cyrillic letters were used for sample, comparison, and contextual stimuli (see Figure 1). When shown on the monitor, the letters projected as white on a black background and were 20mm wide and 30mm high.

Procedure

General procedure. Throughout this experiment, the subjects' task was a nominal matching-to-sample procedure in one of two formats. One was four-term matching to sample with a sample stimulus centered 80mm from the top of the screen and three comparison stimuli arrayed horizontally below it. The other was five-term matching to sample with a contextual stimulus centered 30mm from the top of the screen, a sample stimulus below it, and three comparisons as before at the bottom of the screen (cf. Zimmerman & Baydan, 1963). Both formats are schematically portrayed in Figure 2.

In the five-term matching-to-sample task, each trial began with the contextual stimulus presented at the top of the screen. When the



<u>Figure 1</u>. Control of the organization of three-member classes by contextual stimuli in Experiment 1A.

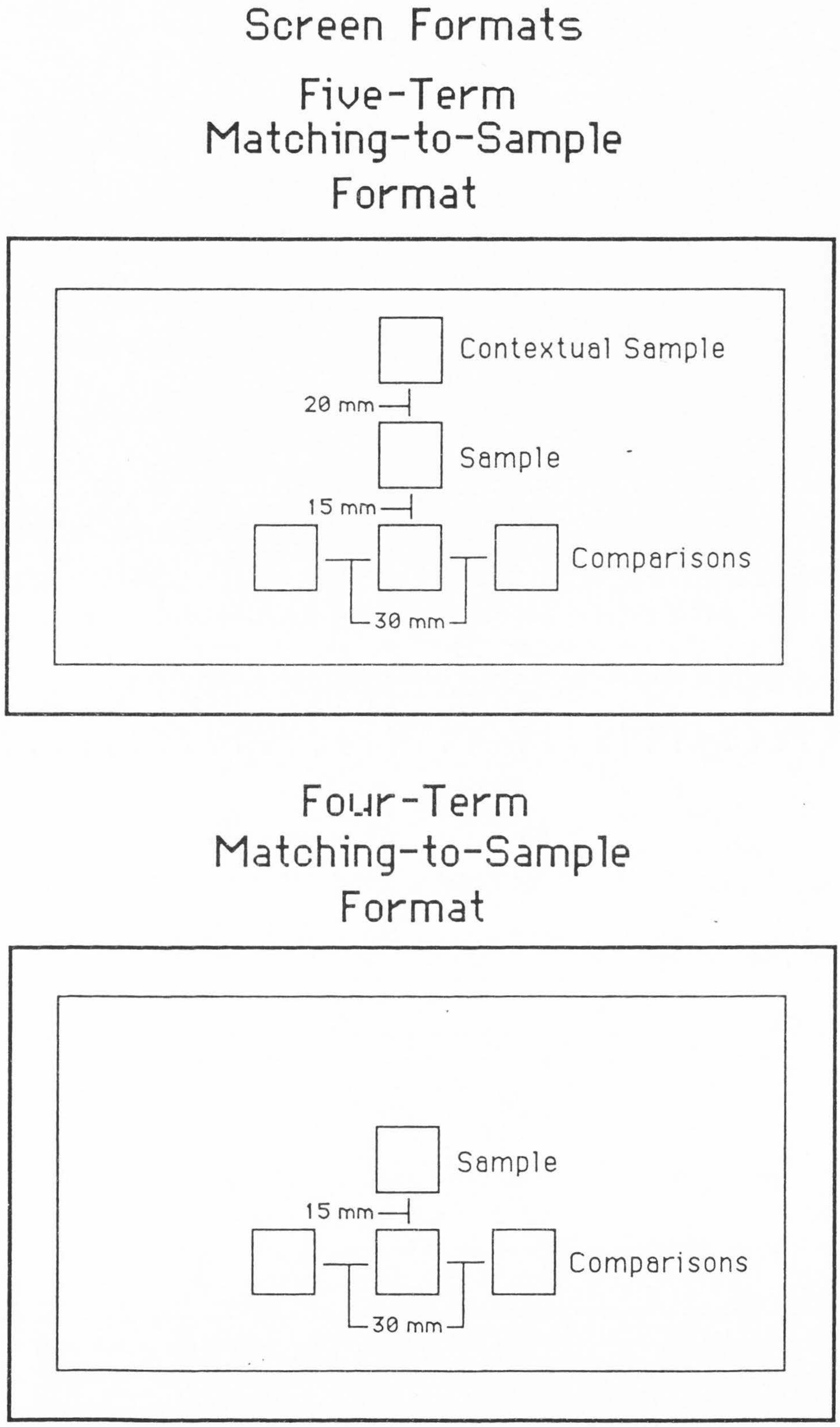


Figure 2. On-screen formats for the matching-to-sample tasks of Experiment 1A.

button on the joystick was pressed, the sample stimulus was presented. When the button was again pressed, the three comparisons were presented. The subject could move the joystick left or right to place a cursor under a comparison stimulus. The subject pressed the joystick button to respond to a particular comparison. For the four-term matching-to-sample task, the contextual stimulus was omitted. In each task, the position of the correct comparison and the two incorrect comparisons varied at random. Incorrect comparisons were drawn at random from the three stimuli not related to the sample under the given contextual stimulus. For example, if the context was X1 and the sample was A1, then the incorrect stimuli could be A2, B2 or C2.

At the beginning of training, each trial performed correctly on the first attempt resulted in the disappearance of the trial stimuli, presentation of the word "CORRECT" on the subject's monitor for 3 seconds and the increment of a points-counter that read "POINTS" followed by the amount of points accumulated. The next trial followed immediately. An incorrect response resulted in a 3-second black-out of the screen followed by the re-presentation of the same trial stimuli--a correction procedure--until the correct response was made. When a correct response was eventually made, the word "CORRECT" appeared on the screen for 3 seconds without the points-counter, and no points were given.

Sessions lasted for 80 trials. Two to six sessions occurred each day for a total of 45-50 minutes, two to three days a week. After two sessions of scoring at least 75 correct responses in 80 trials, end-of-trial feedback was reduced from 100% of correct responses to approximately 35% of correct responses over two to four sessions. If the feedback reduction was to occur over more than one day, on the next day, feedback was increased to 90% of correct responses on the first session to ensure correct responding and then reduced on subsequent sessions.

Phase 1 training. Training began with the fifth-term matching-to-sample procedure. The subject was shown a contextual stimulus and a sample stimulus, and on the first trial of the experiment was instructed to select the comparison stimulus which went with the two stimuli above. (Verbatim instructions are presented in Appendix B. The same instructions were used throughout the experiments with appropriate modifications in wording to fit the particular procedures.) In separate trial types, the subjects were trained to relate two stimuli to each sample stimulus. How the comparisons were to be matched to the sample depended upon which contextual stimulus was present. For example, when X1 was presented as the contextual cue, the subject earned points for responding in the presence of A1 to B1 or C1. However, if X2 was the contextual cue, the subject earned points for responses to B2 or C2 in the presence of A1. Which comparisons were to be related to A2 when it appeared as a sample were likewise controlled by the contextual stimuli. The potential stimulus relations established by such training are shown in Phase 1 of Figure 1. The two incorrect comparisons for each trial were chosen randomly from the other three-member set of stimuli. For example, if X1 was the contextual stimulus, and A1 the sample, then the incorrect comparisons could have been A2, B2 or C2. Generic training trial types are shown in Table 3.

Phase 1 testing. Test 1 evaluated symmetry. Training trial types were randomly mixed approximately 50% with trial types in which sample and correct comparison were interchanged (i.e., B1, B2, C1, or C2 were presented in the sample position, and A1 or A2 was consistent with an inference of symmetry depending on the contextual stimulus). Test 2 evaluated the emergence of derived (transitive) relations under the control of the contextual stimulus for each of the four, three-member classes. On the transitivity tests, training trial types were randomly mixed with 50 percent transitivity trial types (e.g., B1 was presented as the sample and a response to C1 was consistent with an inference of transitivity). At least four sessions were performed for each test. If the number of trials consistent with inferences of symmetry, transitivity or contextual control per session was increasing, further test sessions were given until three to four sessions of performance of at least 75 consistent responses in 80 trials occurred. No feedback was ever presented on any trial during test sessions. Generic trial types are depicted in Table 3.

Phase 2 training. This training incorporated the four-term matching-to-sample procedure. In separate trial types the subjects were trained to relate two new stimuli to each of the contextual stimuli used in Phase 1 in order to potentially establish the relations illustrated in Phase 2 of Figure 1. The two incorrect comparisons for each trial were chosen at random from the other three-member class. For example, X1 was presented as the sample, Y1 was the correct

Table 3

Trial Types for Experiment 1A Phase 1*

Training

1. X1	3. X1	5. X1	7. X1
A1	A1	A2	A2
B1 Co- Co-	C1 Co- Co-	B2 Co- Co-	C2 Co- Co-
(Co- = A2, B2, or C2)		(Co- = A1, B1, or C1)	
2. X2	4. X2	6. X2	8. X2
A1	A1	A2	A2
B2 Co- Co-	C2 Co- Co-	B1 Co- Co-	C1 Co- Co-
(Co- = A2, B1, or C1)		(Co- = A1, B2, or C2)	

Symmetry

1. X1	3. X1	5. X1	7. X1
B1	C1	B2	C2
A1 Co- Co-	A1 Co- Co-	A2 Co- Co-	A2 Co- Co-
(Co- = A2, B2, or C2)		(Co- = A1, B1, or C1)	
2. X2	4. X2	6. X2	8. X2
B2	C2	B1	C1
A1 Co- Co-	A1 Co- Co-	A2 Co- Co-	A2 Co- Co-
(Co- = A2, B1, or C1)		(Co- = A1, B2, or C2)	

Transitivity

1. X1	2. X1	3. X2	4. X2
B1	C1	B2	C2
C1 Co- Co-	B1 Co- Co-	C2 Co- Co-	B2 Co- Co-
(Co- = A2, B2, or C2)		(Co- = A1, B1, or C1)	
5. X1	6. X1	7. X2	8. X2
B2	C2	B1	C1
C2 Co- Co-	B2 Co- Co-	C1 Co- Co-	B1 Co- Co-
(Co- = A2, B1, or C1)		(Co- = A1, B2, or C2)	

* Correct choices are shown on the left in all tables. Location of the comparisons is randomized during all experiments.

comparison, and Y2 and Z2 were incorrect comparisons. Generic training trial types are shown in Table 4.

Phase 2 testing. Test 3 evaluated symmetry. The trial types used in Phase 2 training were randomly mixed with approximately 50% of trial types in which sample and correct comparison were interchanged. That is, Y1, Y2, Z1, or Z2 were presented in the sample position, and the correct comparison was X1 or X2, depending on the contextual cue. Test 4 evaluated transitivity. Trial types employed in Phase 2 training were randomly mixed with 50% transitive trial types (e.g., Y1 was presented as the sample and Z1 was the correct comparison). Generic trial types are depicted in Table 4.

Contextual class test. This phase tested whether the derived contextual class stimuli controlled the trained conditional relations of Phase 1. Testing took place with the training trial types of Phase 1 randomly mixed with approximately 50% of the new contextual class members in the fifth-term position (see the last panel 3 of Figure 1). Generic trial types are shown in Table 4. Testing occurred for a minimum of four sessions of performance at 75/80 correct. The subjects were debriefed following this test. The format for the debriefing is at the end of Appendix C. The same format was used for all experiments.

Results

Figure 3 shows the number of trials per session for training and testing trial types for each subject in each phase of the experiment consistent with inferences of contextual control, symmetry, and

Table 4

Trial Types for Experiment 1A Phase 2

Training

1. X1	2. X1	3. X2	4. X2
Y1 Co- Co-	Z1 Co- Co-	Y2 Co- Co-	Z2 Co- Co-

Symmetry

1. Y1	2. Z1	3. Y2	4. Z2
X1 Co- Co-	X1 Co- Co-	X2 Co- Co-	X2 Co- Co-

Transitivity

1. Y1	2. Z1	3. Y2	4. Z2
Z1 Co- Co-	Y1 Co- Co-	Z2 Co- Co-	Y2 Co- Co-
(Co- = X2, Y2, or Z2)		(Co- = X1, Y1, or Z1)	

Contextual Class Test

1. Y1	3. Y1	5. Y1	7. Y1
A1	A1	A2	A2
B1 Co- Co-	C1 Co- Co-	B2 Co- Co-	C2 Co- Co-
(Co- = A2, B2, or C2)		(Co- = A1, B1, or C1)	
2. Y2	4. Y2	6. Y2	8. Y2
A1	A1	A2	A2
B2 Co- Co-	C2 Co- Co-	B1 Co- Co-	C1 Co- Co-
(Co- = A2, B1, or C1)		(Co- = A1, B2, or C2)	
9. Z1	10. Z1	11. Z1	12. Z1
A1	A1	A2	A2
B1 Co- Co-	C1 Co- Co-	B2 Co- Co-	C2 Co- Co-
(Co- = A2, B2, or C2)		(Co- = A1, B1, or C1)	
13. Z2	14. Z2	15. Z2	16. Z2
A1	A1	A2	A2
B2 Co- Co-	C2 Co- Co-	B1 Co- Co-	C1 Co- Co-
(Co- = A2, B1, or C1)		(Co- = A1, B2, or C2)	

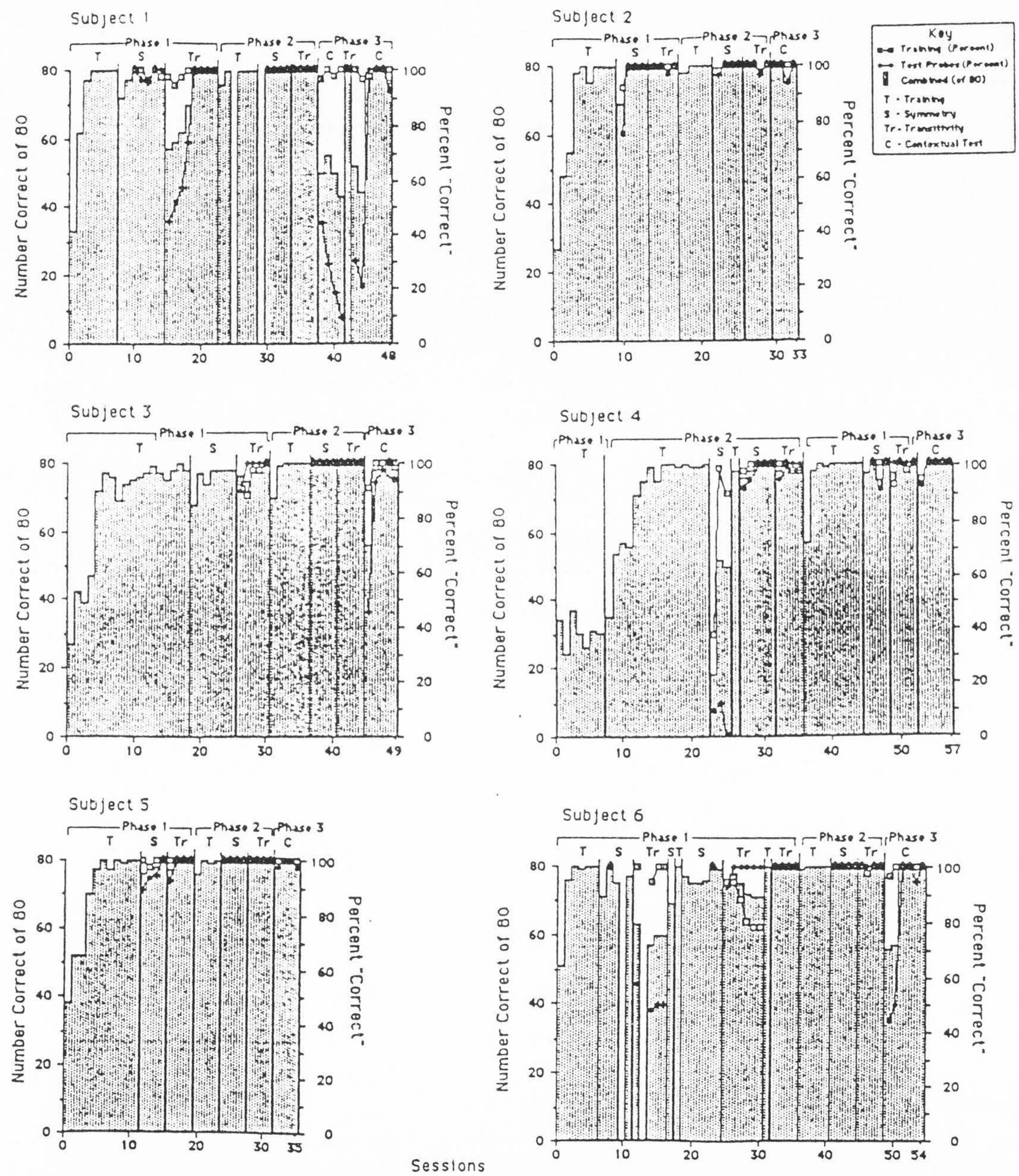


Figure 3. Percentage of correct responses in 80 trials for each session in each phase of Experiment 1A.

transitivity combined expressed as a total of 80 trials (shaded bars), and separately as percents (dots and lines). The relative measure was employed to express the data on test sessions because the random program of the computer scheduled a widely variable number of test trial types each test session.

Phase 1

Training. The conditional responses of all subjects came under the control of the contextual stimuli in Phase 1. The length of time to acquire the contextual discrimination varied across subjects from 6 to 18 sessions. S4 received four sessions of training and did not exhibit any acquisition. This subject was then exposed to Phase 2 before continuing with Phase 1. Data in Figure 3 for Subject 4 are presented in the order in which the phases occurred.

Symmetry. Separate symmetry data were lost for S3 (the entire test), S6 (Sessions 7, 9, and 10), S1 (Sessions 8 and 9), and S4 (Session 45). S1 was given two additional sessions because of the loss of the separated data. Four of the six subjects (S1, S2, S3, S5) showed perfect responding on symmetry test trial types within a few sessions. (This conclusion is by inference for S3 from the combined data on which by the fourth symmetry test session, S3 responded consistently on all 80 trials.) S6's combined data met criterion in five sessions, although responding was not perfect.

Transitivity. All subjects except S6 demonstrated transitivity within 4-8 test sessions. Of these subjects, only S1 showed a considerable acquisition-like function on the transitivity trial types.

For the remaining subjects responding on the transitivity trial types was at 100% by the first (S2, S4) or second (S3, S5) test session. (S4's data are read from Sessions 49-52.)

S6's unchanging performance around 50% on the transitivity test trial types suggested the need to re-examine the symmetric relations. Recall that in the absence of separate symmetry data S6 met criterion in Phase 1 symmetry testing without being all the way to 100%. On a second symmetry test combined data of 69 of 80 correct on Session 17 further suggested that the symmetry relations were weak. Accordingly, S6 was returned to training for one session (18) and six more sessions (19-24) of symmetry testing were necessary before symmetry performance reached criterion. Transitivity testing was reinstated at Session 25 and performance was near or above 75/80 combined, but performance on the trained trial types deteriorated. Since a week and a half had passed from the last training session, one session of training was administered at session 31. The subject then exhibited four consecutive sessions of perfect responding to transitivity and training trial types.

Phase 2

Training. Most subjects learned the four-term matching-to-sample task rapidly, requiring no more than 4 or 5 sessions. S4, who had never come to criterion on Phase 1 before being introduced to Phase 2, required 15 sessions.

Symmetry. All subjects but S4 demonstrated symmetrical relations on testing in Phase 2 (see Figure 3). S4's criterion performance on the training trial types was considerably disrupted by the introduction of symmetrical trial types in the symmetry test. The combined performance of S4 leveled off at 50/80 after three sessions. Responses to training trial types were much more accurate than those to symmetry test trial types. Within one session of symmetry testing, responses to training trial types recovered to near 90%. However, symmetry responding began at around 10% and fell to zero. An additional training session was presented at Session 27 to get the training trial type baseline back near 100 percent. With a subsequent return to symmetry testing, S4's symmetry responses were at 100 percent of symmetry test trial types by the third session of this exposure to symmetry testing.

Transitivity. All subjects demonstrated transitive relations at criterion on testing.

Contextual Class Test

On the contextual class test, Subjects 2-6 performed at criterion within 4-6 sessions. Both S3 and S6 exhibited considerable acquisition-like functions on their responses to the derived contextual stimuli. When asked after the experiment to verbally report the conditional relations (as described in Appendix C), Subjects 2-6 were able to do so correctly for all the relations.

S1 scored below criterion on the contextual class test. The subject had no difficulty with the trained relations, scoring 97% to 100% correct. Test probe performance started at 46% and continuously fell, reaching 10% by the fourth session. A return to transitivity testing at Session 42 indicated that responses both to the training trial types and the transitive trial types were consistent, so two more sessions of the contextual test were presented. S1 continued to perform below criterion and requested to end the experiment. Again, trained relations were intact (97%-100%) and test probe performance was poor (32%-22%). During debriefing, S1 was able to report correctly each of the relations, except those of the contextual class test. She reported not knowing what to do when Y1, Y2, Z1, or Z2 were on the top of the screen (contextual class probes). She then asked whether how those four stimuli were related to X1 and X2 was supposed to determine how to perform on the contextual class test. The experimenter responded by asking if she would like to try the test again. Four more sessions were performed, and S1 performed at criterion.

Discussion

In the present study, each of the six subjects acquired four, three-member classes of equivalent stimuli under the control of two contextual stimuli in a five-term matching-to-sample task. In a subsequent four-term matching-to-sample task, it was then possible to relate two additional stimuli to each of the contextual stimuli, forming two, three-member classes of contextual stimuli. Finally, it was shown that the equivalent stimuli in the contextual classes controlled performance of the four-term matching-to-sample task without directly having been trained in this function.

The research described here systematically replicates prior research on contextual control (e.g., Bush et al., 1989; Fucini, 1982;

Lazar & Kotlarchyk, 1986) and extends the stimulus equivalence paradigm to the study of classes of contextual stimuli. Such an extension sets the stage for further analysis of fifth-term control (Sidman, 1986) and its usefulness in predicting and controlling development of complex stimulus classes such as those found in language.

The present data also provide a more detailed analysis of the conditions under which contextual control is established, since all possible symmetrical and transitive relations were tested. In much of the literature, symmetry is not tested unless transitivity is not exhibited. If transitivity is present, then logically, symmetry must also be present (Sidman & Tailby, 1982). One consequence of testing all relations is the reaffirmation that symmetry and transitivity are frequently derived during testing, not training (Sidman et al., 1985). Gradual acquisition of transitivity by Subjects 1, 3, and 6 in Phase 1 and gradual acquisition of symmetry by all subjects in Phase 1 lend support to such an inference. Where transitive relations were found to be weak, return to symmetry testing indicated that the symmetrical relations were also weak, as illustrated by the test results for S6 in Phase 1. That a return to a prior test phase could improve mastery over a current test phase provides indirect evidence that learning the relations does take place on testing (cf. Sidman & Tailby, 1982). Some subjects evidently require the opportunity to verify that the relations work symmetrically before they can demonstrate transitivity.

Transitive performance in Phase 1 was not dependent in any way on the presence of the contextual stimuli--B1 was always related to B2 and C1 to C2 independent of the contextual stimuli. This was inevitable, given the limits to rearranging three-member classes. Such a limitation does not compromise the results, since all the trained conditional relations were dependent upon the contextual stimuli.

A possibility remains that the subjects may have simply learned to exclude B1-C1 and B2-C2 whenever both members of one of the pairs appeared as incorrect comparisons. Also, A1 and A2 were used as incorrect comparisons and never were correct comparisons during training or transitivity testing. The subjects may have learned to exclude A1 and A2 during training or transitivity testing. However, during symmetry testing, both A1 and A2 served as the correct comparisons.

Some of the subjects had initial difficulty with the five-term matching-to-sample task. This showed up primarily in the number of sessions necessary for criterion attainment. For the most part however, acquisition proceeded steadily for all subjects except one (i.e., S4). Since Subject 4 was able to perform the four-term matching-to-sample task after experiencing much difficulty on the five-term matching-to-sample task, perhaps acquisition of the five-term matching-to-sample task would have been easier if the unconditional matching-to-sample task was taught first. Kennedy and Laitinen (1988) reported having great difficulty establishing contextual control when using a task in which the contextual stimulus was present from the beginning (analogous to the five-term matching-to-sample task in this experiment). In the present experiment, only one subject (S4) demonstrated serious difficulty in learning the task. The most notable difference between the present procedures and those of Kennedy and

Laitinen (1988) was that the present experiment employed three comparison stimuli per trial while they used two comparisons (see also Bush et al., 1989). Serna (1987) and Sidman (1987) have suggested that using two comparisons may not work as well as using three or more.

Unequivocal evidence for transfer of function would seem to require performance that was instantly at criterion on test trial types. In the present experiment several sessions were required by some subjects before control by the derived contextual stimuli was perfect. As mentioned above, this is common in this literature and suggests that acquisition is ongoing during the actual test of the outcome. But where transferred function is the focus, the question might be raised as to whether simply the insertion of novel stimuli as probes in the location of the fifth-term stimulus in a circumscribed experimental environment such as this might not have led to the same outcome. It is, of course, an empirical question, but one potentially of some importance.

Little can be said about what produced the sudden change in S1's contextual classification performance, except to note that the change came during debriefing after she had verbally described all of the other relations in the task, except for those relations controlled by the potentially equivalent contextual stimuli. This rehearsal potentially may have contributed to the end result; however, it is distinctly possible that uncontrolled factors involved in the debriefing may have produced the same outcome.

EXPERIMENT 1B

Experiment 1A demonstrated that basic stimulus equivalence procedures could be used to extend contextual stimulus function. Sidman et al. (1985) demonstrated that stimulus classes can be extended rapidly by relating together one stimulus from each of two classes. They taught subjects two three-member classes and then related together one stimulus from each class. The two classes became one, larger class. The question arises whether such a rapid extension of stimulus equivalence will extend to transfer of function, and whether such procedures would work with a class at the fifth-term level. In Experiment 1B, contextual control of two three-member stimulus classes was established in direct replication of Experiment 1A. Two new three-member classes were trained, and subjects were taught to relate one stimulus from each of the new classes to one stimulus in a contextual class. Tests were conducted to verify whether two six-member classes were formed, and to find whether the new stimuli would function as contextual stimuli.

Method

Subjects

Three subjects were recruited from the undergraduate introductory psychology class at Utah State University. Two were males aged 22 and 23, and one was a female aged 31. They were given class points for participating in the research, and bonus points were given for completing the experiment.

Apparatus

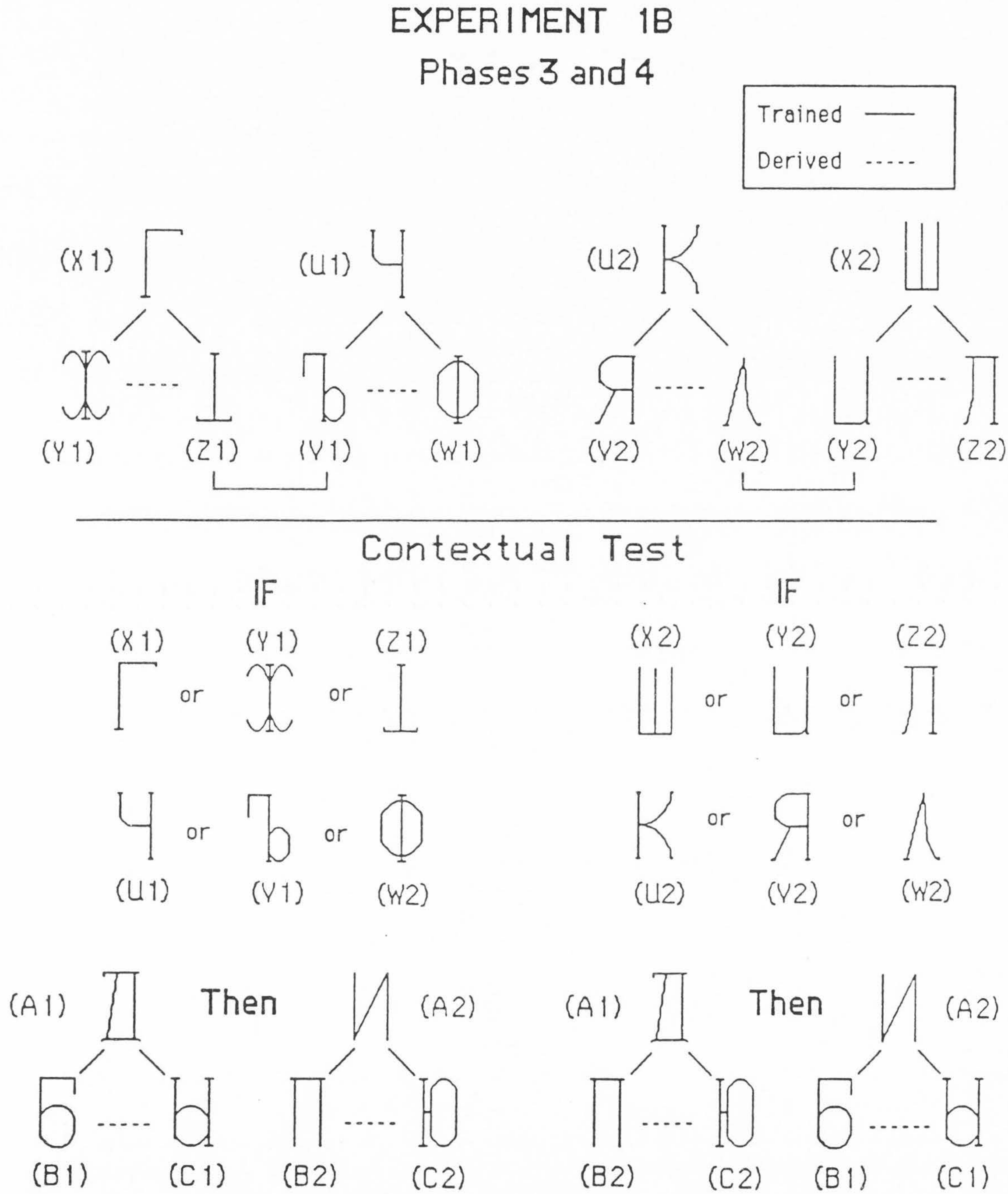
The same apparatus as in Experiment 1A was used.

Procedure

Phases 1 and 2 of Experiment 1A were repeated. All sessions except the contextual generality tests in Phase 2 and Phase 4 lasted for 64 trials. Each task was ended when a criterion of two consecutive sessions of at least 61/64 correct (95%) on combined performance was achieved. Sessions were shortened in length from 80 trials in order to lessen subject fatigue. The fading of feedback was discontinued because it lengthened the number of sessions, and was possibly of no benefit. Feedback was presented on every trial during training tasks, and no feedback was ever presented during testing tasks.

Immediately following the contextual class test, Phase 3 was begun. Two new three-member classes were trained, U1-V1-W1 and U2-V2-W2 (see Figure 4). Symmetry and transitivity were tested in separate sessions. Sessions were 64 trials long, half test relations and half trained relations presented in random order. Symmetry was tested first, followed by transitivity testing. Individual generic trial types for Phase 3 are depicted in Table 5.

Phase 4 involved connecting the new three-member classes to the contextual classes established in Phase 2, and testing for the existence of derived relations. One stimulus from each of the two new three-member classes was related to one stimulus from a contextual class, i.e., V1-Z1 and W2-Y2. When training was complete, each of the possible derived relations was tested. Generic training and testing



<u>Figure 4</u>. Control of the organization of three-member classes by classes of contextual stimuli in Experiment 1B.

Table 5

Trial Types for Experiment 1B Phase 3

					Training						
1.	U1		2.	U1		3.	U2		4.	U2	
V1	Co-	Co-	W1	Co-	Co-	V2	Co-	Co-	W2	Co-	Co-
					Symmetry						
1.	V1		2.	W1		3.	V2		4.	W2	
U1	Co-	Co-	U1	Co-	Co-	U2	Co-	Co-	U2	Co-	Co-
					Transitivity						
1.	V1		2.	W1		3.	V2		4.	W2	
W1	Co-	Co-	V1	Co-	Co-	W2	Co-	Co-	V2	Co-	Co-
	(Co- = U2, V2, W2)						(Co- = U1, V1, W1)				

trial types for Phase 4 are shown in Table 6. When testing demonstrated that two six-member classes existed, the Contextual Class Test of Phase 2 was repeated with the new stimuli serving in the fifth-term position instead of the three-term contextual class established in Phase 2. Individual generic trial types for the Contextual Class Test are shown in Table 7.

Results

Phase 1

Results are illustrated in Figure 5. Due to an error in the computer programs, S7 and S8 both received two training sessions with only two trial types (numbers 7 and 8 from Table 3). A session of symmetry testing was given before the error was discovered. S7 scored

Table 6

Trial Types for Experiment 1B Phase 4

Training

1. Z1			2. W2		
V1	Co-	Co-	Y2	Co-	Co-

(Co- = X2,Y2,Z2,U2,V2,W2) (Co- = X1,Y1,Z1,U1,V1,W1)

Derived Relations

1. X1			2. X1			3. X1			4. Y1		
U1	Co-	Co-	V1	Co-	Co-	W1	Co-	Co-	U1	Co-	Co-
5. Y1			6. Y1			7. Z1			8. Z1		
V1	Co-	Co-	W1	Co-	Co-	U1	Co-	Co-	W1	Co-	Co-
9. U1			10. V1			11. W1			12. U1		
X1	Co-	Co-	X1	Co-	Co-	X1	Co-	Co-	Y1	Co-	Co-
13. V1			14. W1			15. U1			16. W1		
Y1	Co-	Co-	Y1	Co-	Co-	Z1	Co-	Co-	Z1	Co-	Co-

(Co- = X2, Y2, Z2, U2, V2, or W2)

17. X2			18. X2			19. X2			20. Y2		
U2	Co-	Co-	V2	Co-	Co-	W2	Co-	Co-	U2	Co-	Co-
21. Y2			22. Z2			23. Z2			24. Z2		
V2	Co-	Co-	U2	Co-	Co-	V2	Co-	Co-	W2	Co-	Co-
25. U2			26. V2			27. W2			28. U2		
X1	Co-	Co-	X1	Co-	Co-	X1	Co-	Co-	Y1	Co-	Co-
29. V2			30. U2			31. V2			32. W2		
Y2	Co-	Co-	Z2	Co-	Co-	Z2	Co-	Co-	Z2	Co-	Co-

(Co- = X1, Y1, Z1, U1, V1, or W1)

Table 7

Contextual Test Trial Types for Experiment 1B

1.	U1	2.	U1	3.	U1	4.	U1
	A1		A1		A2		A2
B1	Co- Co-	C1	Co- Co-	B2	Co- Co-	C2	Co- Co-
5.	V1	6.	V1	7.	V1	8.	V1
	A1		A1		A2		A2
B1	Co- Co-	C1	Co- Co-	B2	Co- Co-	C2	Co- Co-
9.	W1	10.	W1	11.	W1	12.	W1
	A1		A1		A2		A2
B1	Co- Co-	C1	Co- Co-	B2	Co- Co-	C2	Co- Co-
	(Co- = A2, B2, or C2)				(Co- = A1, B1, or C1)		
13.	U2	14.	U2	15.	U2	16.	U2
	A1		A1		A2		A2
B2	Co- Co-	C2	Co- Co-	B1	Co- Co-	C1	Co- Co-
17.	V2	18.	V2	18.	V2	19.	V2
	A1		A1		A2		A2
B2	Co- Co-	C2	Co- Co-	B1	Co- Co-	C1	Co- Co-
21.	W2	22.	W2	23.	W2	24.	W2
	A1		A1		A2		A2
B2	Co- Co-	C2	Co- Co-	B1	Co- Co-	C1	Co- Co-
	(Co- = A2, B1, or C1)				(Co- = A1, B2, or C2)		

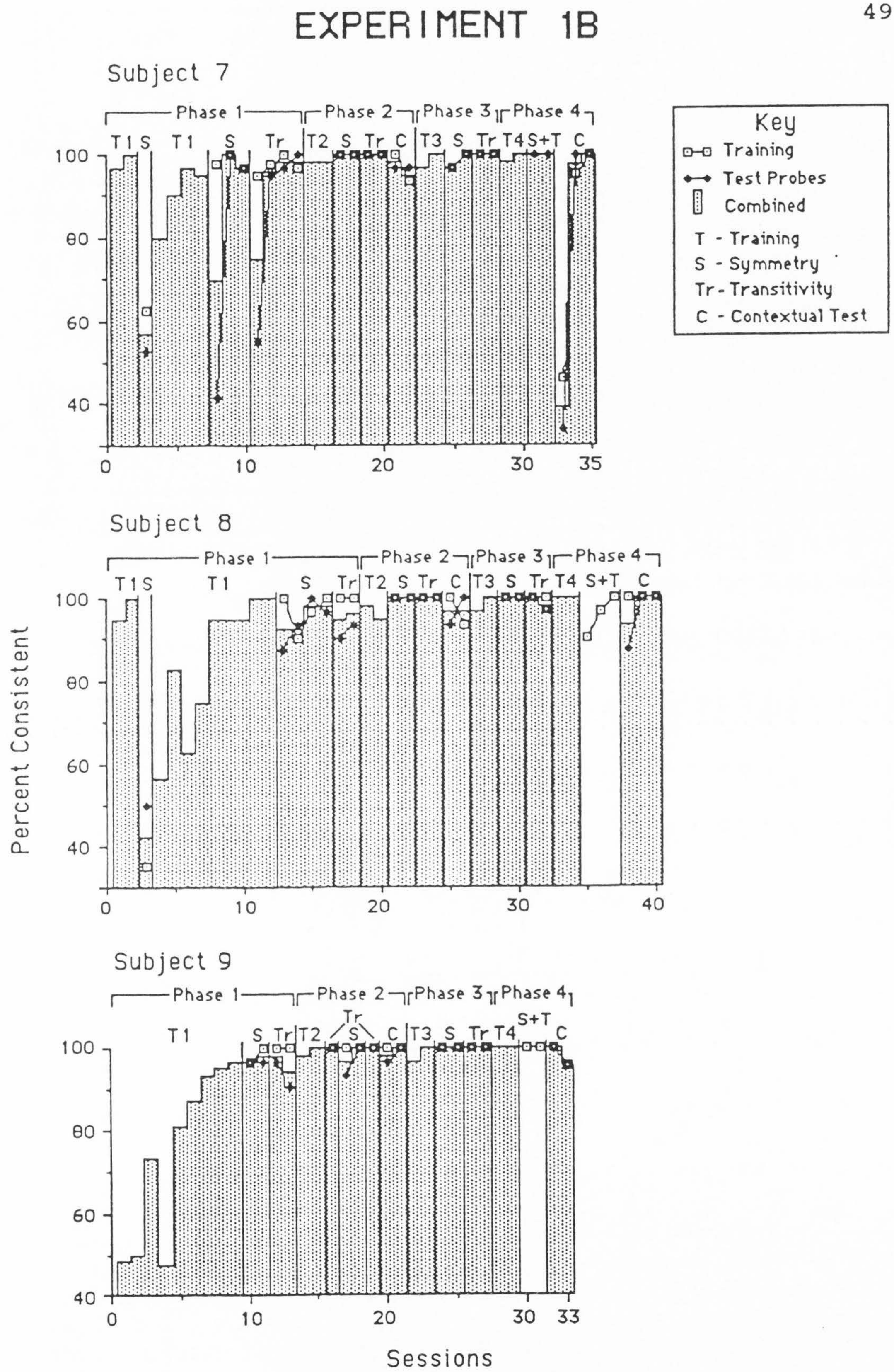


Figure 5. Percentage of correct reponses in 64 trials for each session in each phase of Experiment 1B.

96.9% on the first session and 100% on the second, while S8 scored 95.3% on the first session and 100% on the second. S7 performed at 57.5% (combined) on the symmetry test. He performed perfectly on not only the two trained relations, but also on the two remaining conditional relations controlled by the contextual stimulus X2. He also got 15/20 correct of the corresponding symmetrical relations. S8 responded correctly on the symmetrical relations corresponding to the two trained relations, and made one error on the relations that had been trained. He scored at or below chance on the remaining relations. S7 quickly learned the remaining relations in five sessions. His scores ranged from 79.7% to 96.9% correct. S8 took nine additional sessions to come to criterion. His scores ranged from 56.3% to 100%. S9 took nine sessions of training to come to criterion. Her scores ranged from 48.4% to 96.9%.

On symmetry testing, S7 took three sessions to reach the criterion, S8 took 4 sessions, and S9 took two sessions. S7 scored poorly on symmetry trials on the first session of testing (Session 8). His scores on symmetry ranged from 41.3% on the first test session to 100% on the second. His performance on the trained relations ranged from 96.9% to 100%. S8 had scores ranging fom 87.5% to 100% on symmetry and 90.6% to 100% on the trained relations. S9 scored at 96.9% correct on symmetry relations both sessions, and made one error (96.9% correct) on the trained relations on the first session of testing.

On transitivity testing, S7 took 4 sessions to come to criterion, and S8 and S9 both took two sessions. The performance of S7 on transitivity relations increased from 55% to 100%, and his performance on the trained relations fluctuated between 95% and 100%. S8 scored perfectly on the trained relations on both sessions of testing, and his performance on transitivity relations increased from 90.6% to 93.8%. S9 also scored perfectly on the trained relations on both testing sessions, and her performance on transitive relations ranged from 96.8% to 90.6%.

Phase 2

All three subjects learned the relations quickly, and displayed near perfect performance on the first session. S7 scored 98.4% on both sessions. S8 scored 98.4% correct on the first training session, and 95.3% on the second. S9 increased her score from 98.4% correct to 100%. All three subjects also demonstrated symmetrical and transitive performances upon testing. S7 and S8 both had perfect sessions of symmetry and transitivity testing. S9 scored at 93.8% correct on symmetry relations on the first session of testing, and at 100% on training both sessions and on symmetry the second session. S9 was given a session of transitivity testing before symmetry testing and one after, due to a recording error. Performance was not affected. She scored at 100% on both transitivity sessions. All three subjects performed at criterion in two sessions on the contextual generality test.

Phase 3

All subjects performed at criterion in two sessions on each portion of Phase 3. Each subject made one error on the first session of training, and performed perfectly on the second. S7 had a combined score of 96.9% on the first symmetry session, and scored 100% correct on the second. S8 and S9 both performed perfectly on the symmetry test. S7 and S9 performed at 100% on transitivity testing. S8 made one error on transitivity on the second session of testing.

Phase 4

All three subjects performed at criterion in two sessions on training. S7 scored 98.4% correct on the first session and 100% on the second. S8 and S9 each scored 100% correct on both of their training sessions. S7 and S9 performed at 100% on two sessions of the derived relations test (combined symmetry and transitivity--S+T on Figure 5). S8 took three sessions to reach criterion. His performance increased from 90.6% correct to 100%.

A programming error occurred on the first session of the contextual generality test for S7. He went on to score 97.9% correct (combined) on the first session, and 100% on the second. S8 took three sessions to reach criterion on the contextual generality test. He scored 93.8% correct (combined) on the first session, and 100% on the two remaining sessions. S9 scored 100% correct on the first session and 95.8% (combined) on the second session of the contextual generality test.

Following Phase 4, all subjects were debriefed. They were asked to describe in words what had happened during the experiment. Only S9 could do so. Each of the three subjects was able to describe the conditional relations they had learned when they were given a list of the stimuli.

Discussion

Three subjects were trained to group stimuli into groups of three based upon the presence of two contextual stimuli. Two novel stimuli were related to each contextual stimulus, and testing demonstrated the existence of two three-member contextual classes. Two new three-member classes were established, and one member from each class was related to one member of a contextual class. Testing demonstrated that two six-member contextual classes were formed, and that the members of the two three-member classes trained in Phase 3 gained contextual function.

Experiment 1B extends the findings of Experiment 1A to six-member classes and demonstrates that the rapid expansion of equivalence classes extends to transfer of contextual function as well. The difficulties in Experiment 1A with long acquisition times on training tasks and the need for several sessions of testing for derived performances to emerge did not occur in Experiment 1B. Phases 1 and 2 only took 21-26 sessions in Experiment 1B rather than the 33-39 sessions needed in Experiment 1A. This is likely due to fewer difficulties with programs and equipment.

Another interesting finding is the ease of training four-term relations after the subjects have been exposed to five-term relations. Apparently, their experimental history allowed the subjects to very quickly learn completely new relations. The subjects often made only one error, which was on the first or second trial. Two trials provided enough information for them to learn four conditional relations.

The incomplete training sessions presented to S7 and S8 at the beginning of the experiment led to some interesting results. S7 was able to infer the remaining conditional relations involved with the contextual stimulus X2. He learned X2-A2-B1 and X2-A2-C1 during training (the leftmost relations on Phase 1 of Figure 1). During session 3, he scored perfectly on those relations and the other two relations controlled by X2 (X2-A1-B2 and X2-A1-C2). He also performed correctly on 75% of the symmetry probe trials. He scored at chance on the relations controlled by X1. The results may be due to exclusion; that is, since A2-B1-C1 go together, then A1-B2-C2 must go together (McIlvane, Kledaras, Munson, King, deRose, & Stoddard, 1987).

The factors which led to the establishment of an entire stimulus class without training may be related to the presence of an explicit contextual stimulus, and are worthy of further research. Regardless of the cause, methods can be devised which will train the relations faster and more efficiently, thus making the methods more practical for applied use.

Exclusion of Incorrect Comparisons

An examination of patterns of incorrect responding indicated that the subjects did exclude A1 and A2 during training but not during testing (Table 8). This did not appear to impair acquisition of symmetry or transitivity. Whether the use of samples as incorrect comparisons impairs or facilitates the acquisition of stimulus classes

Table 8

Number of Times Each Stimulus Is Chosen as an Incorrect Comparison for Each Subject Each Session of Experiment 1B Phase 1 and Contextual Class Test

S7 Session	Incorrect Comparisons A1	B1	C1	A2	B2	C2
1				0	1	1
2				0	0	0
3	11	1	1	1	2	10
4	1	3	3	0	3	3
5	0	0	2	0	4	0
6	0	0	1	0	1	0
7	0	1	1	0	0	1
8	0	1	1	0	0	1
9	0	0	0	0	0	0
10	0	1	0	1	0	0
11	3	2	1	9	4	1
12	0	0	0	2	0	1
13	0	1	0	0	0	0
14	0	1	0	0	0	0
30	4	1	12	3	3	6
31	0	1	0	0	0	0
32	0	0	0	0	0	0

S8 Session	Incorrect Comparisons A1	B1	C1	A2	B2	C2
1				0	1	2
2				0	0	0
3	10	2	2	11	0	10
4	1	4	6	5	7	5
5	0	5	0	1	3	2
6	0	7	4	1	6	6
7	1	4	3	0	3	5
8	0	1	1	0	1	0
9	0	1	0	0	0	2
10	0	1	1	0	1	0
11	0	0	0	0	0	0
12	0	0	0	0	0	0
13	1	0	0	2	1	0
14	1	0	1	2	1	0
15	0	1	0	0	0	0
16	0	0	0	0	0	1
17	3	0	0	0	0	0
18	1	0	0	1	0	0
38	0	1	1	0	1	0
39	0	0	0	0	0	0
40	0	0	0	0	0	0

S9 Session	Incorrect Comparisons A1	B1	C1	A2	B2	C2
1	2	9	7	1	5	9
2	0	6	11	0	8	7
3	0	2	2	0	2	11
4	0	7	8	0	9	10
5	0	4	3	0	4	1
6	0	3	2	0	3	0
7	0	3	1	0	0	0
8	0	0	3	0	0	0
9	0	2	0	0	0	0
10	1	1	0	0	0	0
11	1	0	0	0	0	0
12	0	0	0	1	0	1
13	3	0	0	1	0	0
33	0	0	0	0	0	0
34	0	1	1	0	0	0

may be valuable methodological information. Table 9 presents data on how often subjects made correct responses when each possible combination of incorrect combinations was present. If subjects excluded B1-C1 or B2-C2, they should make more correct responses on those trials than when other combinations of incorrect comparisons were present. No consistent differences between combinations of incorrect comparisons are evident, which indicates that subjects did not learn to exclude B1-C1 or B2-C2 when those stimuli served as incorrect comparisons together either on training or tests.

Table 9

Proportion of Responses Away from Each Possible Combination of Incorrect Comparisons for Each Session of Each Subject in Experiment 1B

S7	Pairs of Incorrect Comparisons									
Session	A1B1	A1C1	B1C1	A2B1	A2C1	A2B2	A2C2	B2C2	A1B2	A1C2
1								.9	.9	1
2								1	1	1
3	.1	.2	.9	.8	1	.8	0	.5	1	.5
4	.7	.6	.9	.8	.8	.7	.6	.8	1	1
5	1	.8	.9	1	1	.5	1	.9	1	1
6	1	1	1	1	.8	1	1	.9	1	1
7	.8	.8	1	1	1	1	.8	1	1	1
8	.8	.8	1	1	1	1	.8	1	1	1
9	1	1	1	1	1	1	1	1	1	1
10	1	1	.9	1	1	1	1	1	1	1
11	.9	.6	.9	.7	.6	.6	.6	.8	.7	1
12	1	1	1	1	1	1	.9	1	1	1
13	.9	1	1	1	1	1	1	1	1	1
14	.9	1	1	1	1	1	1	1	1	1
30	.4	.2	.1	.5	.3	.6	.4	.6	.3	0
31	.8	1	1	1	1	1	1	1	1	1
32	1	1	1	1	1	1	1	1	1	1

S8	Pairs of Incorrect Comparisons									
Session	A1B1	A1C1	B1C1	A2B1	A2C1	A2B2	A2C2	B2C2	A1B2	A1C2
1								1	.9	.9
2								1	1	1
3	.1	.2	.9	.3	.6	.2	0	.4	1	1
4	.5	.8	.5	.5	.4	.3	.2	.5	1	1
5	.5	1	.8	1	1	.8	.6	.8	.8	1
6	.5	.8	.7	.7	.4	.3	0	.7	1	1
7	.7	1	.7	.7	.8	.8	.8	.6	.8	.8
8	1	1	.9	.8	1	.8	1	1	1	1
9	1	1	1	.8	1	1	.8	.9	1	1
10	.8	.8	1	1	1	1	1	.9	1	1
11	1	1	1	1	1	1	1	1	1	1
12	1	1	1	1	1	1	1	1	1	1
13	1	.8	1	.8	.8	1	1	1	.9	1
14	1	.8	1	.8	.8	1	1	.9	1	.5
15	.9	1	1	1	1	1	1	1	1	1
16	1	1	1	1	1	1	1	.9	1	1
17	.8	1	1	1	1	1	1	1	.9	1
18	1	.8	1	1	1	1	1	1	1	1
38	.8	.8	1	1	1	1	1	1	.8	1
39	1	1	1	1	1	1	1	1	1	1
40	1	1	1	1	1	1	1	1	1	1

(table continues)

Table 9 (Continued)

S9	Pairs of Incorrect Comparisons									
Session	A1B1	A1C1	B1C1	A2B1	A2C1	A2B2	A2C2	B2C2	A1B2	A1C2
1	.7	.2	.6	.3	.4	.7	.6	.2	.7	.6
2	.7	.4	.2	.7	.6	.7	.6	.3	.7	.6
3	.8	1	.7	1	1	1	.6	.5	.7	.2
4	.8	.8	.4	.3	.4	.7	.4	.3	.5	.2
5	1	.8	.7	.7	.8	1	.8	.8	.7	1
6	1	1	.7	1	.6	1	1	.8	.8	1
7	.8	1	1	.7	.8	1	1	1	1	1
8	1	1	.8	1	.8	1	1	1	1	1
9	1	1	1	.7	1	1	1	1	1	1
10	1	1	1	.8	1	1	1	1	1	1
11	1	1	1	1	1	1	1	1	1	.7
12	1	1	1	.8	1	1	1	1	1	.8
13	1	1	1	1	1	1	1	1	.8	1
33	1	1	1	1	1	1	1	1	1	1
34	1	1	1	.8	.8	1	1	1	1	1

EXPERIMENT 2

Experiments 1A and 1B provided further support for Sidman's (1986) hierarchical framework for stimulus control. The two experiments demonstrated fifth-term control of stimulus classes, and explored some of the effects of stimulus equivalence on transfer of contextual function. Experiment 2 demonstrates that sixth-term control of stimulus classes, which corresponds to third-order stimulus-stimulus conditioning, is possible within an operant procedure. Specifically, four college students were taught to order six stimuli into groups of three based on which of two contextual stimuli (fifth-term) and which of two sixth-term stimuli were present. They were then taught to relate novel stimuli to the two sixth-term stimuli to form two classes of sixth-term stimuli. A test was then conducted to determine whether the novel stimuli would function similarly to the original sixth-term stimuli.

Method

Subjects

Four undergraduate college students, two females and two males served as subjects. Three were recruited for the study from the introductory psychology class at Utah State University. Their ages ranged from 21 to 27. They received class points for participating in the experiment, with bonus points available for completing the experiment. The fourth subject heard about the experiment through a friend and volunteered.

Apparatus

Apparatus was the same as in prior experiments with the following exceptions. Subjects were seated in a small room at one of two tables with an Apple monitor and a joystick. An on-line Apple IIe or II+ microcomputer was located behind a partition to arrange events and record data.

Procedure

The general procedure throughout the experiment was a nominal matching-to-sample task in one of two formats. The first was the sixth-term task in which the conditional stimuli were presented in a column with the sixth-term stimulus at the top, the fifth-term stimulus immediately below, followed by the sample, with three comparisons centered below the sample (see Figure 6). A trial began with the sixth-term stimulus on the screen. As in prior experiments, the subject was required to make a response by pressing a button on the joystick. Each conditional stimulus was added one at a time, dependent on a button response for each. When the third-term stimulus (i.e., sample) appeared, a button press produced three comparison stimuli arrrayed horizontally. Choice of comparisons was made as in prior experiments.

The second format was a four-term three-choice matching-to-sample task identical to that used to prior experiments. The sample and comparisons appeared in the same location as in the sixth-term task (see Figure 6). No trial-end feedback was given during test sessions. Sessions were 64 trials long, and 3 to 6 sessions for a total of 40-50 minutes each day were conducted 2 to 3 days a week.

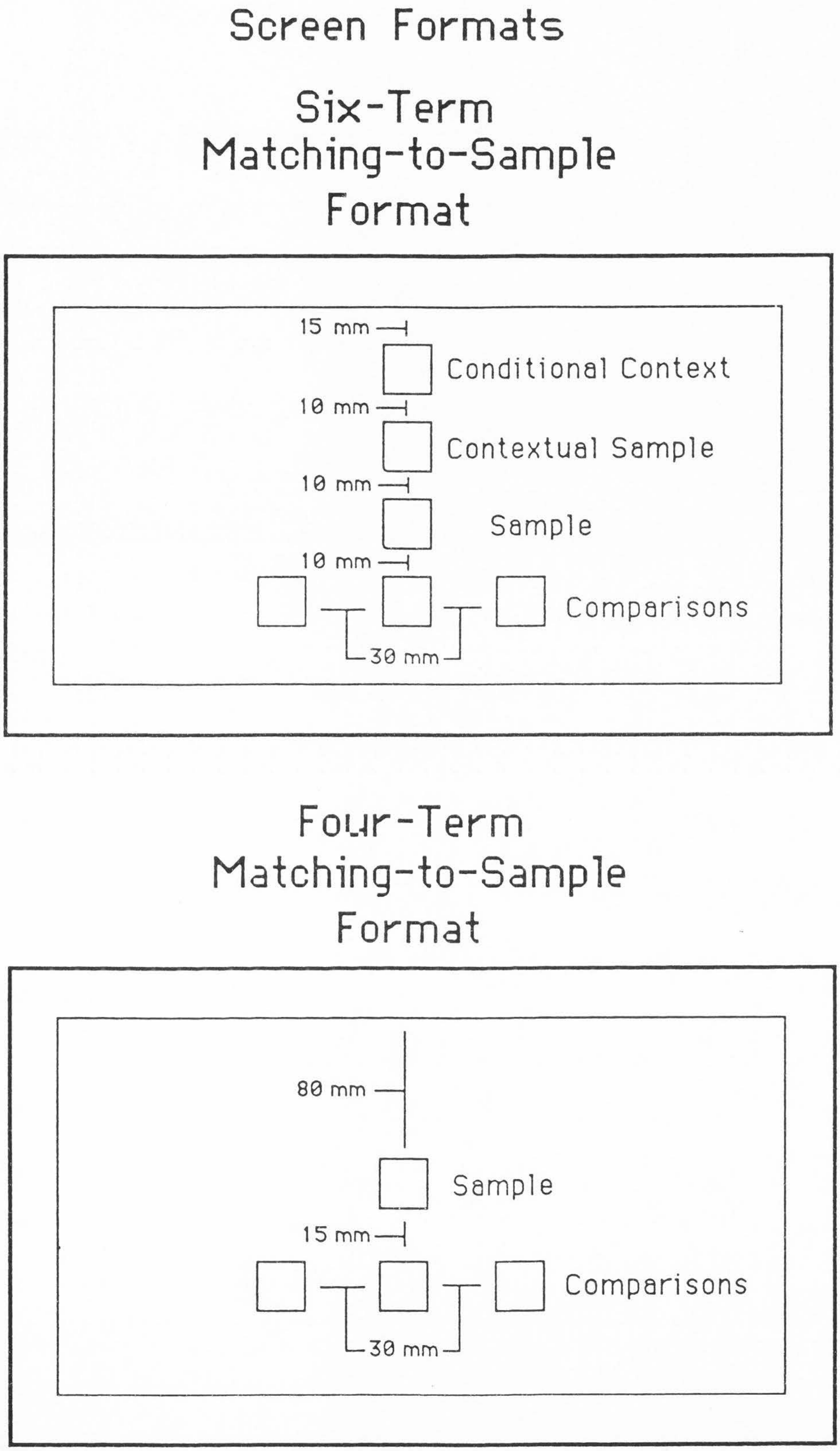


Figure 6. On-screen formats for the matching-to-sample tasks in Experiment 2.

Phase 1 training. Sixteen conditional relations were trained using the sixth-term task in order to establish the six-term contingency shown in Phase 1, Figure 7. For example, when given X1 at the top of the screen, M1 below it, and A1 as the sample the subject earned points for selecting B1 or C1, but given X1 at the top, M2 below it, and A1 as the sample the subject earned points for selecting B2 or C2. Generic training trial types are depicted in Table 10. Training ended when a criterion of two consecutive sessions of 61/64 correct or greater occurred.

S12 was trained on subsets of the conditional relations in an attempt to improve performance. Set 1 was comprised of the two conditional relations on the top far left and the two on the bottom far right of Figure 7, Phase 1, i.e., X1-M1-A1-B1, X1-M1-A1-C1, X2-M2-A2-B2, and X2-M2-A2-C2. Set 2 was comprised of X1-M1-A2-B2, X1-M1-A2-C2, X2-M2-A1-B1, and X2-M2-A1-C1. Sessions were 64 trials long, 16 trials for each relation. Set 1 was trained to criterion, and then Set 2 was trained to criterion.

Phase 1 testing. Symmetry and transitivity tests were conducted upon completion of training. Test sessions consisted of 50% probe trials in a training (Phase 1) baseline for 64 trials per session. At least two sessions of testing were conducted. If accurate performance was increasing, further sessions were conducted until the subjects demonstrated two consecutive sessions of at least 61/64 correct. Test 1 examined symmetry, in which the samples and comparisons were reversed, for example, X1-M1-B1-A1. Test 2 examined transitivity, for

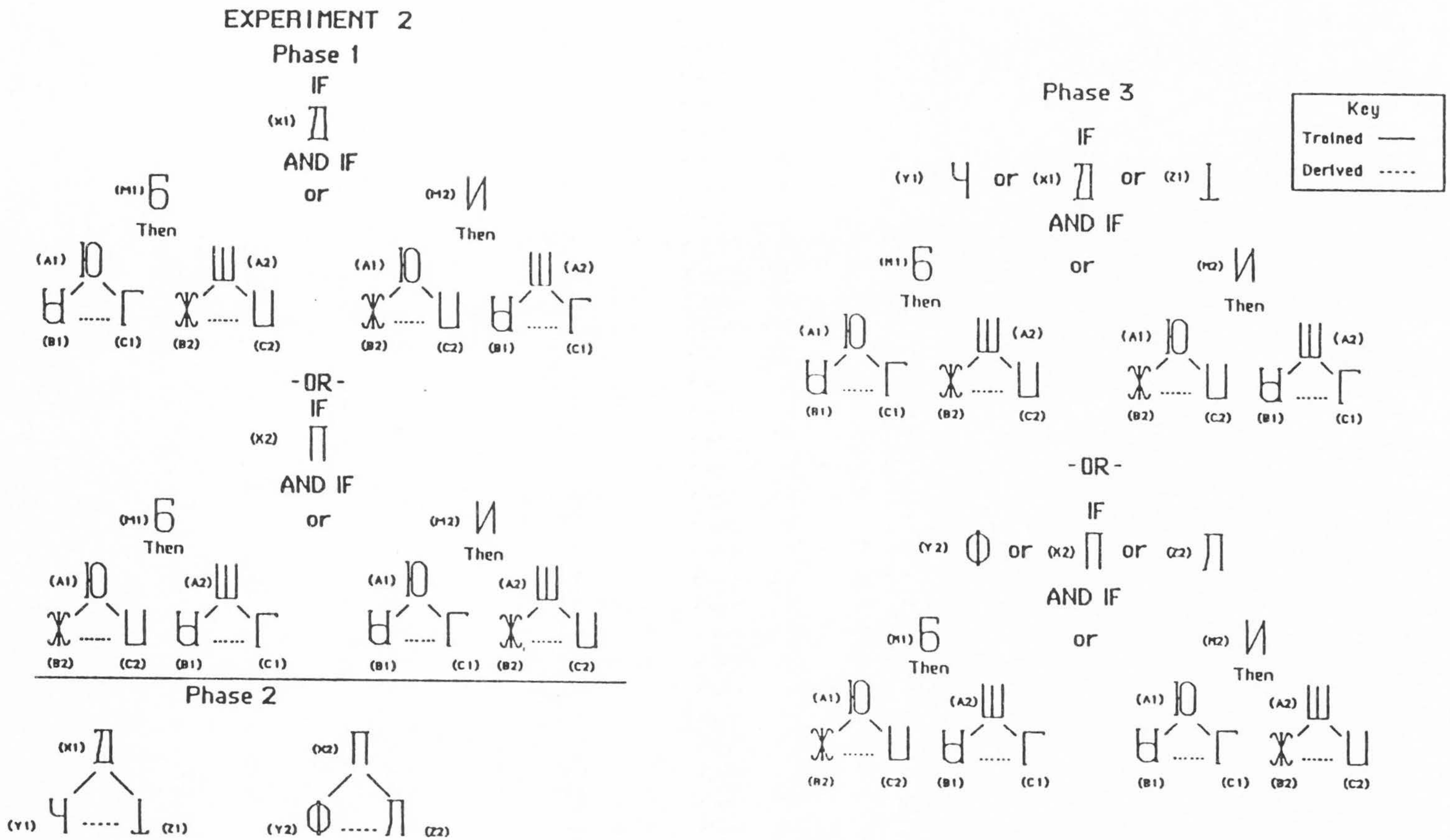


Figure 7. Control of the organization of three-member classes by fifth- and sixth-term stimuli in Experiment 2.

Table 10

Training Trial Types for Experiment 2 Phase 1

1.	X1	2.	X1	3.	X1	4.	X1
	M1		M1		M1		M1
	A1		A1		A2		A2
B1	Co- Co-	C1	Co- Co-	B2	Co- Co-	C2	Co- Co-
(Co- = A2, B2, or C2)				(Co- = A1, B1, or C1)			
5.	X1	6.	X1	7.	X1	8.	X1
	M2		M2		M2		M2
	A1		A1		A2		A2
B2	Co- Co-	C2	Co- Co-	B1	Co- Co-	C1	Co- Co-
(Co- = A2, B1, or C1)				(Co- = A1, B2, or C2)			
9.	X2	10.	X2	11.	X2	12.	X2
	M1		M1		M1		M1
	A1		A1		A2		A2
B2	Co- Co-	C2	Co- Co-	B1	Co- Co-	C1	Co- Co-
(Co- = A2, B1, or C1)				(Co- = A1, B2, or C2)			
13.	X2	14.	X2	15.	X2	16.	X2
	M2		M2		M2		M2
	A1		A1		A2		A2
B1	Co- Co-	C1	Co- Co-	B2	Co- Co-	C2	Co- Co-
(Co- = A2, B2, or C2)				(Co- = A1, B1, or C1)			

example, X1-M1-B1-C1. Generic testing trial types are shown in Table 11.

Phase 2 training. Two of the subjects participated in Phase 2 (S11 and S13). The four-term matching-to-sample task was used. The subjects were trained to relate two stimuli to each of the sixth-term stimuli used in Phase 1 (See Figure 7, Phase 2). The relations were X1-Y1, X1-Z1, X2-Y2, X2-Z2. Training trial types are shown in Table 12. The incorrect stimuli were selected at random from the other three-member class. The criterion for completeing training was the same as in Phase 1.

Phase 2 testing. Testing began when the criterion was reached. Test 3 evaluated symmetry. Phase 2 training trial types were mixed randomly with 50% symmetry trial types in which the sample and comparison were reversed, i.e., Y1-X1, Z1-X1, Y2-X2, and Z2-X2. Test 4 evaluated transitivity. Phase 2 training trial types were mixed randomly with 50% transitive trial types, i.e., Y1-Z1, Z1-Y1, Y2-Z2, Z2-Y2. Testing trial types are depicted in Table 12.

Phase 3 contextual class test. Fifty percent of the trials were comprised of the Phase 1 training trial types. In the remaining 50 percent, stimuli from the three-member classes taught in Phase 2 were used in the sixth-term position (See Figure 7, Phase 3). Individual trial types are depicted in Table 13. Testing lasted for at least two sessions of 64 trials. The subjects were debriefed following this test.

Table 11

Testing Trial Types for Experiment 2 Phase 1

	Symmetry		
1. X1	2. X1	3. X1	4. X1
M1	M1	M1	M1
B1	C1	B2	C2
A1 Co- Co-	A1 Co- Co-	A2 Co- Co-	A2 Co- Co-
(Co- = A2, B2, or C2)		(Co- = A1, B1, or C1)	
5. X1	6. X1	7. X1	8. X1
M2	M2	M2	M2
B1	C1	B2	C2
A2 Co- Co-	A2 Co- Co-	A1 Co- Co-	A1 Co- Co-
(Co- = A2, B1, or C1)		(Co- = A1, B2, or C2)	
9. X2	10. X2	11. X2	12. X2
M1	M1	M1	M1
B1	C1	B2	C2
A2 Co- Co-	A2 Co- Co-	A1 Co- Co-	A1 Co- Co-
(Co- = A2, B1, or C1)		(Co- = A1, B2, or C2)	
13. X2	14. X2	15. X2	16. X2
M2	M2	M2	M2
B1	C1	B2	C2
A1 Co- Co-	A1 Co- Co-	A2 Co- Co-	A2 Co- Co-
(Co- = A2, B2, or C2)		(Co- = A1, B1, or C1)	
	Conceptual transitivity test trial types		
1. Sixth	2. Sixth	3. Sixth	4. Sixth
Ctxt	Ctxt	Ctxt	Ctxt
B1	C1	B2	C2
C1 Co- Co-	B1 Co- Co-	C2 Co- Co-	B2 Co- Co-

If X1M1 or X2M2: (Co- = A2, B2, or C2) (Co- = A1, B1, or C1)
If X1M2 or X2M1: (Co- = A2, B1, or C1) (Co- = A1, B2, or C2)

Table 12

Trial Types for Experiment 2 Phase 2

					Training						
1.	X1		2.	X1		3.	X2		4.	X2	
Y1	Co-	Co-	Z1	Co-	Co-	Y2	Co-	Co-	Z2	Co-	Co-
					Symmetry						
1.	Y1		2.	Z1		3.	Y2		4.	Z2	
X1	Co-	Co-	X1	Co-	Co-	X2	Co-	Co-	X2	Co-	Co-
					Transitivity						
1.	Y1		2.	Z1		3.	Y2		4.	Z2	
Z1	Co-	Co-	Y1	Co-	Co-	Z2	Co-	Co-	Y2	Co-	Co-

(Co- = X2, Y2, or Z2)   (Co- = X1, Y1, or Z1)

Results

Phase 1

Results are depicted in Figure 8. S10, S11, and S13 acquired the sixth-term task in 12, 15, and 16 sessions, respectively. S10 and S11 demonstrated symmetry upon testing while S13 required three sessions to reach criterion. S10 and S13 showed transitivity upon testing, while S11 took 3 sessions to reach criterion.

S12 was unable to learn the task within the time limits of the academic quarter. Initially, he scored between 29.7% and 50% correct for 10 sessions. When the procedure was changed for him to a subset of the possible stimulus relations seen by the other subjects, he took 5

Table 13

Testing Trial Types for Experiment 2 Phase 3

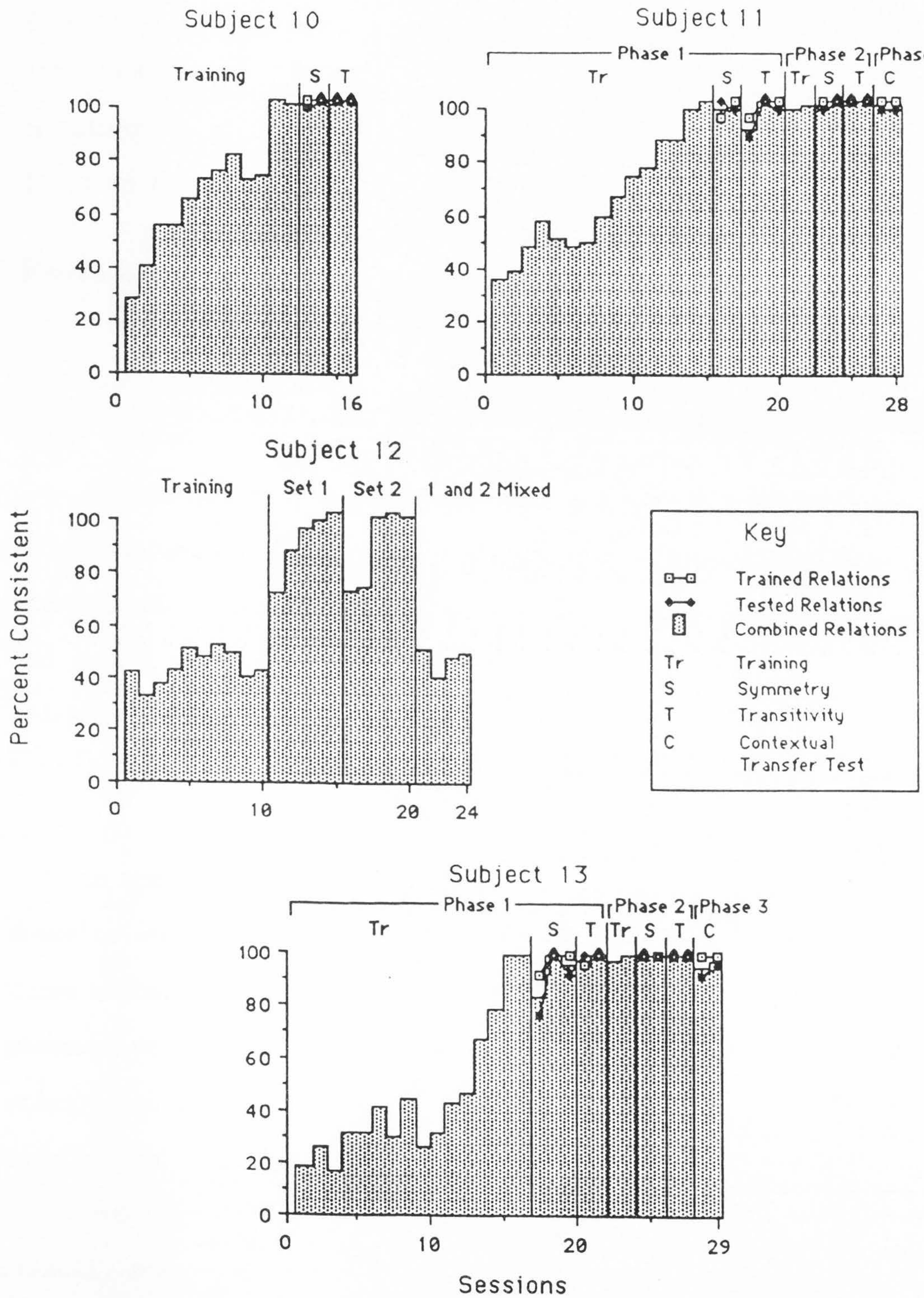
1.	Y1	2.	Y1	3.	Y1	4.	Y1
	M1		M1		M1		M1
	A1		A1		A2		A2
B1	Co- Co-	C1	Co- Co-	B2	Co- Co-	C2	Co- Co-
(Co- = A2, B2, or C2)				(Co- = A1, B1, or C1)			
5.	Y1	6.	Y1	7.	Y1	8.	Y1
	M2		M2		M2		M2
	A1		A1		A2		A2
B2	Co- Co-	C2	Co- Co-	B1	Co- Co-	C1	Co- Co-
(Co- = A2, B1, or C1)				(Co- = A1, B2, or C2)			
9.	Z1	10.	Z1	11.	Z1	12.	Z1
	M1		M1		M1		M1
	A1		A1		A2		A2
B1	Co- Co-	C1	Co- Co-	B2	Co- Co-	C2	Co- Co-
(Co- = A2, B2, or C2)				(Co- = A1, B1, or C1)			

(table continues)

Table 13 (Continued)

13. Z1	14. Z1	15. Z1	16. Z1
M2	M2	M2	M2
A1	A1	A2	A2
B2 Co- Co-	C2 Co- Co-	B1 Co- Co-	C1 Co- Co-
(Co- = A2, B1, or C1)		(Co- = A1, B2, or C2)	
17. Y2	18. Y2	19. Y2	20. Y2
M1	M1	M1	M1
A1	A1	A2	A2
B2 Co- Co-	C2 Co- Co-	B1 Co- Co-	C1 Co- Co-
(Co- = A2, B1, or C1)		(Co- = A1, B2, or C2)	
21. Y2	22. Y2	23. Y2	24. Y2
M2	M2	M2	M2
A1	A1	A2	A2
B1 Co- Co-	C1 Co- Co-	B2 Co- Co-	C2 Co- Co-
(Co- = A2, B2, or C2)		(Co- = A1, B1, or C1)	
25. Z2	26. Z2	27. Z2	28. Z2
M1	M1	M1	M1
A1	A1	A2	A2
B2 Co- Co-	C2 Co- Co-	B1 Co- Co-	C1 Co- Co-
(Co- = A2, B1, or C1)		(Co- = A1, B2, or C2)	
29. Z2	30. Z2	31. Z2	32. Z2
M2	M2	M2	M2
A1	A1	A2	A2
B1 Co- Co-	C1 Co- Co-	B2 Co- Co-	C2 Co- Co-
(Co- = A2, B2, or C2)		(Co- = A1, B1, or C1)	

EXPERIMENT 2



<u>Figure 8</u>. Percentage of correct responses in 64 trials for each session and phase of Experiment 2.

sessions to come to criterion on Set 1, and 5 additional sessions to come to criterion on Set 2. He then scored 48.4% on a session comprised of all trial types but Set 1, which was presented accidentally due to a computer error. Subsequently, he performed from 37.5% to 46.9% on 3 sessions of Set 1 and Set 2 combined.

Phases 2 and 3

In Phase 2, S11 and S13 demonstrated criterion performance in two sessions each for training, symmetry and transitivity testing, and the Phase 3 test.

During debriefing, S10, S11, and S13 identified the conditional relations between the stimuli. S12 was unable to describe the conditional relations used and was shown Figure 6. He stated that he had lumped the sample (fourth-term stimulus) with the fifth-term stimulus.

Discussion

In the present study, three of four subjects demonstrated behavior under the control of a six-term contingency, in which four three-member classes of equivalent stimuli were signalled by the presence of two contextual stimuli. The function of these contextual stimuli was signalled, in turn, by the presence of two additional (sixth-term) stimuli. A four-term matching-to-sample task followed, in which two further stimuli were related to both of the sixth-term stimuli, forming two classes of sixth-term stimuli. Finally, the equivalent stimuli in the sixth-term classes were shown to control the six-term matching-to-sample task without having been trained directly in that function.

This experiment extends empirically Sidman's (1986) analysis of the hierarchical nature of stimulus-stimulus contingencies to six terms. The present study also demonstrates that transfer of function can take place via equivalence at the sixth-term level. Such a finding is important since it systematically replicates earlier work which used fourth-term or fifth-term contingencies (e.g., Hayes et al., in press; Lazar & Kotlarchyk, 1986; Wulfert & Hayes, 1988). Together, all these studies indicate that the basic findings of equivalence apply at a number of different levels from simple matching-to-sample to complex hierarchical tasks.

Delprato (1987) criticizes the possibility of the infinite regress of Sidman's formulation. However, how complex a hierarchy of stimuli by which human behavior can be controlled is unknown. If there is a limit, then it should be found. If not, then how such hierarchies are established and how they function should be studied, in order that more complex behavior can be addressed.

Another possible criticism of Sidman's formulation is that the levels of conditional stimuli do not act independently within a hierarchy, but are simply stimulus compounds which can be explained more parsimoniously with a three-term model (Delprato, 1987). Two findings suggest that compounding does not explain the present results. First is the finding in the present study and in Experiment 1A that a group of stimuli can be related via equivalence to one of the contextual stimuli and will come to take on the function of that contextual stimulus without training. In Experiment 1A, novel stimuli were related to the two fifth-term stimuli and transference of the fifth-term function to the novel stimuli was found. The subjects did not treat the novel stimuli as third or fourth-term stimuli. Likewise, in Experiment 2, when novel stimuli were related to the two sixth-term stimuli, they functioned as sixth-term stimuli. A potential counterargument is that the screen location constrained the possibility of the novel stimuli functioning in other roles since they appeared in the location of the sixth-term stimuli. Location of the stimuli as a controlling factor was not examined, but has been shown to be important to the development and maintenance of conditional discriminations in animals (Iversen, Sidman, & Carrigan, 1986).

Second, is the anecdotal evidence provided by S12 in the present experiment. He reported compounding the third and fourth-term stimuli, and he failed to learn the task. Examination of the data indicates that as long as he was presented trial types in which the roles of the fourth and fifth-term stimuli were redundant he had no difficulty. He reached a perfect score on both subsets of the conditional discriminations in five sessions, and scored well above chance on his first training session on each of the subsets. When he was presented the combined subsets, in which he had to look at both the fourth and fifth-term stimuli in order to choose correctly (e.g. if M1 and A1, then B1, but if M1 and A2, then B2), he had great difficulty. This result suggests that if stimulus compounding does occur, higher-order conditional relations cannot be learned.

As in Experiment 1B, the subjects were found to exclude A1 and A2 during training (Table 14). Again, performance on symmetry and transitivity tests did not seem to be affected. Three of the four subjects did not learn during training to exclude B1-C1 or B2-C2 when they served as incorrect comparisons together (Table 15). None of the subjects excluded B1-C1 or B2-C2 during testing. An assumption can be made that the presence of two constant relations did not affect equivalence class formation. However, in Experiments 3A, 3B, and 3C of this dissertation (below), incorrect comparisons are chosen from more than one class so that any such potential confound is avoided.

Table 14

Number of Times Each Stimulus Is Chosen as an Incorrect Comparison for Each Subject Each Session of Experiment 2 Phase 1 and Contextual Class Test

S10	Incorrect Comparisons						S11	Incorrect Comparisons					
Session	A1	B1	C1	A2	B2	C2	Session	A1	B1	C1	A2	B2	C2
1	6	10	9	6	2	14	1	7	9	3	8	8	8
2	0	12	10	0	10	8	2	7	8	7	2	8	9
3	0	8	7	0	8	7	3	2	13	5	1	8	6
4	0	8	6	0	7	3	4	0	11	6	0	8	4
5	0	7	5	0	6	1	5	0	13	5	0	9	6
6	0	2	4	0	5	4	6	0	10	5	0	11	9
7	0	1	5	0	3	4	7	0	9	8	0	6	11
8	0	6	3	0	6	4	8	0	8	7	0	4	9
9	0	5	3	0	6	4	9	0	8	4	0	4	7
10	0	0	0	0	0	0	10	0	4	2	0	6	6
11	0	0	0	0	0	0	11	0	3	2	0	6	5
12	0	0	0	0	0	0	12	0	1	1	0	3	4
13	0	0	0	0	0	0	13	0	2	1	0	2	4
14	0	0	0	0	0	0	14	0	0	0	0	0	2
15	0	0	0	0	0	0	15	0	0	0	0	0	0
16	0	0	0	0	0	0	16	0	1	0	0	0	1
17	0	0	0	0	0	0	17	1	0	0	1	0	0
18	0	0	0	0	0	0	18	1	0	1	1	0	2
19	0	0	0	0	0	0	19	0	0	0	0	0	0
20	1	0	0	0	0	0	20	0	0	0	0	0	1
21	0	0	0	0	0	0	27	0	0	1	0	0	0
22	0	0	0	0	0	0	28	0	1	0	0	0	0
23	0	0	0	0	0	0							
24	0	0	0	0	0	0							
25	0	0	0	0	0	0							

(table continues)

Table 14 (Continued)

S12 Session	A1	B1	C1	A2	B2	C2	S13 Session	A1	B1	C1	A2	B2	C2
	Incorrect Comparisons							Incorrect Comparisons					
1	5	10	2	1	10	11	1	1	7	6	4	3	7
2	10	11	4	2	7	11	2	1	0	0	0	1	3
3	9	12	2	0	11	8	3	0	0	0	0	0	0
4	1	8	4	0	14	11	4	0	0	0	0	0	0
5	2	8	6	0	9	8	5	0	13	7	1	14	8
6	0	12	4	1	9	9	6	0	8	11	0	11	9
7	0	6	9	0	12	5	7	2	7	13	1	10	11
8	0	8	8	0	12	6	8	0	8	9	0	13	16
9	0	9	11	0	15	5	9	0	9	8	0	8	11
10	0	7	9	0	18	4	10	0	8	2	0	12	9
11	0	4	6	0	7	3	11	0	11	7	2	9	8
12	0	7	0	0	1	1	12	0	6	7	0	7	9
13	0	2	0	0	2	0	13	0	9	9	0	13	8
14	0	1	0	0	1	0	14	0	10	5	0	11	10
15	0	0	0	0	0	0	15	0	7	7	0	6	10
16	0	5	2	0	6	6	16	0	6	6	0	8	8
17	0	8	3	0	5	2	17	0	3	2	0	7	5
18	0	0	0	0	1	0	18	0	1	4	0	2	4
19	0	0	0	0	0	0	19	0	0	0	0	0	0
20	0	0	1	0	0	0	20	0	0	0	0	0	0
21	0	7	7	0	10	9	21	1	1	1	2	2	1
22	0	9	9	0	14	8	22	0	0	0	0	0	0
23	0	4	10	0	13	8	23	1	0	0	1	0	0
24	0	2	11	0	13	8	24	0	0	0	0	0	1
							25	0	0	0	0	0	0
							32	0	1	0	0	0	0
							33	0	0	1	0	0	0

Table 15

Proportion of Responses Away from Each Possible Combination of Incorrect Comparisons for Each Session of Each Subject in Experiment 2

S10					Pairs of Incorrect Comparisons					
Session	A1B1	A1C1	B1C1	A2B1	A2C1	A2B2	A2C2	B2C2	A1B2	A1C2
1	.2	.2	.2	.5	.2	.3	.4	.3	.2	.2
2	.2	.4	.4	.3	.2	.5	.2	.5	.2	.8
3	.8	.6	.2	.7	.6	.7	.6	.5	.5	.4
4	.5	.4	.8	.3	.6	.7	1	.6	.5	.8
5	.3	.4	1	.5	.6	.5	1	1	.5	.8
6	.8	.4	1	.8	.8	.5	.6	1	.7	.6
7	1	.4	1	.8	.6	.7	.6	.9	.8	.8
8	.7	.6	.9	.5	.8	.7	.8	1	.3	.4
9	.3	.6	1	.8	.8	.7	.8	1	.8	.4
10	1	1	1	1	1	1	1	1	1	1
11	1	1	1	1	1	1	1	1	1	1
12	1	1	1	1	1	1	1	1	1	1
13	1	1	1	1	1	1	1	1	1	1
14	1	1	1	1	1	1	1	1	1	1
15	1	1	1	1	1	1	1	1	1	1
16	1	1	1	1	1	1	1	1	1	1
17	1	1	1	1	1	1	1	1	1	1
18	1	1	1	1	1	1	1	1	1	1
19	1	1	1	1	1	1	1	1	1	1
20	1	1	1	1	1	1	1	1	1	.8
21	1	1	1	1	1	1	1	1	1	1
22	1	1	1	1	1	1	1	1	1	1
23	1	1	1	1	1	1	1	1	1	1
24	1	1	1	1	1	1	1	1	1	1
25	1	1	1	1	1	1	1	1	1	1

(table continues)

Table 15 (Continued)

S11 Session	Pairs of Incorrect Comparisons A1B1	A1C1	B1C1	A2B1	A2C1	A2B2	A2C2	B2C2	A1B2	A1C2
1	.3	.4	.3	.3	.4	.5	0	.3	.3	.4
2	.7	.2	.4	.2	.8	.5	.2	.3	.3	0
3	.5	.4	.3	.2	.6	.7	.4	.5	.5	.6
4	.5	.4	.7	.2	.4	.5	.1	.6	.5	.6
5	.7	.6	.3	.2	.6	.5	.8	.4	.5	.6
6	1	.6	.4	.2	.6	.8	.4	.2	0	.6
7	.7	.6	.6	.3	0	1	.2	.3	.3	.6
8	.8	.8	.6	.2	.2	.8	.4	.4	.8	.6
9	.8	1	.4	.3	.8	.7	.6	.5	.8	.8
10	1	1	.8	.7	.6	.7	.6	.4	.8	.8
11	.8	1	1	.7	.6	.7	.6	.4	1	.8
12	.8	1	.9	1	1	.7	6	.8	1	.8
13	1	1	.8	.8	1	.8	.8	.8	1	.6
14	1	1	1	1	1	1	1	.9	1	.8
15	1	1	1	1	1	1	1	1	1	1
16	1	1	1	.8	1	1	1	.9	1	1
17	1	1	1	1	1	1	1	1	.8	1
18	1	1	1	.8	.8	1	1	.8	1	.8
19	1	1	1	1	1	1	1	1	1	1
20	1	1	1	1	1	1	1	1	1	.8
27	1	1	1	1	.8	1	1	1	1	1
28	1	1	1	.8	1	1	1	1	1	1

(table continues)

Table 15 (Continued)

S12	Pairs of Incorrect Comparisons									
Session	A1B1	A1C1	B1C1	A2B1	A2C1	A2B2	A2C2	B2C2	A1B2	A1C2
1	.7	.4	.6	.2	.8	.2	0	.4	.3	.2
2	.7	0	.1	.3	1	.3	.2	.2	.2	.2
3	.3	.6	.1	.5	1	.2	.2	.3	.3	.2
4	.5	.8	.6	.7	.6	0	0	.1	.3	.6
5	.5	.8	.6	.3	.6	.2	.4	.4	.7	.4
6	.3	.8	.6	.2	.6	.5	.4	.2	.7	.4
7	.8	.4	.5	.3	.6	.3	.6	.5	.3	.6
8	.5	.6	.5	.3	.6	.2	.1	.3	.5	.4
9	.2	.2	.4	.5	.6	.3	.8	.2	.2	.6
10	.7	.2	.7	.2	.6	.2	.8	.2	0	.6
11	.7	.6	.7			.7	.7	.6		
12	.7	1	.6			.9	1	.9		
13	.9	1	.9			.9	1	.9		
14	.9	1	1			.9	1	1		
15	1	1	1			1	1	1		
16	.7	.9	.7			.6	.7	.6		
17	.6	.8	.6			.7	1	.6		
18	1	1	1			.9	1	1		
19	1	1	1			1	1	1		
20	1	.9	1			1	1	1		
21	.7	.2	.4	.7	1	.7	.2	.2	.5	.6
22	.4	.6	.4			.4	.3	.3		
23	.6	.6	.5			.3	.6	.2		
24	.8	.4	.5			.4	.4	.3		

(table continues)

EXPERIMENT 3A

Kennedy and Laitinen (1988) found that most of their subjects (college students) were not able to learn a five-term matching-to-sample task. They then tried a different procedure in which the subjects were taught a four-term matching-to-sample task. The four-term contingency was then placed under fifth-term control. They reported that their subjects learned these tasks much more easily than those subjects taught the fifth-term task from the start. Experiments 1A, 1B, and 2 indicated, contrary to Kennedy and Laitinen, that higher-order control can be directly established. One purpose of Experiment 3A was to examine how subjects acquire higher-order conditional discriminations by successively adding levels of control. The other purpose was to utilize a more complex task to see whether equivalence performance is maintained when a larger number of stimuli and more complex interactions are used.

In Experiment 3A, three subjects were taught four three-member stimulus classes. They were then taught to organize the three-member classes into six-member classes based upon the presence of contextual stimuli. The subjects were then to be taught to vary the organization of six-member classes based upon the presence of sixth-term contextual stimuli. However, subjects did not learn the fifth-term task, so the sixth-term task was not trained.

Method

Subjects

Three subjects were recruited from the introductory psychology class at Utah State University. All were male, and their ages ranged from 18 to 20 years. They were given class points for participation, and bonus points were given to those who completed the research.

Apparatus

The apparatus was the same as in prior experiments.

Procedure

General procedures. The same general procedures as in prior experiments were used. Subjects were first taught the four-term task, and then the five-term task. Training and testing sessions of the four-term task lasted for 64 trials. A criterion of at least 61 correct of 64 (95%) for two consecutive sessions was used to determine when to end a task. On the five-term task, testing sessions lasted for 60 trials. Criterion for Phase 2 testing was two consecutive sessions of at least 57 of 60 correct. The length of training sessions varied and is discussed in detail below.

Two to five sessions for a total of 40-50 minutes each day were conducted two days a week. No feedback was ever given during testing. Incorrect comparisons were selected from the other three-member classes. Stimuli from the same class were never presented as incorrect comparisons on the same trial. Due to a programming error, A3 was never present as an incorrect comparison during Test 1.

Phase 1. The subjects were trained to group 12 stimuli into four groups of three as illustrated in Figure 9. Eight conditional discriminations were taught and are shown in Table 16. When the criterion was met, each subject underwent symmetry and transitivity testing. Each session of testing was comprised of 50% trained relations and 50% test relations. Symmetry was tested first, followed by transitivity. Generic trial types for symmetry and transitivity are depicted in Table 16. Upon completion of testing, the subjects began Phase 2.

Phase 2. As illustrated in Figure 9, subjects were trained to combine two three-member classes into a six-member class in three different ways depending upon the presence of one of three contextual stimuli. Generic trial types are shown in Table 17. Group 1 (A1, B1, C1) went with Group 2 (A2, B2, C2) when M1 was present. Group 1 went with Group 3 (A3, B3, C3) when M3 was present, and Group 2 went with Group 4 (A4, B4, C4) when M4 was present. Subjects were trained to relate one stimulus from one three-member class to one stimulus from the other three-member class in the presence of a contextual stimulus. Sessions were 24 trials long, and criterion was at least 22/24 correct for two consecutive sessions.

Two tests were conducted. In Test A, each potential derived stimulus relation was tested. For example, the subject was presented A1-A2, A1-B2, and A1-C2 in the presence of M1 to see if A1 became related to Group 2. Generic trial types are depicted in Table 18. In Test B, the relations between the members of the original three-member classes were retested to see if control had changed. Trial types are shown in Table 19.

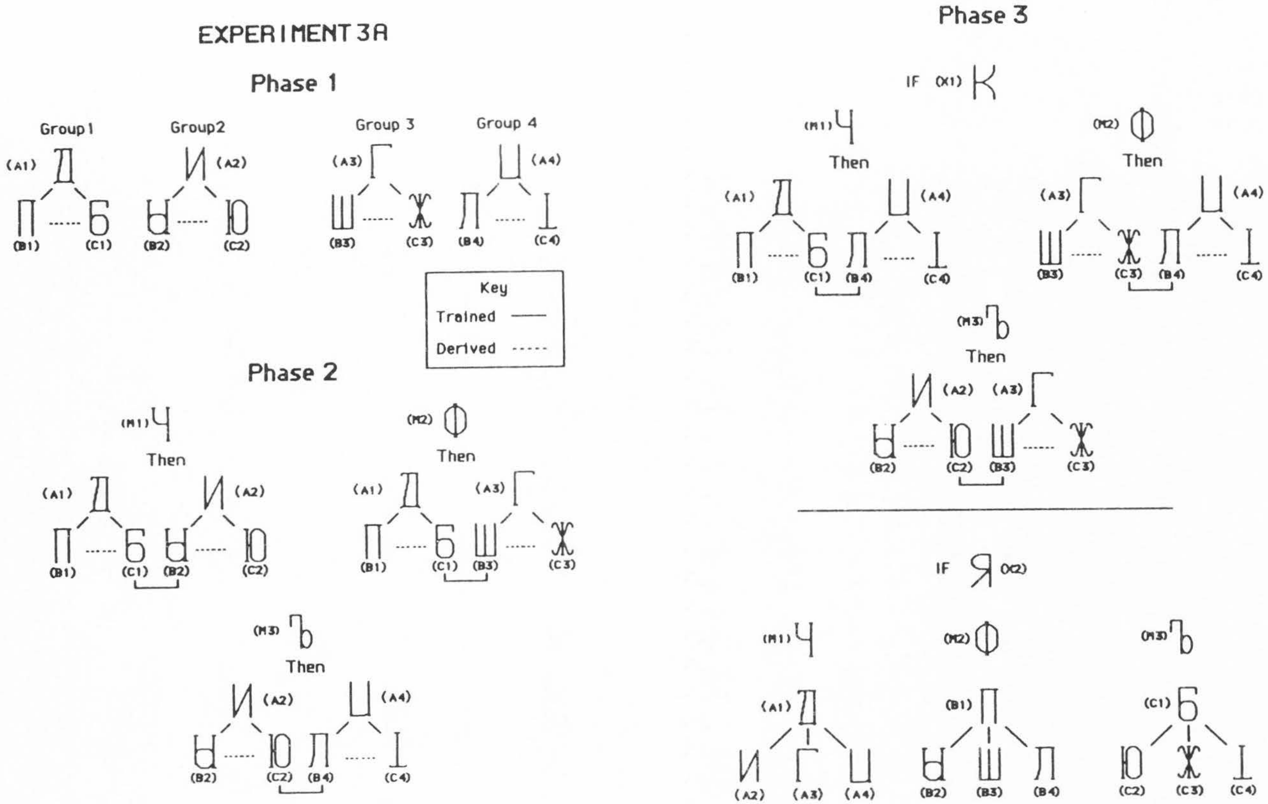


Figure 9. Control of the organization of three-member into six-member classes by fifth- and sixth-term stimuli in Experiment 3A.

Table 16

Trial Types for Experiments 3A Phase 1

	Training		
1. A1	2. A1	3. A2	4. A2
B1 Co- Co-	C1 Co- Co-	B2 Co- Co-	C2 Co- Co-
5. A3	6. A3	7. A4	8. A4
B3 Co- Co-	C3 Co- Co-	B4 Co- Co-	C4 Co- Co-
	Symmetry		
1. B1	2. C1	3. B2	4. C2
A1 Co- Co-	A1 Co- Co-	A2 Co- Co-	A2 Co- Co-
5. B3	6. C3	7. B4	8. C4
A3 Co- Co-	A3 Co- Co-	A4 Co- Co-	A4 Co- Co-
	Transitivity		
1. B1	2. C1	3. B2	4. C2
C1 Co- Co-	B1 Co- Co-	C2 Co- Co-	B2 Co- Co-
5. B3	6. C3	7. B4	8. C4
C3 Co- Co-	B3 Co- Co-	C4 Co- Co-	B4 Co- Co-

Co- for trial types 1 and 2
(A2,B2,C2,A3,B3,C3,A4,B4,C4)

Co- for trial types 3 and 4
(A1,B1,C1,A3,B3,C3,A4,B4,C4)

Co- for trial types 5 and 6
(A1,B1,C1,A2,B2,C2,A4,B4,C4)

Co- for trial types 7 and 8
(A1,B1,C1,A2,B2,C2,A3,B3,C3)

Table 17

Training Trial Types for Experiment 3A Phase 2

Original Training

1.		2.		3.	
	M1		M3		M4
	B2		B3		B4
	C1 Co- Co-		C1 Co- Co-		C2 Co- Co-

(Co- = A3,B3,C3,A4,B4,C4; A3,B3,C3,A4,B4,C4; A3,B3,C3,A4,B4,C4)

Revised Training

1.			2.			3.			4.			5.		
	M1			M1			M1			M1			M1	
	A1			A1			A2			A2			B2	
B1	Co-	Co-	C1	Co-	Co-	B2	Co-	Co-	C2	Co-	Co-	C1	Co-	Co-
6.	M2		7.	M2		8.	M2		9.	M2		10.	M2	
	A1			A1			A3			A3			B3	
B1	Co-	Co-	C1	Co-	Co-	B3	Co-	Co-	C3	Co-	Co-	C1	Co-	Co-
11.	M3		12.	M3		13.	M3		14.	M3		15.	M3	
	A2			A2			A4			A4			B4	
B2	Co-	Co-	C2	Co-	Co-	B4	Co-	Co-	C4	Co-	Co-	C2	Co-	Co-

Revised Training 2

1.			2.			3.			4.			5.		
	M1			M1			M1			M1			M1	
	B1			C1			B2			C2			C1	
A1	Co-	Co-	A1	Co-	Co-	A2	Co-	Co-	A2	Co-	Co-	B2	Co-	Co-
6.	M2		7.	M2		8.	M2		9.	M2		10.	M2	
	B1			C1			B3			C3			C1	
A1	Co-	Co-	A1	Co-	Co-	A3	Co-	Co-	A3	Co-	Co-	B3	Co-	Co-
11.	M3		12.	M3		13.	M3		14.	M3		15.	M3	
	B2			C2			B4			C4			C2	
A2	Co-	Co-	A2	Co-	Co-	A4	Co-	Co-	A4	Co-	Co-	B4	Co-	Co-

Trial types 1-5 Trial types 6-10 Trial types 11-15

(Co- = A3,B3,C3,A4,B4,C4; A3,B3,C3,A4,B4,C4; A3,B3,C3,A4,B4,C4)

Table 18

<u>Test A Trial Types for Experiment 3A Phase 2</u>

1.	M1		2.	M1		3.	M1		4.	M1	
	A1			A1			A1			B1	
A2	Co-	Co-	B2	Co-	Co-	C2	Co-	Co-	A2	Co-	Co-
5.	M1		6.	M1		7.	M1		8.	M1	
	B1			B1			C1			C1	
B2	Co-	Co-	C2	Co-	Co-	A2	Co-	Co-	C2	Co-	Co-

(Co- = A3,B3,C3,A4,B4,C4)

9.	M2		10.	M2		11.	M2		12.	M2	
	A1			A1			A1			B1	
A3	Co-	Co-	B3	Co-	Co-	C3	Co-	Co-	A3	Co-	Co-
13.	M2		14.	M2		15.	M2		15.	M2	
	B1			B1			C1			C1	
B3	Co-	Co-	C3	Co-	Co-	A3	Co-	Co-	C3	Co-	Co-

(Co- = A3,B3,C3,A4,B4,C4;

17.	M3		18.	M3		19.	M3		20.	M3	
	A2			A2			A2			B2	
A4	Co-	Co-	B4	Co-	Co-	C4	Co-	Co-	A4	Co-	Co-
21.	M3		22.	M3		23.	M3		24.	M3	
	B2			B2			C2			C2	
B4	Co-	Co-	C4	Co-	Co-	A4	Co-	Co-	C4	Co-	Co-

(Co- = A3,B3,C3,A4,B4,C4)

Table 19

Test B Trial Types for Experiment 3A Phase 2

1.	A1		2.	A1		3.	A1		4.	A1	
B1	A2	A4	B1	A3	B4	C1	B2	C4	C1	B2	A4
5.	B1		6.	B1		7.	A2		8.	A2	
C1	C2	B4	C1	C3	C4	B2	C1	A3	B2	B4	B3
9.	A2		10.	A2		11.	B2		12.	B2	
C2	C4	B3	C2	A1	C3	C2	B1	A3	C2	A4	C3
13.	A3		14.	A3		15.	B3		16.	A4	
B3	C1	A2	C3	A1	C2	C3	B1	B2	B4	A2	A1

All subjects demonstrated difficulty during training, and a revised training procedure was used. The original trial types of the four-term contingency were trained in the presence of the contextual stimuli, along with the previous three five-term trial types. The generic trial types are shown in Table 17. This training lasted for 64 trials. Upon completion of this training, the tests were repeated. S16 received additional training in which the symmetrical counterparts to the relations in the revised training were presented as well.

Phase 3. The subjects were to have received the training shown in the last portion of Figure 9 in which sixth-term control would have been superimposed on the existing relations. However, since none of the subjects learned the fifth-term task, Phase 3 was not conducted.

Results

Phase 1

Overall accuracy of responding for each subject on each session is depicted in Figure 10. S14 learned the task in three sessions and

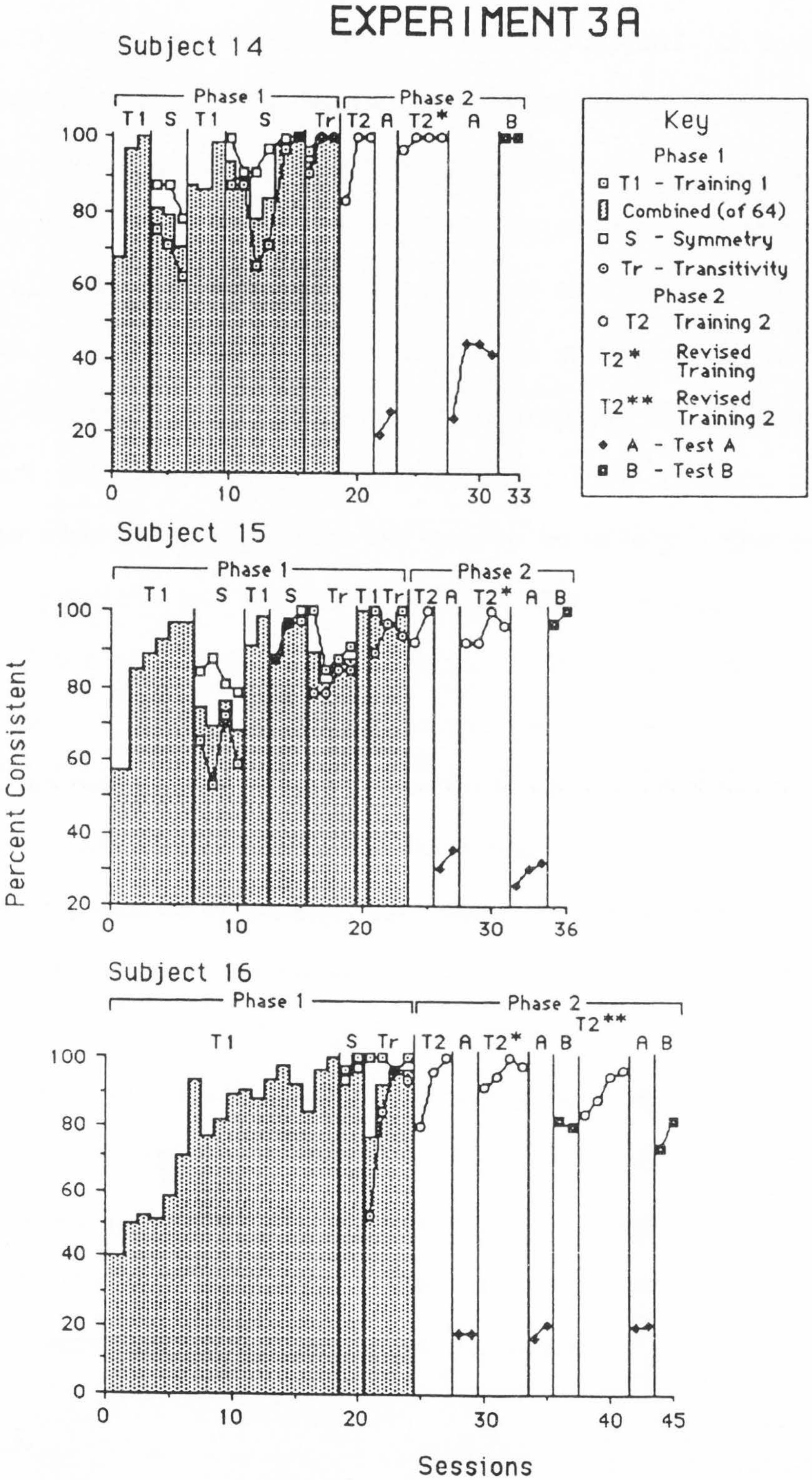


Figure 10. Percentage of correct responses for each session and phase of Experiment 3A.

S15 took six sessions. S16 had difficulty with arbitrary matching and took 18 sessions of training to reach criterion. On symmetry testing, the performance of S14 dropped from 84.4% to 68.8% correct. His scores on the baseline (trained) relations ranged from 12 to 16 percentage points lower on than on the symmetry relations. He was then returned to training. He received 3 sessions of training, on which his scores ranged from 85.9% to 98.4% correct. He was retested on symmetry. His score on the training baseline again dropped, this time to 65.6% correct, and then gradually increased to 100% correct. His symmetry scores also fluctuated, but not nearly so widely. The range on symmetry trials was between 90.6% and 100% correct.

S15 also had difficulty during symmetry testing and required additional training. His performance on trained relations fell to 53.1% correct, while symmetry performance ranged from 78.1% to 87.5% correct. After two additional sessions of training, he demonstrated symmetry in three sessions. S16 demonstrated symmetry upon testing.

S14 took three sessions to meet the criterion on transitivity testing. His combined score ranged from 93.8% to 100%. S15 performed poorly on four sessions of transitivity testing. He was given another session of training, and demonstrated criterion on transitivity in three sessions. S16 took four sessions to reach criterion. He made only one error on baseline trials, and performance on transitivity trials increased from 53.1% to 96.8% correct.

Phase 2

S14 took three sessions to reach criterion, and performed at 100% on the last two sessions. S15 demonstrated performance at criterion on the first two sessions. S16 also took three sessions to reach criterion. On Test A, S14 performed between 19.4% and 26.4% correct. S15 performed between 30.6% and 36.1%, and S16 performed at 18.1% correct.

On the revised training, S14 scored 96.7% correct on the first session, and at 100% for three more sessions. S15 scored 91.7% correct on his first two sessions, and then increased his score to 100% correct. The performance of S16 ranged from 91.7% to 100% correct.

Upon return to Test A, S14 scored a 25% correct and then his scores increased to between 41.7% and 44.4% correct. S15 ranged between 26.4% and 31.9% correct, while S16 ranged between 19.4% and 20.8% correct. They were then given Test B. S14 performed at 100% on two sessions of Test B. S15 scored 96.9% correct on the first session and 100% correct on the second. S16 performed between 68.8% and 76.6% correct. On the Revised Training 2, S16 gradually increased from 83.3% to 96.7%. He then scored 23.3% and 25% on two sessions of Test A, and 73.3% and 81.7% on two sessions of Test B.

Table 20 shows how often the subjects responded to members of each class given the sample and contextual stimulus. Columns one and two show how subjects responded when they were supposed to combine Group 1 and Group 2 together. Column one shows responses when stimuli from Group 1 were samples, and column two shows responses to the symmetrical situation when stimuli from Group 2 were samples. Likewise, columns three and four show responses when stimuli from Group 1 and Group 3 were to be combined, and columns five and six show responses when stimuli from Group 2 and Group 4 were to be combined.

Table 20

Number of Responses by S14, S15, and S16 to Each Group for Each Contextual Stimulus in Both Directions*

Test Following Training 1

	M1						M2						M3					
SA:	(Group 1-			(Group 2-			(Group 1-			(Group 3-			(Group 2-			(Group 4-		
Co+:	Group 2)			Group 1)			Group 3)			Group 1)			Group 4)			Group 2)		
Group:	2	3	4	1	3	4	3	2	4	1	2	4	4	1	3	2	1	3
S14	4	5	7	6	3	7	5	7	4	8	5	3	11	9	12**	-------		
S15	8	4	4	15	1	0	8	6	2	9	6	1	1	14	1	7	8	1
S16	7	4	5	7	6	3	3	10	3	3	10	3	5	13	6***	1	6	1
Test Following Revised Training																		
S14	26	3	3	28	1	3	2	25	5	29	2	1	1	14	1	25	5	2
S15	17	1	6	19	2	3	6	13	5	7	17	0	4	19	1	11	11	2
S16	6	4	6	6	5	5	4	6	6	3	12	1	4	9	3	3	10	3
Test Following Revised Training 2																		
S16	5	7	4	10	5	1	1	11	4	6	9	1	1	12	3	5	9	2

* (e.g., Group 1 as sample and Group 2 as correct comparison and Group 2 as sample and Group 1 as correct comparison). Number of responses in each cell (Context by Sample/Comparison by Subject) should total 16 for Testing after Training 1, and for Testing after Training 2, should total 32 for S14, 24 for S15 and 16 for S16. The first column for each task gives number of responses to the Group that was considered correct for that task. The second two columns give the number of responses to groups that were incorrect

** Due a programming error, S14 did not receive Group 4 - Group 2 trials, and received twice as many Group 2 - Group 4 trials for both test sessions after Training 1.

*** S16 experienced the programming on the first test session after Training 1. S16 had one and one half times as many Group 2 - Group 4 trials (24 total) than Group 4 - Group 2 trials (8 total). 2, and all reported that they found the task confusing. S14 and S15 both said that there were no right answers to the trials.

After the first training, no control can be seen for S14 and S15 in any situation. S16 demonstrated a weak tendency to choose stimuli from Group 1 or Group 2. He tended to relate Group 3 to Group 2 and Group 4 to Group 1. After the revised training, S14 had a strong tendency to choose stimuli from Group 1 if any were present, and stimuli from Group 2 if no stimuli from Group 1 were present. S15 also demonstrated a strong tendency to choose stimuli from Group 1 or Group 2, and showed a preference for Group 2 when stimuli from Group 3 were samples. S16 demonstrated a marked weakening of control by Group 1 and Group 2. After the additional training, S16 showed some strengthening of his preference to choose Group 1 or Group 2.

Each subject was debriefed as he finished the experiment. All three were able to describe the relations taught in Phase 1. None of the subjects were able to describe the relations of Phase 2, and all reported that they found the task confusing. S14 and S15 both said that there were no right answers to the trials.

Discussion

Three subjects learned to group 12 stimuli into four three-member classes. An attempt to establish control over combinations of three-member classes into six-member classes via contextual stimuli was not effective. Instead the subjects based their responding on familiarity, or else their responding became random. All of the subjects tended to respond mostly to Group 1 stimuli which were present as samples during two thirds of the training trials. Group 2 stimuli were also more familiar, and the subjects tended to make more responses to Group 2 than Groups 3 or 4. Group 2 stimuli were also present during two thirds of the training trials, one third of the time as samples, and one third as comparisons. Stimuli from Groups 3 and 4 were present half as often as stimuli from Groups 1 and 2. Both groups served as comparisons on one third of the training trials.

Subjects did not form six-member classes during this experiment. Two possible reasons may serve as explanations. First, three possible combinations created too large a change in the environment, and the subjects suffered from "information overload." Second, the combinations overlapped; that is, Group 1 went with Group 2 in one situation and with Group 3 in another situation. Group 2 (already related to Group 1 in one situation) went with Group 4 in a third situation. The overlap may have presented an ambiguous situation to the subjects. Logically, the contextual stimuli should have separated the three situations from each other. However, since the subjects did not perform according to the experimenter-defined contingencies, the task may have been contradictory given the subjects' histories.

Computer problems also plagued the experiment. Frequent program malfunctions occurred during Phase 1 sessions of S14 and S15. All of these malfunctions occurred before or on the first trial of a session, so none of the malfunctions are shown in Figure 10. The subjects found the malfunctions distracting. Also, a computer program error caused two "correct" comparisons to be shown on the screen during 3-4 trials each session during the initial phases of symmetry for both S14 and S15. This may also have led to confusion on the part of the subject. All problems were corrected before S16 participated, and did not effect Experiments 3B and 3C.

These difficulties probably do not seriously compromise the validity of these results. Only the first sessions of symmetry were directly affected, and later performance on Phase 1 appeared to be very similar to that of the remaining subjects in Experiments 3A, 3B, and 3C. Also, S16 was entirely unaffected by the problems, and his performance differed very little from that of S14 and S15.

EXPERIMENT 3B

The purpose of Experiment 3B was to test the hypothesis raised in Experiment 3A that the overlapping of combinations created an ambiguous, and hence difficult to learn situation. The possibility that three contexts may have been overwhelming as well was also considered. Three subjects were taught to group 12 stimuli into 4 groups of 3 as in Experiment 3A. They were then taught to group two three-member classes into six-member classes dependent upon the presence of a contextual stimulus. Figure 11 illustrates the experimental design. Only two contextual stimuli were used in the initial training, M1 and M2. The classes were not overlapped; that is, Group 1 went with Group 2 and Group 3 went with Group 4. Each group was used only once.

In the second training, two new contextual stimuli were used. There was no overlapping within the training; Group 1 went with Group 3 and Group 2 went with Group 4. However, there was overlap between the two training conditions. When the subjects completed the second training, they were tested on all four contextual situations. The design addressed a number of issues. As there was no overlap within training conditions, the possibility that overlap was the factor which led to the difficulties in Experiment 3A is addressed. If the subjects can learn the task, then overlap could have been a potential cause of the difficulties. Two contextual stimuli were used in each training to make the task simpler. However, when two conditions were combined, the subjects had four contexts, which is more complex than in Experiment

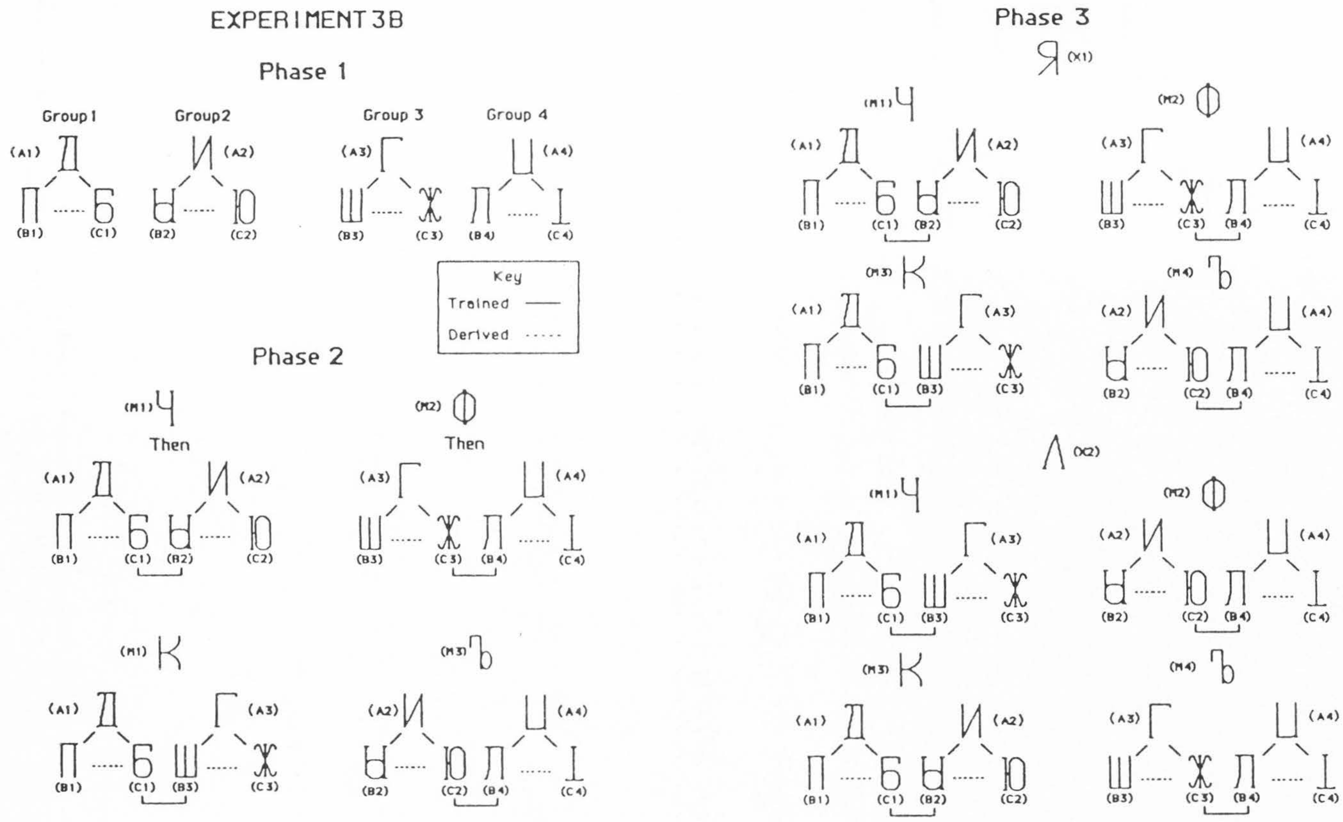


Figure 11. Control of the organization of three-member into six-member classes by fifth- and sixth-term stimuli in Experiment 3B.

3A. With four contexts, the proposal that information overload may have contributed to the difficulty in Experiment 3A could be tested.

Methods

Subjects

Three subjects were recruited from undergraduate classes at Utah State University. One subject was recruited from the introductory psychology class and two were recruited from the undergraduate psychology statistics class. They were given class points for participating, and were given a bonus for completeing the research. All three subjects were female, and their ages ranged from 21 to 49 years.

Apparatus

The apparatus was the same as that used in Experiment 3A.

Procedures

Phase 1. The general procedures followed those of Experiment 3A with a few exceptions which are noted below in the relevant section. Phase 1 procedures followed those of Experiment 3A with one exception. S18 received special training on Sessions 6 and 7 in which the trials were presented in blocks rather than randomly in order to facilitate training (Saunders & Spradlin, 1989). Eight trials of trial type 1 were presented, then eight trials of trial type 2, and so on (See Table 16, page 84).

Phase 2. During this phase, the four three-member classes were combined into six-member classes dependent upon the presence of one of four contextual stimuli as illustrated in the second panel of Figure 11. During Training 2, the subjects were taught the sets of relations controlled by M1 and M2. During Training 3, the subjects were taught the sets of relations controlled by M3 and M4.

For Training 2, subjects were taught to combine stimuli from Group 1 with Group 2 when M1 was present, and to combine Group 3 with Group 4 when M2 was present. The revised training method used in Phase 2 of Experiment 3A was used. The previously trained relations (A1-B1, A1-C1, A2-B2, A2-C2) and their symmetrical counterparts were retrained in the presence of the contextual stimuli, and the two connecting relations and their symmetrical counterparts (B2-C1, C1-B2, B4-C3, C3-B4) were also trained. Training sessions lasted for 60 trials, and the criterion for completion was at least 57/60 correct for two consecutive sessions. Trial types for training appear in Table 21.

When training was complete, the subjects were tested on all possible relations within the two potential six-member classes (Test A). The two trained relations for each six-member class that connected the two three-member classes were also tested. Of the 18 possible relations that could have been derived from training for each six-member class, 2 were trained, and 16 were not. Trial types are shown in Table 22. Sessions for Test A were 72 trials long, and the criterion was two consecutive sessions of at least 68/72 correct. No feedback was ever given during testing. After testing, the subjects proceeded to the second training condition.

During Training 3, the subjects were taught to relate stimuli from Group 1 with stimuli from Group 3 in the presence of M3, and to

Table 21

<u>Training Trial Types for Experiment 3B Phase 2</u>

Training 2

1.	M1		2.	M1		3.	M1		4.	M1		5.	M1	
	A1			A1			A2			A2			B2	
B1	Co-	Co-	C1	Co-	Co-	B2	Co-	Co-	C2	Co-	Co-	C1	Co-	Co-
6.	M1		7.	M1		8.	M1		9.	M1		10.	M1	
	B1			C1			B2			C2			C1	
A1	Co-	Co-	A1	Co-	Co-	A2	Co-	Co-	A2	Co-	Co-	B2	Co-	Co-

(Co- = A3, B3, C3, A4, B4, C4)

11.	M2		12.	M2		13.	M2		14.	M2		15.	M2	
	A3			A3			A4			A4			B4	
B3	Co-	Co-	C3	Co-	Co-	B4	Co-	Co-	C4	Co-	Co-	C3	Co-	Co-
16.	M2		17.	M2		18.	M2		19.	M2		20.	M2	
	B3			C3			B4			C4			C3	
A3	Co-	Co-	A3	Co-	Co-	A4	Co-	Co-	A4	Co-	Co-	B4	Co-	Co-

(Co- = A1, B1, C1, A2, B2, C2)

Training 3

1.	M3		2.	M3		3.	M3		4.	M3		5.	M3	
	A1			A1			A3			A3			B3	
B1	Co-	Co-	C1	Co-	Co-	B3	Co-	Co-	C3	Co-	Co-	C1	Co-	Co-
6.	M3		7.	M3		8.	M3		9.	M3		10.	M3	
	B1			C1			B3			C3			C1	
A1	Co-	Co-	A1	Co-	Co-	A3	Co-	Co-	A3	Co-	Co-	B3	Co-	Co-

(Co- = A2, B2, C2, A4, B4, C4)

11.	M4		12.	M4		13.	M4		14.	M4		15.	M4	
	A2			A2			A4			A4			B4	
B2	Co-	Co-	C2	Co-	Co-	B4	Co-	Co-	C4	Co-	Co-	C2	Co-	Co-
16.	M4		17.	M4		18.	M4		19.	M4		20.	M4	
	B2			C2			B4			C4			C2	
A2	Co-	Co-	A2	Co-	Co-	A4	Co-	Co-	A4	Co-	Co-	B4	Co-	Co-

(Co- = A1, B1, C1, A3, B3, C3)

Table 22

<u>Test A Trial Types for Experiment 3B Phase 2</u>

1. M1	2. M1	3. M1	4. M1	5. M1	6. M1
A1	A1	A1	B1	B1	B1
A2 Co- Co-	B2 Co- Co-	C2 Co- Co-	A2 Co- Co-	B2 Co- Co-	C2 Co- Co-
7. M1	8. M1	9. M1	10. M1	11. M1	12. M1
C1	C1	C1	A2	B2	C2
A2 Co- Co-	B2 Co- Co-	C2 Co- Co-	A1 Co- Co-	A1 Co- Co-	A1 Co- Co-
13. M1	14. M1	15. M1	16. M1	17. M1	18. M1
A2	B2	C2	A2	B2	C2
B1 Co- Co-	B1 Co- Co-	B1 Co- Co-	C1 Co- Co-	C1 Co- Co-	C1 Co- Co-

(Co- = A3, B3, C3, A4, B4, C4)

19. M2	20. M2	21. M2	22. M2	23. M2	24. M2
A3	A3	A3	B3	B3	B3
A4 Co- Co-	B4 Co- Co-	C4 Co- Co-	A4 Co- Co-	B4 Co- Co-	C4 Co- Co-
25. M2	26. M2	27. M2	28. M2	29. M2	30. M2
C3	C3	C3	A4	B4	C4
A4 Co- Co-	B4 Co- Co-	C4 Co- Co-	A3 Co- Co-	A3 Co- Co-	A3 Co- Co-
31. M2	32. M2	33. M2	34. M2	35. M2	36. M2
A4	B4	C4	A4	B4	C4
B3 Co- Co-	B3 Co- Co-	B3 Co- Co-	C3 Co- Co-	C3 Co- Co-	C3 Co- Co-

(Co- = A1, B1, C1, A2, B2, C2)

relate Group 2 to Group 4 when M4 was present. The same training approach as used in Training 2 was used. Trial types are depicted in Table 21. When training reached criterion, testing was begun.

S17 was tested on all possible relations under all four contexts (Test AB). Test AB was comprised of all the trial types used in Test A and Test B. Due to her difficulty, a test (Test B) which examined only the relations possible from Training 3 was presented to the remaining subjects immediately after Training 3. Trial types for Test B are depicted in Table 23. Upon completion of Test B, all subjects were then given Test AB. Testing sessions were again 72 trials long, and had the same criterion as Test A.

Phase 3. S18 was taught a sixth-term contingency which is illustrated in the last panel of Figure 11. When X1 was present, then the fifth-term contingency learned in Phase 2 held. When X2 was present, relations learned in the two different training conditions were flip-flopped. For example, Group 1 and Group 3 went together when M1 was present, instead of Group 1 and Group 2 as before. Training sessions were 80 trials long because of the large number of relations to train. Trial types are shown in Table 24.

Test 1 of Phase 3 tested the possible derived relations when X1 was present. Relations were tested in only one direction; that is, symmetrical relations were not tested. Without the symmetrical relations, 36 relations were tested. If the symmetrical relations had been included, 72 different relations would have been tested each session. Testing would have become extremely long and tedious.

Table 23

Test B Trial Types for Experiment 3B Phase 2

1. M3	2. M3	3. M3	4. M3	5. M3	6. M3
A1	A1	A1	B1	B1	B1
A3 Co- Co-	B3 Co- Co-	C3 Co- Co-	A3 Co- Co-	B3 Co- Co-	C3 Co- Co-
7. M3	8. M3	9. M3	10. M3	11. M3	12. M3
C1	C1	C1	A3	B3	C3
A3 Co- Co-	B3 Co- Co-	C3 Co- Co-	A1 Co- Co-	A1 Co- Co-	A1 Co- Co-
13. M3	14. M3	15. M3	16. M3	17. M3	18. M3
A3	B3	C3	A3	B3	C3
B1 Co- Co-	B1 Co- Co-	B1 Co- Co-	C1 Co- Co-	C1 Co- Co-	C1 Co- Co-

(Co- = A1, B1, C1, A3, B3, C3)

19. M4	20. M4	21. M4	22. M4	23. M4	24. M4
A2	A2	A2	B2	B2	B2
A4 Co- Co-	B4 Co- Co-	C4 Co- Co-	A4 Co- Co-	B4 Co- Co-	C4 Co- Co-
25. M4	26. M4	27. M4	28. M4	29. M4	30. M4
C2	C2	C2	A4	B4	C4
A4 Co- Co-	B4 Co- Co-	C4 Co- Co-	A2 Co- Co-	A2 Co- Co-	A2 Co- Co-
31. M4	32. M4	33. M4	34. M4	35. M4	36. M4
A4	B4	C4	A4	B4	C4
B2 Co- Co-	B2 Co- Co-	B2 Co- Co-	C2 Co- Co-	C2 Co- Co-	C2 Co- Co-

(Co- = A2, B2, C2, A4, B4, C4)

Table 24

Training 4 Trial Types for Experiment 3B Phase 3

1.	2.	3.	4.	5.
X1	X1	X1	X1	X1
M1	M1	M1	M1	M1
A1	A1	A2	A2	B2
B1 Co- Co-	C1 Co- Co-	B2 Co- Co-	C2 Co- Co-	C1 Co- Co-

(Co- = A3, B3, C3, A4, B4, C3)

6.	7.	8.	9.	10.
X1	X1	X1	X1	X1
M2	M2	M2	M2	M2
A3	A3	A4	A4	B4
B3 Co- Co-	C3 Co- Co-	B4 Co- Co-	C4 Co- Co-	C3 Co- Co-

(Co- = A1, B1, C1, A2, B2, C2)

11.	12.	13.	14.	15.
X1	X1	X1	X1	X1
M3	M3	M3	M3	M3
A1	A1	A3	A3	B3
B1 Co- Co-	C1 Co- Co-	B3 Co- Co-	C3 Co- Co-	C1 Co- Co-

(Co- = A2, B2, C2, A4, B4, C4)

16.	17.	18.	19.	20.
X1	X1	X1	X1	X1
M4	M4	M4	M4	M4
A2	A2	A4	A4	B4
B2 Co- Co-	C2 Co- Co-	B4 Co- Co-	C4 Co- Co-	C2 Co- Co-

(Co- = A1, B1, C1, A3, B3, C3)

21.	22.	23.	24.	25.
X2	X2	X2	X2	X2
M1	M1	M1	M1	M1
A1	A1	A3	A3	B3
B1 Co- Co-	C1 Co- Co-	B3 Co- Co-	C3 Co- Co-	C1 Co- Co-

(Co- = A2, B2, C2, A4, B4, C4)

26.	22.	28.	29.	30.
X2	X2	X2	X2	X2
M2	M2	M2	M2	M2
A2	A2	A4	A4	B4
B2 Co- Co-	C2 Co- Co-	B4 Co- Co-	C4 Co- Co-	C2 Co- Co-

(Co- = A1, B1, C1, A3, B3, C3)

31.	32.	33.	34.	35.
X2	X2	X2	X2	X2
M3	M3	M3	M3	M3
A1	A1	A2	A2	B2
B1 Co- Co-	C1 Co- Co-	B2 Co- Co-	C2 Co- Co-	C1 Co- Co-

(Co- = A3, B3, C3, A4, B4, C4)

36.	37.	38.	39.	40.
X2	X2	X2	X2	X2
M4	M4	M4	M4	M4
A3	A3	A4	A4	B4
B3 Co- Co-	C3 Co- Co-	B4 Co- Co-	C4 Co- Co-	C3 Co- Co-

(Co- = A1, B1, C1, A2, B2, C2)

Test 2 tested 50% of the possible derived relations when X2 was present. Again, symmetrical relations were not tested. Testing sessions were 72 trials long. No trained relations were presented, and no feedback was given. Trial types for Test 1 are shown in Table 25, and trial types for Test 2 are shown in Table 26.

Results

Phase 1

Figure 12 illustrates overall performance for each subject each session. S17 and S19 each learned the initial training in 7 sessions. After 5 sessions of random performance (29.7% to 37.5% correct, chance = 33.3% correct), S18 was given two sessions of training in which the trial types were presented in blocks. Her performance increased from 60.9% to 85.9% correct. When normal training resumed, her performance dropped at first to 73.4% correct and then rose to 100% correct. All three subjects demonstrated symmetry upon testing. S17 and S18 demonstrated transitivity upon testing, while S19 took three sessions to reach criterion.

Phase 2

All three subjects took three sessions to learn the Training 2 task. S17 took six sessions to reach criterion on Test A. A programming error caused the wrong stimuli to be presented as incorrect comparisons on the first four sessions of Test A. Her scores ranged from 58.3% to 65.3% correct for those four sessions and then increased to 100% correct. S18 took three sessions to reach criterion, and S19 demonstrated criterion performance upon testing.

Table 25

<u>Test 1 Trial Types for Experiment 3B Phase 3</u>

1. X1	2. X1	3. X1	4. X1	5. X1	6. X1
M1	M1	M1	M1	M1	M1
A2	A2	A2	B2	B2	B2
A1 Co- Co-	B1 Co- Co-	C1 Co- Co-	A1 Co- Co-	B1 Co- Co-	C1 Co- Co-
7. X1	8. X1	9. X1	10. X1	11. X1	12. X1
M1	M1	M1	M2	M2	M2
C2	C2	C2	A4	A4	A4
A1 Co- Co-	B1 Co- Co-	C1 Co- Co-	A3 Co- Co-	B3 Co- Co-	C3 Co- Co-
13. X1	14. X1	15. X1	16. X1	17. X1	18. X1
M2	M2	M2	M2	M2	M2
B4	B4	B4	C4	C4	C4
A3 Co- Co-	B3 Co- Co-	C3 Co- Co-	A3 Co- Co-	B3 Co- Co-	C3 Co- Co-
19. X1	20. X1	21. X1	22. X1	23. X1	24. X1
M3	M3	M3	M3	M3	M3
A3	A3	A3	B3	B3	B3
A1 Co- Co-	B1 Co- Co-	C1 Co- Co-	A1 Co- Co-	B1 Co- Co-	C1 Co- Co-
25. X1	26. X1	27. X1	28. X1	29. X1	30. X1
M3	M3	M3	M4	M4	M4
C3	C3	C3	A4	A4	A4
A1 Co- Co-	B1 Co- Co-	C1 Co- Co-	A2 Co- Co-	B2 Co- Co-	C2 Co- Co-
31. X1	32. X1	33. X1	34. X1	35. X1	36. X1
M4	M4	M4	M4	M4	M4
B4	B4	B4	C4	C4	C4
A2 Co- Co-	B2 Co- Co-	C2 Co- Co-	A2 Co- Co-	B2 Co- Co-	C2 Co- Co-

(Co- for trial types 1- 9 = A3, B3, C3, A4, B4, C4
(Co- for trial types 10-18 = A1, B1, C1, A2, B2, C2
(Co- for trial types 19-27 = A2, B2, C2, A4, B4, C4
(Co- for trial types 28-36 = A1, B1, C1, A3, B3, C3

Table 26

Test 2 Trial Types for Experiment 3B Phase 3

1. X2	2. X2	3. X2	4. X2	5. X2	6. X2
M1	M1	M1	M1	M1	M1
A3	A3	A3	B3	B3	B3
A1 Co- Co-	B1 Co- Co-	C1 Co- Co-	A1 Co- Co-	B1 Co- Co-	C1 Co- Co-
7. X2	8. X2	9. X2	10. X2	11. X2	12. X2
M1	M1	M1	M2	M2	M2
C3	C3	C3	A4	A4	A4
A1 Co- Co-	B1 Co- Co-	C1 Co- Co-	A2 Co- Co-	A2 Co- Co-	A2 Co- Co-
13. X2	14. X2	15. X2	16. X2	17. X2	18. X2
M2	M2	M2	M2	M2	M2
B4	B4	B4	C4	C4	C4
B2 Co- Co-	B2 Co- Co-	B2 Co- Co-	C2 Co- Co-	C2 Co- Co-	C2 Co- Co-
19. X2	20. X2	21. X2	22. X2	23. X2	24. X2
M3	M3	M3	M3	M3	M3
A2	A2	A2	B2	B2	B2
A1 Co- Co-	B1 Co- Co-	C1 Co- Co-	A1 Co- Co-	B1 Co- Co-	C1 Co- Co-
25. X2	26. X2	27. X2	28. X2	29. X2	30. X2
M3	M3	M3	M4	M4	M4
C2	C2	C2	A4	A4	A4
A1 Co- Co-	B1 Co- Co-	C1 Co- Co-	A3 Co- Co-	B3 Co- Co-	C3 Co- Co-
31. X2	32. X2	33. X2	34. X2	35. X2	36. X2
M4	M4	M4	M4	M4	M4
B4	B4	B4	C4	C4	C4
A3 Co- Co-	B3 Co- Co-	C3 Co- Co-	A3 Co- Co-	B3 Co- Co-	C3 Co- Co-

(Co- for trial types 1- 9 = A2, B2, C2, A4, B4, C4
(Co- for trial types 10-18 = A1, B1, C1, A3, B3, C3
(Co- for trial types 19-27 = A3, B3, C3, A4, B4, C4
(Co- for trial types 28-36 = A1, B1, C1, A2, B2, C2

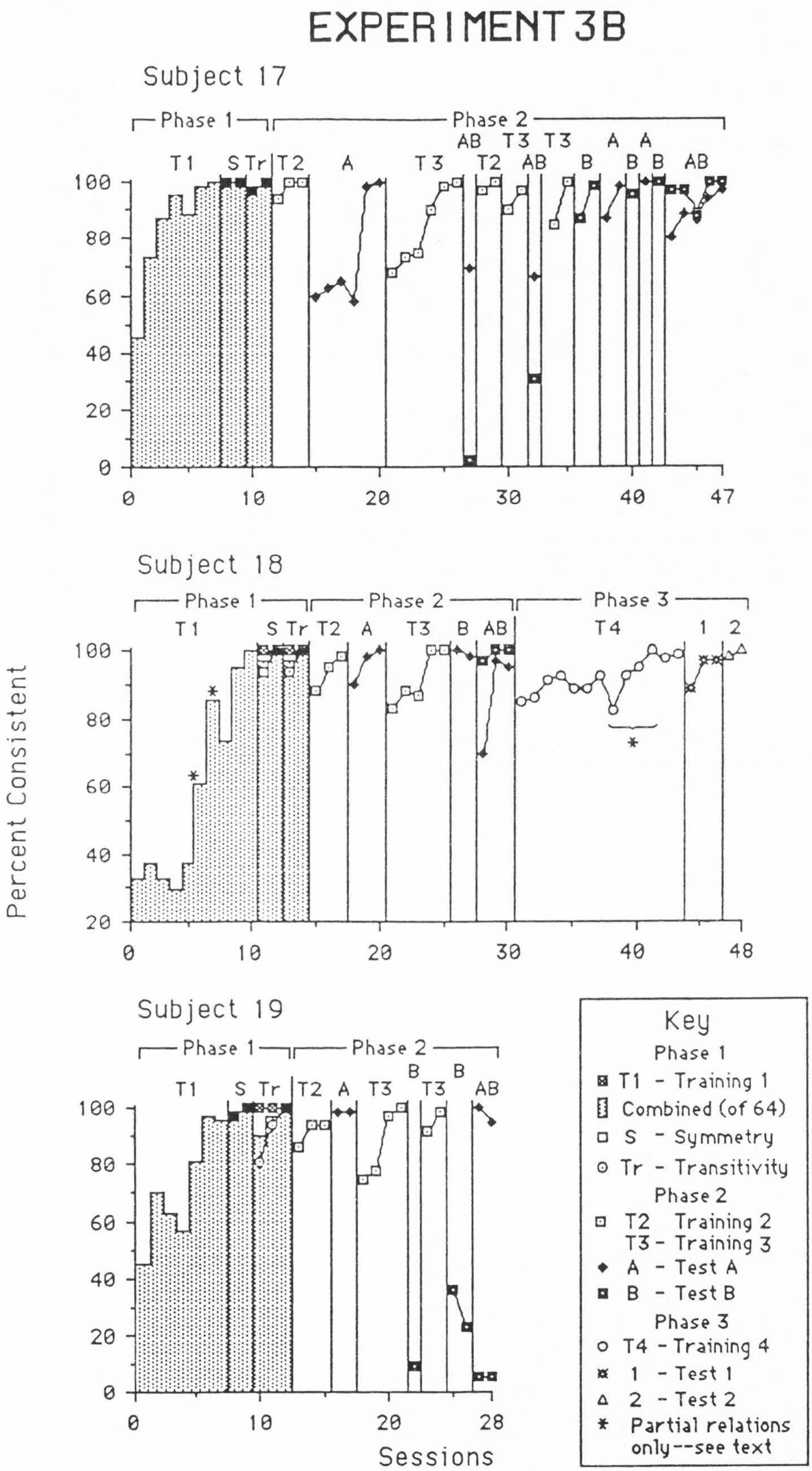


Figure 12. Percentage of correct responses for each session and phase of Experiment 3B.

S17 took six sessions to reach criterion on Training 3. Her scores increased gradually from 68.3% to 100% correct. S18 gradually increased her scores from 83.3% to 100% correct over five sessions. S19 took four sessions, and her performance ranged from 75% to 100% correct. S18 demonstrated criterion on Test B upon testing, and took three sessions to reach criterion on Test AB.

S17 received Test AB first. Her performance on Test A relations was only 69.4% correct, and Test B performance was 0. Two sessions each of Training 2 and Training 3 were conducted and performance was always above 90% correct. On another session of Test AB, her performance on Test A relations dropped to 66.7% correct, but performance on Test B relations increased to 30.6% correct. Two additional sessions of Training 3 were conducted. Her scores increased from 85% to 100% correct. Single sessions of Test B and Test A alternated until she could perform at above 95% on the first session after an alternation. She scored 100% correct on her last session of both Test A and Test B. She then took 5 sessions to reach criterion on Test AB.

S19 scored poorly on Test B with 9.7% correct. Two further sessions of Training 3 were conducted, and she performed at 91.7% and 98.3% correct. Two additional sessions of Test B were conducted, and S19 performed between 36.1% and 23.6% correct. On the combined test (Test AB) she performed nearly perfectly on Test A relations and nearly zero on Test B relations.

Phase 3

After six sessions of Training 4, S18 performed consistently on the relations within each three-member class (e.g., X1-M1-A1-B1 or X1-M1-A1-C1), but had difficulty on those relations which connected two three-member classes (e.g., X1-M1-B2-C1 or X1-M2-B4-C3). Four 80 trial sessions of only the four connecting relations (numbers 5,10, 15, and 20 in Table 24) were presented on sessions 37-40. When her performance on the four relations reached 100% correct, training with all trials was presented on sessions 41 and 42, and she performed at criterion. S18 took three sessions to reach criterion on Test 1 and demonstrated criterion on Test 2 upon testing.

At the debriefing, each of the three subjects was able to verbally describe the relations taught in Phase 1; that is, each stated that they learned to group stimuli into four groups of three. None of the three could accurately describe the relations in Phase 2 or 3, but when given a list of the stimuli, could indicate how they went together. They did say that the contextual stimuli changed how things went together, but could not describe how without the stimulus list. S19 said she knew that Test B involved reversing the contingencies in some way, but that the task took too much work, so she just responded as she had for Test A. Examination of the results indicated that her verbal behavior was accurate. The correct responses on the last two sessions of Test B were almost all on the trained relations.

Discussion

Three subjects were trained to establish four three-member classes. They were then taught to combine three-member classes into six-member classes based upon the presence of a contextual stimulus. Further, one subject learned a task in which the contextual task was brought under sixth-term stimulus control. The study demonstrates that larger, more complex classes can be established via stimulus equivalence.

The three subjects had much less difficulty with the task in Phase 1 than did the subjects in Experiment 3A, which indicates that the procedures are sound. The difficulties of the acquisition of Phase 1 in Experiment 3A were probably due to difficulties with the computer programs mentioned in Experiment 3A.

All three subjects were able to learn to combine two three-member classes into six-member classes dependent upon contextual control during Training 1, and two of the three subjects were able to do so during Training 2 of Phase 2. One subject also completed Phase 3, in which sixth-term control over the connecting classes was established. These results indicate that the overlapping classes may have contributed to the problems in Experiment 3A, since no overlap was present within each training task.

However, overlap was present between training tasks. One subject, S19, did not learn to generalize Training 3 to the test relations. S19 was the eldest subject, and claimed that when she was younger, she could deal with the large amount of information involved in remembering all the relations (120 in both parts of Phase 3). However, to do so at her age (49) was very difficult, she said. The small amount of class points available were clearly not enough to motivate her performance. The idea of information overload seems to be supported by her verbal behavior.

All subjects learned the second set of trained contextual relations (Training 2), although they did take longer than for the first (Training 1). This finding weakens the position that overlap was a causal factor in the previous experiment. However, the subjects may have learned the new, overlapping relations because they were trained in completely separate sessions. The longer training times and the difficulties of S17 and S19 seem to bear this idea out. S17 had great difficulty with Test AB, which was a combined test of Test A and Test B. After she had been separately tested on Test B, and had experience alternating sessions of Test A and Test B, she was able to do Test AB.

A number of questions remain that preclude a clear answer to the difficulties of Experiment 3A. Perhaps separating the two sets of contexts was enough to allow learning, but the results of Experiment 3B may also have been due to having only two contexts at a time. Having four contextual stimuli overall weakens that notion, but the idea of overlap is still not clearly supported.

In order to save time and subject fatigue not all possible derived relations were examined in Test A. Fifty percent of the possible relations were tested, including symmetrical and transitive relations. Test A examined half of the relations between two three member classes while in a six-member class. Some were transitive relations (e.g., for X1-M1: A2-A1, A2-B1, A2-C1, and B2-A1, B2-B1), and some were equivalence relations (e.g., for X1-M1: C2-A1, C2-B1, C2-C1). Since transitive relations were present, by the axioms, symmetry must have been present, and therefore equivalence classes developed (Fields et al., 1984; Sidman & Tailby, 1982).

EXPERIMENT 3C

Experiment 3B demonstrated that the larger stimulus classes could be controlled contextually and that a large number of relations (72 not counting symmetrical relations) could be learned and maintained. However, the nature of the factors which led to the difficulties of Experiment 3A still has not been made clear. Experiment 3C addresses the issue of whether complexity or overlapping produced the difficulties. Two contextual stimuli were again established in each of two training conditions, and class overlap within a training condition was programmed. If the subjects learned the tasks then the difficulty in Experiment 3A could be said to be due to the number of contextual stimuli, and if the subjects did not learn the tasks then the difficulties could be said to be due to overlap.

Three subjects were taught to group 12 stimuli into 4 groups of three. They were then taught to combine three-member classes into six-member classes based upon the presence of a contextual stimulus as illustrated in Figure 13. When M1 was present, Group 1 and Group 2 went together. Group 1 and Group 3 went together when M2 was present. Group 2 and Group 4 went together when M3 was present, and when M4 was present, Group 1 and Group 4 went together. Tests were conducted to examine whether six-member classes were formed under the control of higher-order stimuli.

Method

Subjects

Three subjects were recruited from undergraduate psychology

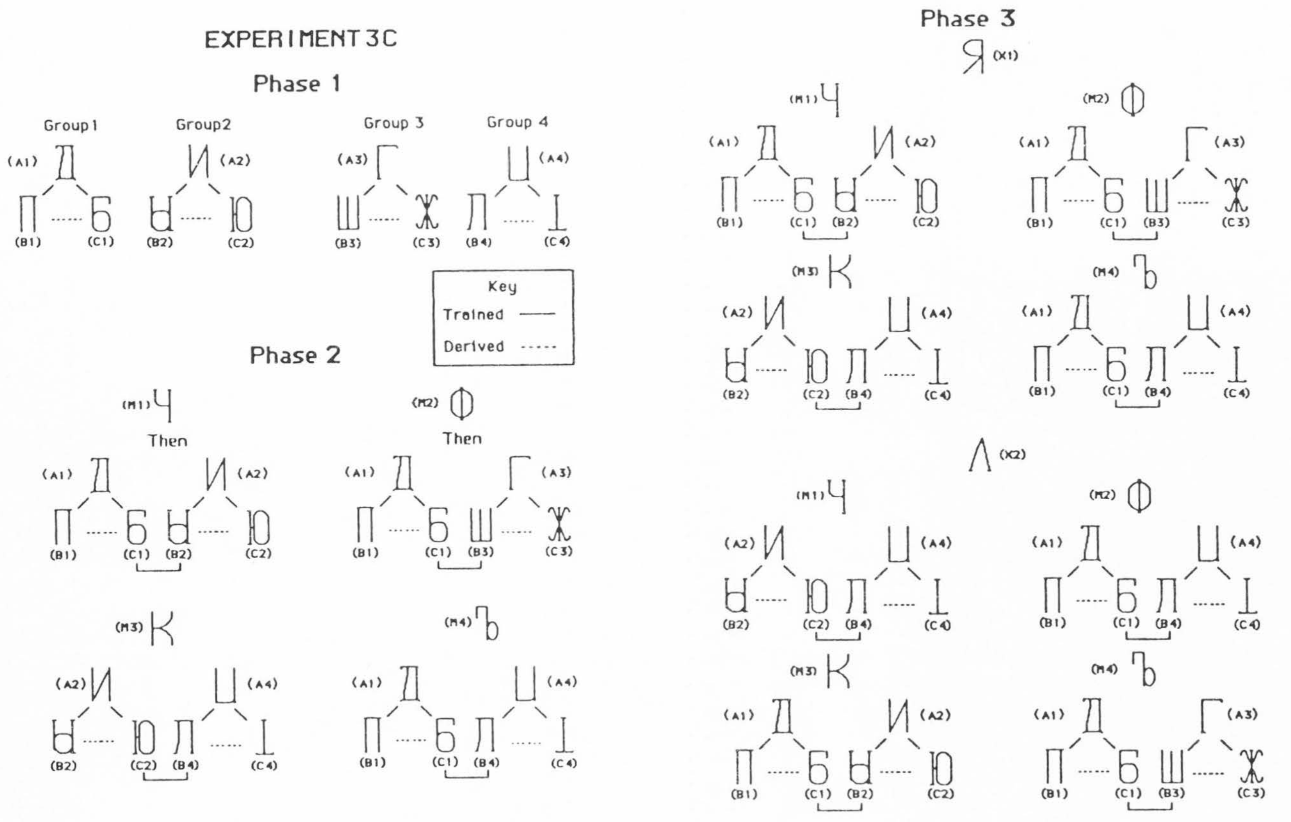


Figure 13. Control of the organization of three-member into six-member classes by fifth- and sixth-term stimuli in Experiment 3C.

classes at Utah State University. Two subjects were recruited from the psychology statistics class, and one was recruited from the human adjustment course. Two subjects were females aged 21 and 29, and one subject was a male aged 30. They were given class points for participation, and received a bonus for completing the research.

Apparatus

The apparatus was the same as that used for Experiment 3A.

Procedures

Phase 1. The same general procedures as followed in Experiment 3B were used. Phase 1 procedures directly replicated those in Experiment 3B.

Phase 2. In Training 2, the subjects were trained to relate stimuli from Group 1 to stimuli in Group 2 in the presence of M1, and to relate Group 1 to Group 3 in the presence of M2. Training trial types are depicted in Table 27. Test A then appraised the existence of derived relations. All possible connections between the two groups were examined, including those which were trained. Trial types are shown in Table 28. Tests were conducted until criterion was reached, or for four sessions if performance remained below criterion, and no improvement was evident.

In Training 3, the subjects learned to connect Group 2 with Group 4 when M3 was present, and to connect Group 1 with Group 4 when M4 was present. Training trial types are shown in Table 27. Test B examined whether a six-member class was formed under the control of each of the two contextual stimuli. Trial types are shown in Table 29. One

Table 27

Training Trial Types for Experiment 3C Phase 2

Training 2

1.	M1		2.	M1		3.	M1		4.	M1		5.	M1	
	A1			A1			A2			A2			B2	
B1	Co-	Co-	C1	Co-	Co-	B2	Co-	Co-	C2	Co-	Co-	C1	Co-	Co-
6.	M1		7.	M1		8.	M1		9.	M1		10.	M1	
	B1			C1			B2			C2			C1	
A1	Co-	Co-	A1	Co-	Co-	A2	Co-	Co-	A2	Co-	Co-	B2	Co-	Co-

(Co- = A3, B3, C3, A4, B4, C4)

11.	M2		12.	M2		13.	M2		14.	M2		15.	M2	
	A1			A1			A3			A3			B3	
B1	Co-	Co-	C1	Co-	Co-	B3	Co-	Co-	C3	Co-	Co-	C1	Co-	Co-
16.	M2		17.	M2		18.	M2		19.	M2		20.	M2	
	B1			C1			B3			C3			C1	
A1	Co-	Co-	A1	Co-	Co-	A3	Co-	Co-	A3	Co-	Co-	B3	Co-	Co-

(Co- = A2, B2, C2, A4, B4, C4)

Training 3.

1.	M3		2.	M3		3.	M3		4.	M3		5.	M3	
	A2			A2			A4			A4			B4	
B2	Co-	Co-	C2	Co-	Co-	B4	Co-	Co-	C4	Co-	Co-	C2	Co-	Co-
6.	M3		7.	M3		8.	M3		9.	M3		10.	M3	
	B2			C2			B4			C4			C2	
A2	Co-	Co-	A2	Co-	Co-	A4	Co-	Co-	A4	Co-	Co-	B4	Co-	Co-

(Co- = A1, B1, C1, A3, B3, C3)

11.	M4		12.	M4		13.	M4		14.	M4		15.	M4	
	A1			A1			A4			A4			B4	
B1	Co-	Co-	C1	Co-	Co-	B4	Co-	Co-	C4	Co-	Co-	C1	Co-	Co-
16.	M4		17.	M4		18.	M4		19.	M4		20.	M4	
	B1			C1			B4			C4			C1	
A1	Co-	Co-	A1	Co-	Co-	A4	Co-	Co-	A4	Co-	Co-	B4	Co-	Co-

(Co- = A2, B2, C2, A3, B3, C3)

Table 28

Test A Trial Types for Experiment 3C Phase 2

1. M1	2. M1	3. M1	4. M1	5. M1	6. M1
A1	A1	A1	B1	B1	B1
A2 Co- Co-	B2 Co- Co-	C2 Co- Co-	A2 Co- Co-	B2 Co- Co-	C2 Co- Co-
7. M1	8. M1	9. M1	10. M1	11. M1	12. M1
C1	C1	C1	A2	B2	C2
A2 Co- Co-	B2 Co- Co-	C2 Co- Co-	A1 Co- Co-	A1 Co- Co-	A1 Co- Co-
13. M1	14. M1	15. M1	16. M1	17. M1	18. M1
A2	B2	C2	A2	B2	C2
B1 Co- Co-	B1 Co- Co-	B1 Co- Co-	C1 Co- Co-	C1 Co- Co-	C1 Co- Co-

(Co- = A3, B3, C3, A4, B4, C4)

19. M2	20. M2	21. M2	22. M2	23. M2	24. M2
A1	A1	A1	B1	B1	B1
A3 Co- Co-	B3 Co- Co-	C3 Co- Co-	A3 Co- Co-	B3 Co- Co-	C3 Co- Co-
25. M2	26. M2	27. M2	28. M2	29. M2	30. M2
C1	C1	C1	A3	B3	C3
A3 Co- Co-	B3 Co- Co-	C3 Co- Co-	A1 Co- Co-	A1 Co- Co-	A1 Co- Co-
31. M2	32. M2	33. M2	34. M2	35. M2	36. M2
A3	B3	C3	A3	B3	C3
B1 Co- Co-	B1 Co- Co-	B1 Co- Co-	C1 Co- Co-	C1 Co- Co-	C1 Co- Co-

(Co- = A2, B2, C2, A4, B4, C4)

Table 29

Test B Trial Types for Experiment 3C Phase 2

1. M3	2. M3	3. M3	4. M3	5. M3	6. M3
A2	A2	A2	B2	B2	B2
A4 Co- Co-	B4 Co- Co-	C4 Co- Co-	A4 Co- Co-	B4 Co- Co-	C4 Co- Co-
7. M3	8. M3	9. M3	10. M3	11. M3	12. M3
C2	C2	C2	A2	B2	C2
A4 Co- Co-	B4 Co- Co-	C4 Co- Co-	A4 Co- Co-	A4 Co- Co-	A4 Co- Co-
13. M3	14. M3	15. M3	16. M3	17. M3	18. M3
A2	B2	C2	A2	B2	C2
B4 Co- Co-	B4 Co- Co-	B4 Co- Co-	C4 Co- Co-	C4 Co- Co-	C4 Co- Co-

(Co- = A1, B1, C1, A3, B3, C3)

19. M4	20. M4	21. M4	22. M4	23. M4	24. M4
A1	A1	A1	B1	B1	B1
A4 Co- Co-	B4 Co- Co-	C4 Co- Co-	A4 Co- Co-	B4 Co- Co-	C4 Co- Co-
25. M4	26. M4	27. M4	28. M4	29. M4	30. M4
C1	C1	C1	A4	B4	C4
A4 Co- Co-	B4 Co- Co-	C4 Co- Co-	A1 Co- Co-	A1 Co- Co-	A1 Co- Co-
31. M4	32. M4	33. M4	34. M4	35. M4	36. M4
A4	B4	C4	A4	B4	C4
B1 Co- Co-	B1 Co- Co-	B1 Co- Co-	C1 Co- Co-	C1 Co- Co-	C1 Co- Co-

(Co- = A2, B2, C2, A3, B3, C3)

subject (S22) also received combined testing (AB) in which all four contextual stimuli were present in each session. S20 and S21 also participated in two sessions of Test B in which 50% of the trials were a baseline of Training 3 trials. No feedback was given on any trials.

Phase 3. One subject completed Phase 2 and participated in Phase 3. In the presence of one of two sixth-term stimuli, the subject was taught to group the three-member classes into six-member classes dependent on the nature of the sixth-term and fifth-term stimuli. The task is depicted in Figure 13. When X1 was present as a sixth-term stimulus, the contingencies taught in Phase 2 remained the same. However, when X2 was present, the groupings were altered. Group 2 went with Group 4 when M1 was present. Group 1 went with Group 4 when M2 was present. Groups 1 and 2 went together when M3 was present, and Groups 1 and 3 went together when M4 was present. Trial types are depicted in Table 30. Symmetrical relations were not trained.

Upon completion of training, tests were administered to test for the existence of six-member classes controlled by the higher-order stimuli. Test 1 examined those relations under the control of X1, and Test 2 examined those under the control of X2. In both tests, the possible derived relations were tested in one direction only. That is, if the relation A2-A4 was tested (in the presence of the appropriate higher-order stimuli), then its symmetrical counterpart A4-A2 was not. The symmetrical relations were omitted because of the restrictive number of relations to be tested and the finite capacity of subjects' patience. Individual trial types for Test 1 are depicted in Table 31, and individual trial types for Test 2 are depicted in Table 32.

Table 30

Training Trial Types for Experiment 3C Phase 3

1.	X1		2.	X1		3.	X1		4.	X1		5.	X1	
	M1			M1			M1			M1			M1	
	A1			A1			A2			A2			B2	
B1	Co-	Co-	C1	Co-	Co-	B2	Co-	Co-	C2	Co-	Co-	C1	Co-	Co-

(Co- = A3, B3, C3, A4, B4, C4)

6.	X1		7.	X1		8.	X1		9.	X1		10.	X1	
	M2			M2			M2			M2			M2	
	A1			A1			A3			A3			B3	
B1	Co-	Co-	C1	Co-	Co-	B3	Co-	Co-	C3	Co-	Co-	C1	Co-	Co-

(Co- = A2, B2, C2, A4, B4, C4)

11.	X1		12.	X1		13.	X1		14.	X1		15.	X1	
	M3			M3			M3			M3			M3	
	A2			A2			A4			A4			B4	
B2	Co-	Co-	C2	Co-	Co-	B4	Co-	Co-	C4	Co-	Co-	C2	Co-	Co-

(Co- = A1, B1, C1, A3, B3, C3)

16.	X1		17.	X1		18.	X1		19.	X1		20.	X1	
	M4			M4			M4			M4			M4	
	A1			A1			A4			A4			B4	
B1	Co-	Co-	C1	Co-	Co-	B4	Co-	Co-	C4	Co-	Co-	C1	Co-	Co-

(Co- = A2, B2, C2, A3, B3, C3)

21.	X2		22.	X2		23.	X2		24.	X2		25.	X2	
	M1			M1			M1			M1			M1	
	A2			A2			A4			A4			B4	
B2	Co-	Co-	C2	Co-	Co-	B4	Co-	Co-	C4	Co-	Co-	C2	Co-	Co-

(Co- = A1, B1, C1, A3, B3, C3)

26.	X2		22.	X2		28.	X2		29.	X2		30.	X2	
	M2			M2			M2			M2			M2	
	A1			A1			A4			A4			B4	
B1	Co-	Co-	C1	Co-	Co-	B4	Co-	Co-	C4	Co-	Co-	C1	Co-	Co-

(Co- = A2, B2, C2, A3, B3, C3)

31.	X2		32.	X2		33.	X2		34.	X2		35.	X2	
	M3			M3			M3			M3			M3	
	A1			A1			A2			A2			B2	
B1	Co-	Co-	C1	Co-	Co-	B2	Co-	Co-	C2	Co-	Co-	C1	Co-	Co-

(Co- = A3, B3, C3, A4, B4, C4)

36.	X2		37.	X2		38.	X2		39.	X2		40.	X2	
	M4			M4			M4			M4			M4	
	A1			A1			A3			A3			B3	
B1	Co-	Co-	C1	Co-	Co-	B3	Co-	Co-	C3	Co-	Co-	C1	Co-	Co-

(Co- = A2, B2, C2, A4, B4, C4)

Table 31

Test 1 Trial Types for Experiment 3C Phase 3

1. X1 M1 A2	2. X1 M1 A2	3. X1 M1 A2	4. X1 M1 B2	5. X1 M1 B2	6. X1 M1 B2
A1 Co- Co-	B1 Co- Co-	C1 Co- Co-	A1 Co- Co-	B1 Co- Co-	C1 Co- Co-
7. X1 M1 C2	8. X1 M1 C2	9. X1 M1 C2	10. X1 M1 A3	11. X1 M1 A3	12. X1 M1 A3
A1 Co- Co-	B1 Co- Co-	C1 Co- Co-	A1 Co- Co-	B1 Co- Co-	C1 Co- Co-
13. X1 M1 B3	14. X1 M1 B3	15. X1 M1 B3	16. X1 M1 C3	17. X1 M1 C3	18. X1 M1 C3
A1 Co- Co-	B1 Co- Co-	C1 Co- Co-	A1 Co- Co-	B1 Co- Co-	C1 Co- Co-
19. X1 M3 A4	20. X1 M3 A4	21. X1 M3 A4	22. X1 M3 B4	23. X1 M3 B4	24. X1 M3 B4
A2 Co- Co-	B2 Co- Co-	C2 Co- Co-	A2 Co- Co-	B2 Co- Co-	C2 Co- Co-
25. X1 M3 C4	26. X1 M3 C4	27. X1 M3 C4	28. X1 M4 A4	29. X1 M4 A4	30. X1 M4 A4
A2 Co- Co-	B2 Co- Co-	C2 Co- Co-	A1 Co- Co-	B1 Co- Co-	C1 Co- Co-
31. X1 M4 B4	32. X1 M4 B4	33. X1 M4 B4	34. X1 M4 C4	35. X1 M4 C4	36. X1 M4 C4
A1 Co- Co-	B1 Co- Co-	C1 Co- Co-	A1 Co- Co-	B1 Co- Co-	C1 Co- Co-

(Co- for trial types 1- 9 = A3, B3, C3, A4, B4, C4
(Co- for trial types 10-18 = A2, B2, C2, A4, B4, C4
(Co- for trial types 19-27 = A1, B1, C1, A3, B3, C3
(Co- for trial types 28-36 = A2, B2, C2, A3, B3, C3

Table 32

Test 2 Trial Types for Experiment 3C Phase 3

1. X2	2. X2	3. X2	4. X2	5. X2	6. X2
M1	M1	M1	M1	M1	M1
A4	A4	A4	B4	B4	B4
A2 Co- Co-	B2 Co- Co-	C2 Co- Co-	A2 Co- Co-	B2 Co- Co-	C2 Co- Co-
7. X2	8. X2	9. X2	10. X2	11. X2	12. X2
M1	M1	M1	M2	M2	M2
C4	C4	C4	A4	A4	A4
A2 Co- Co-	B2 Co- Co-	C2 Co- Co-	A1 Co- Co-	A1 Co- Co-	A1 Co- Co-
13. X2	14. X2	15. X2	16. X2	17. X2	18. X2
M2	M2	M2	M2	M2	M2
B4	B4	B4	C4	C4	C4
B1 Co- Co-	B1 Co- Co-	B1 Co- Co-	C1 Co- Co-	C1 Co- Co-	C1 Co- Co-
19. X2	20. X2	21. X2	22. X2	23. X2	24. X2
M3	M3	M3	M3	M3	M3
A2	A2	A2	B2	B2	B2
A1 Co- Co-	B1 Co- Co-	C1 Co- Co-	A1 Co- Co-	B1 Co- Co-	C1 Co- Co-
25. X2	26. X2	27. X2	28. X2	29. X2	30. X2
M3	M3	M3	M4	M4	M4
C2	C2	C2	A3	A3	A3
A1 Co- Co-	B1 Co- Co-	C1 Co- Co-	A3 Co- Co-	B3 Co- Co-	C3 Co- Co-
31. X2	32. X2	33. X2	34. X2	35. X2	36. X2
M4	M4	M4	M4	M4	M4
B3	B3	B3	C3	C3	C3
A1 Co- Co-	B1 Co- Co-	C1 Co- Co-	A1 Co- Co-	B1 Co- Co-	C1 Co- Co-

(Co- for trial types 1- 9 = A1, B1, C1, A3, B3, C3
(Co- for trial types 10-18 = A2, B2, C2, A3, B3, C3
(Co- for trial types 19-27 = A3, B3, C3, A4, B4, C4
(Co- for trial types 28-36 = A2, B2, C2, A4, B4, C4

Results

Phase 1

Figure 14 illustrates overall performance on each session for each subject. S20 learned the task in eight sessions. His performance steadily increased from 37.5% to 100% correct. S21 learned the task in four sessions, and S22 learned the task in three. S20 demonstrated symmetry in three sessions. S21 and S22 both demonstrated symmetry upon testing. S21 took three sessions to reach criterion on transitivity, while S20 and S22 both demonstrated transitivity upon testing.

Phase 2

S20 took five sessions to reach criterion on the training task. His performance dropped after one session of 95% accuracy, and then increased to 100%. S21 took six sessions to reach criterion. S22 reached criterion in two sessions. On four sessions of Test A, S20 scored between 41.7% and 65.3% correct. S21 ranged between 34.7% and 59.7% correct on Test A. S22 demonstrated criterion performance on Test A upon testing.

A closer look at the performance of S20 and S21 indicates that their responding was controlled to some degree by familiarity (see Table 33). S20 had a marked tendency to choose stimuli from Group 1 and Group 2 together regardless of the contextual stimulus present. When M1 was present, he chose stimuli from Group 2 given stimuli from Group 1 65 times of 72, and chose stimuli from Group 1 45 of 72 times when stimuli from Group 2 served as the sample. When M2 was present,

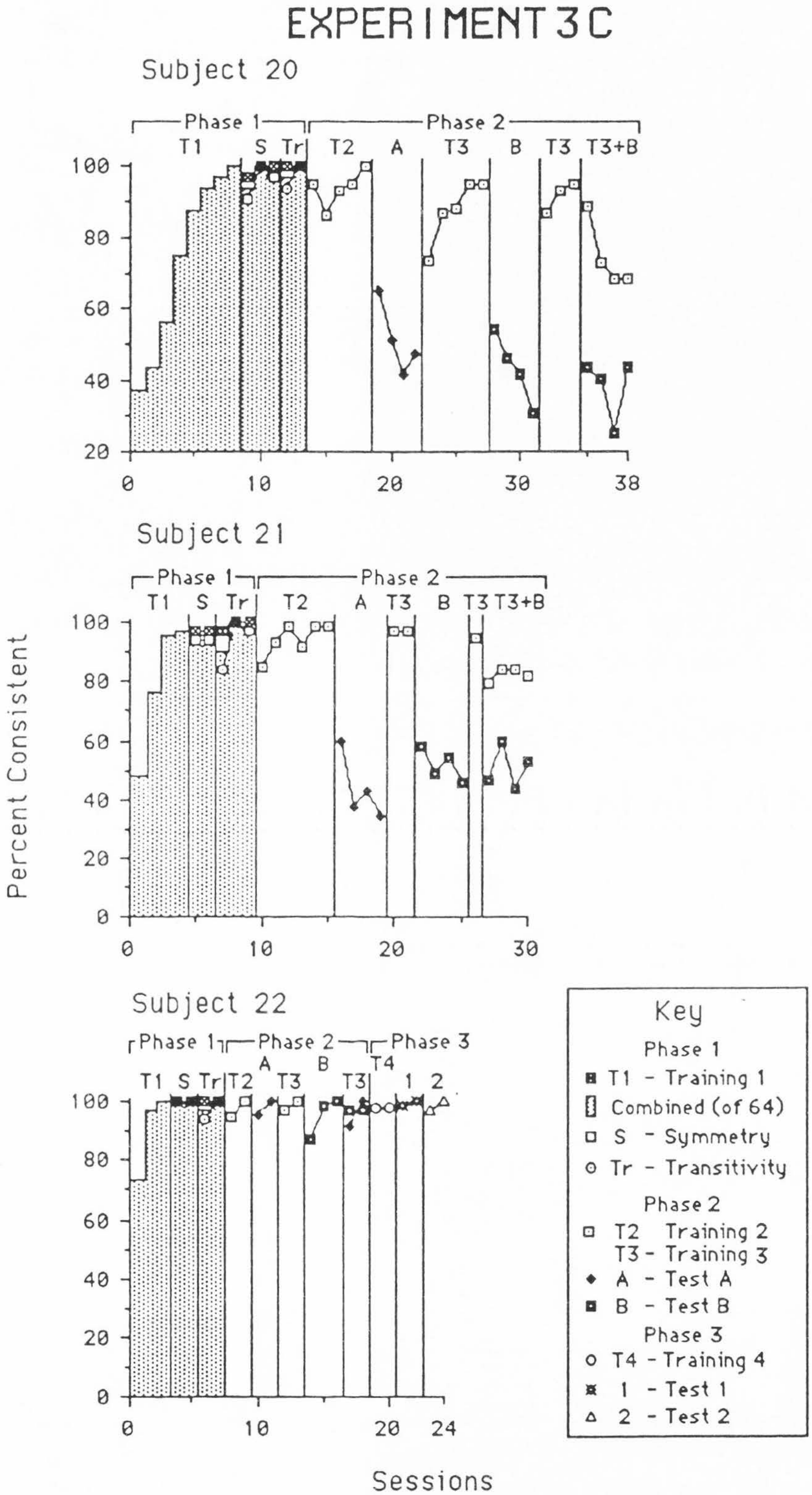


Figure 14. Percentage of correct responses for each session and phase of Experiment 3C .

Table 33

Number of Responses by S20 and S21 to Each Group for Each Contextual Stimulus in Both Directions

Test A

	M1						M2					
	(Group 1-Group 2)			(Group 2-Group 1)			(Group 1-Group 3)			(Group 3-Group 1)		
Group:	2	3	4	1	3	4	3	2	4	1	2	4
S20	65	5	2	45	22	5	14	49	9	23	29	20
S21	28	29	15	37	22	13	27	29	16	35	26	11

Test B

	M3						M4					
	(Group 2-Group 4)			(Group 4-Group 2)			(Group 1-Group 4)			(Group 4-Group 1)		
Group:	4	1	3	2	1	3	4	2	3	1	2	3
S20	25	46	1	13	58	1	41	25	6	44	26	2
S21	26	41	5	29	39	4	46	24	2	48	21	3

Test B with Baseline

	M3						M4					
	(Group 2-Group 4)			(Group 4-Group 2)			(Group 1-Group 4)			(Group 4-Group 1)		
Group:	4	1	3	2	1	3	4	2	3	1	2	3
S20	15	21	0	10	26	0	9	27	0	20	16	0
S21	14	18	4	4	29	3	27	9	0	30	5	1

* (e.g., Group 1 as sample and Group 2 as correct comparison and Group 2 as sample and Group 1 as correct comparison). Number of responses in each cell (Context by Sample/Comparison by Subject) should total 72 for Test A and Test B, and should total 36 for Test B with baseline. The first column for each task gives number of responses to the Group that was considered correct for that task. The second two columns give the number of responses to groups that were incorrect.

he still related Group 2 to Group 1 49 of 72 times, and when stimuli from Group 3 served as samples, his behavior was close to random.

S21 demonstrated a slight tendency to choose stimuli from Group 1, 37/72 when M1 was present, and 35/72 when M2 was present. She also had a tendency to respond away from stimuli from Group 4, which never served as correct comparisons. She typically chose Group 4 stimuli one half to one third as often as stimuli from the other groups.

On Training 3, S20 took five sessions to reach criterion. His scores ranged from 73.3% to 95% correct. S21 and S22 both reached criterion on Training 3 in two sessions. S22 demonstrated criterion performance on Test B upon testing. S20 scored between 30.6% and 54.2% correct on Test B. He received three additional sessions of Training 3. His performance dropped to 86.7% correct on the first session, and increased to 95% correct. On four sessions of Test B with baseline added, he scored between 68.2% and 88.6% correct on the training baseline trials and between 25% and 43.8% correct on the Test B trials. S21 scored between 45.8% and 58.3% correct on Test B. Her performance was at 95% on a session of Training 3. She performed between 79.5% and 84.1% correct on baseline trials and between 43.8% and 59.4% correct on four sessions of Test B with baseline.

Number of responses to each Group for Test B and Test B with baseline for S20 and S21 are depicted in Table 33. Both subjects again demonstrated a marked tendency to choose stimuli from Groups 1 or 2 regardless of the contextual stimulus. When stimuli from Group 2 were samples and Group 4 were correct comparisons, S20 chose Group 1 stimuli 46/72 times and S21 chose Group 1 stimuli 41/72 times. On the symmetrical task, S20 chose from Group 2 58/72 times, and S21 chose from Group 2 39/72 times. Likewise, when Group 4 stimuli were samples and Group 1 stimuli were correct comparisons, S20 chose Group 1 44/72 times and S21 chose Group 1 48/72 times. The most notable exception is that both subjects tended to choose stimuli from Group 4 when M4 was present. S20 chose Group 4 stimuli 41/72 times and S21 chose Group 4 stimuli 46/72 times.

During Test B with baseline, selections of Group 3 dropped nearly to zero for S21 and completely to zero for S20. The bias for Group 1 weakened when Group 2 stimuli were samples. S20 selected from Group 1 only 21/36 times, and S21 only 18/36 times. When Group 1 stimuli were samples, the bias of S20 for Group 4 over Group 2 switched, and he chose Group 2 stimuli 27/36 times.

Phase 3

S22 reached criterion on the sixth-term training task in two sessions. She then demonstrated control of the six-member classes by sixth-term contextual stimuli upon testing.

Debriefing

Each of the subjects was debriefed when the experiment was completed. All subjects were able to describe the relations learned in Phase 1. S20 and S21 both indicated that there were no consistently correct answers to the Phase 2 relations. S22 was able to describe the relations in the experiment in detail without the need of the stimulus list. She reported that she noticed that the three-member classes always stayed together, and only had to learn the new connecting relations on each new training task. She noted that there were four new rules for each training task (which corresponded to the four different connecting relations which were trained). She reported that she struggled at first, but then devised mnemonics (her word) to help remember. She named each stimulus and devised a verbal phrase which summarized the relations, for example, "Arby's 10 to 6". "R" was her name for X1, "B" was her name for M1, "10" for B2 and "6" for C1 (hence R-B-10-6). This phrase accurately describes the upper left connecting relation in Phase 3 of Figure 13. She reported that since she knew the three-member classes always went together, she could extend the rule to all stimuli which were related to the stimuli in her rule.

Discussion

Three subjects learned to group twelve stimuli into four groups of three. They were then taught to relate stimuli from one three-member class to another three-member class in the presence of a contextual stimulus. Two of the three subjects did not demonstrate the formation of six-member classes upon testing. One subject, S22, performed each task at criterion in the minimum possible time with the exception of the initial training. She demonstrated the formation of six-member classes contingent upon the contextual stimuli. She also demonstrated sixth-term control of the six-member classes after training on a six-term task.

The three subjects had much less difficulty with the task in Phase 1 than did the subjects in Experiment 3A. The earlier difficulties were probably due to individual differences between the subjects and fewer difficulties with the programs and equipment, rather than an inherent weakness with stimulus equivalence procedures.

The failure of S20 and S21 to form contextually controlled six-member classes indicates that overlapping rather than number of contextual stimuli or other sources of "information overload" is the source of interference in Experiment 3A. Both subjects responded primarily to familiarity. Stimuli from Group 1 were chosen most often, and they were the most frequently shown in training. In Training 2, Group 1 stimuli were samples or correct comparisons in 100% of the trials. Group 2 and Group 3 stimuli were samples or correct comparisons on 50% of the trials, and Group 4 stimuli were never samples or correct comparisons. On Test A, S20 appeared to relate Groups 1 and 2 independent of context, and his performance was random when Group 3 served as samples. The connection of Groups 1 and 2 seemed to pre-empt any connection of Group 1 to Group 3. S21 however, indicated very little preference for Group 2 or Group 3 stimuli, as expected if control was by familiarity. Both subjects chose Group 4 stimuli much less often than stimuli from other groups.

On Training 3, Group 1 and Group 2 stimuli were samples or correct comparisons on 50% of the trials, Group 4 stimuli on 100% of trials, and Group 3 stimuli were never samples or correct comparisons. Both subjects exhibited a marked preference for stimuli from Group 1, which was the most common across both training situations. The degree of preference for Groups 3 and 4 switched. Group 3 stimuli were rarely chosen, and Group 4 more often, particularly when Group 1 stimuli were samples. When baseline trials were added to testing, responses to Group 3 nearly disappeared, perhaps because of the absence of Group 3 stimuli as part of a correct relation. S20 switched back to connecting Groups 1 and 2 when Group 1 stimuli were samples. Why this occurred is

Groups 1 and 2 when Group 1 stimuli were samples. Why this occurred is unknown.

S22 succeeded in demonstrating all the relations and did so in very nearly the minimum possible number of sessions. She said several times throughout the debriefing that she could not have possibly performed the task without the names and rules. Apparently, S22 was able to perform a confusing task because of the use of a self-generated rule.

Experiments 3A, 3B, and 3C resolve a methodological difficulty of Experiments 1A, 1B, and 2. In those experiments, only three-member classes were divided. Since there was an odd number in each class, two stimuli were always related regardless of the higher-order stimuli. Even though 6 of 7 subjects in Experiments 1B and 2 did not take advantage of the consistent pairing, the potential remained. In Experiments 3A, 3B, and 3C, stimulus Groups were intentionally left separate, and the interactions between Groups were noted. In Experiments 3A, 3B, and 3C, the two incorrect comparisons were always from different three-member classes, and so exclusion of paired relations could not occur.

Data from Experiments 3A, 3B, and 3C do indicate that subjects tended to learn the relations for each level over again, and did not keep the three-member classes together without specific training. An example is the need to train the relations of the three-member classes along with the relations that connected the classes. S22 of Experiment 3C was the sole exception, and she used verbal rules to maintain the three-member classes as integral.

A related problem of the prior experiments was that all three members of the incorrect stimulus class could serve as incorrect comparisons. Since one member (A1 or A2) always served as the sample stimulus, it never served as a correct comparison, and therefore could be excluded as a possibility when it appeared as an incorrect comparion. The same problem occurred during Experiments 3A, 3B, and 3C. The difference between these experiments and the prior experiments is that Experiments 3A, 3B, and 3C utilized four three-member classes rather than two. No evidence of exclusion of A1, A2, A3, or A4 can be found in frequency of choices of each stimulus when a comparison (see Appendix D).

EXPERIMENT 4A

Experiments 1A, 1B, and 2 demonstrated that contextual stimuli can control formation of stimulus classes. Experiments 3A, 3B, and 3C demonstrated that other contextual factors such as incorrect comparisons and the other learned relations can affect how subjects classify sets of stimuli. In Experiment 4A, the purpose was to establish contextual control over the type of matching task, whether identity, oddity, or arbitrary. The kind of task to which a subject has been exposed may effect the way in which the subject may treat the conditional relations. Identity and oddity matching to sample may produce a bias of responding towards or away from a particular stimulus, while arbitrary matching to sample may produce a bias of grouping topographically dissimilar stimuli into groups. In this experiment, contextual control over different types of matching tasks is established to demonstrate that the responses characteristic to the particular tasks can be turned on and off with contextual stimuli. Then subjects will be exposed to groups of novel trial types in which the stimulus configurations are identical except for the contextual stimulus. If the subjects choose the comparisons based on the contextual stimulus, evidence will be provided that the type of task can serve as a context for determining whether and how people classify stimuli.

Method

Subjects

One subject was recruited from the undergraduate introductory psychology class, and one from the undergraduate behavior modification class at Utah State University. Both subjects were female. They were given class points for participating in the research, and bonus points were given for completing the experiment. Ages were not obtained from these subjects, but likely fell in the 18-24 year old range.

Apparatus

Apparatus was the same as in prior experiments.

Procedure

General Procedures. The same general procedures as in prior experiments were used with the following exceptions. Training sessions lasted for 60 trials and testing sessions lasted for 48 trials. Two to seven sessions for a total of 40-50 minutes each day were conducted two days a week. The three-comparison five-term task was used throughout the experiment.

Training. Training was comprised of three types of matching: identity matching, oddity matching, and stimulus equivalence via arbitrary matching (See Figure 15). A unique contextual stimulus was present during each type of matching. On Task 1, identity and oddity trials were mixed 50/50. Trial types for Task 1 are depicted in Table 34. Sessions continued until the subject performed at 95% (57/60) for two consecutive sessions. Upon completion of Task 1, each subject was presented with Task 2, which was an arbitrary-matching stimulus equivalence procedure. Each subject was taught four conditional relations: A1-B1, A1-C1, A2-B2, A2-C2. Individual trial types are

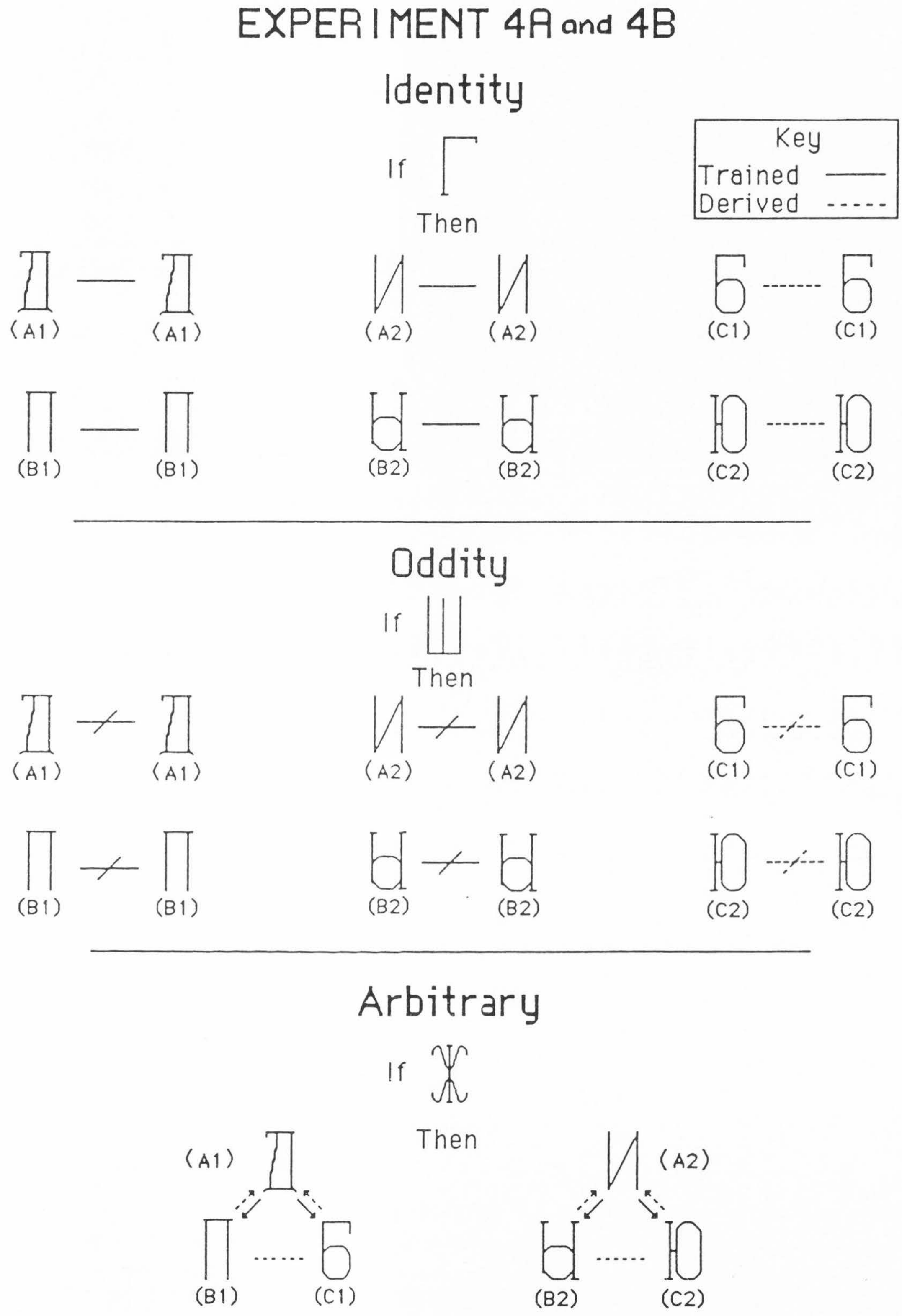


Figure 15. Control of matching performances by contextual stimuli in Experiments 4A and 4B.

Table 34

Trial Types for Experiment 4A Task 1

```
                              Identity
 1. X        2. X        3. X        4. X        5. X        6. X

   A1          A1          A1          A1          A1          A1
  /           /           /           /           /           /
A1 B1 A2    A1 B1 B2    A1 B1 C2    A1 C1 A2    A1 C1 B2    A1 C1 C2
--------------------------------------------------------------------
 7. X        8. X        9. X       10. X       11. X       12. X

   B1          B1          B1          B1          B1          B1
  /           /           /           /           /           /
B1 A1 A2    B1 A1 B2    B1 A1 C2    B1 C1 A2    B1 C1 B2    B1 C1 C2
--------------------------------------------------------------------
13. X       14. X       15. X       16. X       17. X       18. X

   A2          A2          A2          A2          A2          A2
  /           /           /           /           /           /
A2 B2 A1    A2 B2 B1    A2 B2 C1    A2 C2 A1    A2 C2 B1    A2 C2 C1
--------------------------------------------------------------------
19. X       20. X       21. X       22. X       23. X       24. X

   B2          B2          B2          B2          B2          B2
  /           /           /           /           /           /
B2 A2 A1    B2 A2 B1    B2 A2 C1    B2 C2 A1    B2 C2 B1    B2 C2 C1

                              Oddity
 1. Y        2. Y        3. Y        4. Y        5. Y        6. Y

   A1          A1          A1          A1          A1          A1
   | \         | \         | \         | \         | \         | \
A1 B1 A2    A1 B1 B2    A1 B1 C2    A1 C1 A2    A1 C1 B2    A1 C1 C2
--------------------------------------------------------------------
 7. Y        8. Y        9. Y       10. Y       11. Y       12. Y

   B1          B1          B1          B1          B1          B1
   | \         | \         | \         | \         | \         | \
B1 A1 A2    B1 A1 B2    B1 A1 C2    B1 C1 A2    B1 C1 B2    B1 C1 C2
--------------------------------------------------------------------
13. Y       14. Y       15. Y       16. Y       17. Y       18. Y

   A2          A2          A2          A2          A2          A2
   | \         | \         | \         | \         | \         | \
A2 B2 A1    A2 B2 B1    A2 B2 C1    A2 C2 A1    A2 C2 B1    A2 C2 C1
--------------------------------------------------------------------
19. Y       20. Y       21. Y       22. Y       23. Y       24. Y

   B2          B2          B2          B2          B2          B2
   | \         | \         | \         | \         | \         | \
B2 A2 A1    B2 A2 B1    B2 A2 C1    B2 C2 A1    B2 C2 B1    B2 C2 C1
```

equivalence procedure. Each subject was taught four conditional relations: A1-B1, A1-C1, A2-B2, A2-C2. Individual trial types are depicted in Table 35. When the subject scored at least 57/60 for two consecutive sessions, testing began.

Table 35

<u>Trial Types for Experiment 4A Task 2</u>

Arbitrary Matching

1. Z	2. Z	3. Z	4. Z	5. Z	6. Z
A1	A1	A1	A1	A1	A1
A1 B1 A2	A1 B1 B2	A1 B1 C2	A1 C1 A2	A1 C1 B2	A1 C1 C2
7. Z	8. Z	9. Z	10. Z	11. Z	12. Z
A2	A2	A2	A2	A2	A2
A2 B2 A1	A2 B2 B1	A2 B2 C1	A2 C2 A1	A2 C2 B1	A2 C2 C1

<u>Testing</u>. Trial types are depicted in Table 36. On each trial, one comparison was identical to the sample, one was in the same experimenter-defined class as the sample, and one was a member of the other experimenter-defined class. No previously trained trial types were presented.

The contextual stimulus which signalled identity-matching (X) was present during 25% of the trials. During those trials, the sample was either C1 or C2, and responses were considered correct if the subject chose the identical comparison (generalized identity-matching).

The contextual stimulus which signalled oddity-matching (Y) was present during another 25% of the trials. Again, the sample was either C1 or C2, but the responses were considered correct if the subject

Table 36

Testing Trial Types for Experiment 4A

```
                              Identity

 1. X       2. X       3. X       4. X       5. X       6. X
    C1         C1         C1         C1         C1         C1
   /          /          /          /          /          /
 C1 A1 A2   C1 A1 B2   C1 A1 C2   C1 B1 A2   C1 B1 B2   C1 B1 C2
-----------------------------------------------------------------
 7. X       8. X       9. X      10. X      11. X      12. X
    C2         C2         C2         C2         C2         C2
   /          /          /          /          /          /
 C2 A2 A1   C2 A2 B1   C2 A2 C1   C2 B2 A1   C2 B2 B1   C2 B2 C1

                               Oddity

13. Y      14. Y      15. Y      16. Y      17. Y      18. Y
    C1         C1         C1         C1         C1         C1
    | \        | \        | \        | \        | \        | \
 C1 A1 A2   C1 A1 B2   C1 A1 C2   C1 B1 A2   C1 B1 B2   C1 B1 C2
-----------------------------------------------------------------
19. Y      20. Y      21. Y      22. Y      23. Y      24. Y
    C2         C2         C2         C2         C2         C2
    | \        | \        | \        | \        | \        | \
 C2 A2 A1   C2 A2 B1   C2 A2 C1   C2 B2 A1   C2 B2 B1   C2 B2 C1

            Symmetry                     Transitivity

25. Z      26. Z      27. Z      28. Z      29. Z      30. Z
    C1         C1         C1         C1         C1         C1
    |          |          |          |          |          |
 C1 A1 A2   C1 A1 B2   C1 A1 C2   C1 B1 A2   C1 B1 B2   C1 B1 C2
-----------------------------------------------------------------
31. Z      32. Z      33. Z      34. Z      35. Z      36. Z
    C2         C2         C2         C2         C2         C2
    |          |          |          |          |          |
 C2 A2 A1   C2 A2 B1   C2 A2 C1   C2 B2 A1   C2 B2 B1   C2 B2 C1
-----------------------------------------------------------------
37. Z      38. Z      39. Z      40. Z      41. Z      42. Z
    B1         B1         B1         B1         B1         B1
    |          |          |          |          |          |
 C2 A2 A1   C2 A2 B1   C2 A2 C1   C2 B2 A1   C2 B2 B1   C2 B2 C1
-----------------------------------------------------------------
43. Z      44. Z      45. Z      46. Z      47. Z      48. Z
    B2         B2         B2         B2         B2         B2
    |          |          |          |          |          |
 C2 A2 A1   C2 A2 B1   C2 A2 C1   C2 B2 A1   C2 B2 B1   C2 B2 C1
```

The contextual stimulus which signalled arbitrary matching (Z) was present during the remaining 50% of the trials. Responses which demonstrated symmetry or transitivity were considered correct. Note that in 75% of the trial types, each configuration was identical except for the contextual stimulus, which was the only cue the subject had to indicate which kind of response to the sample (oddity, identity, or arbitrary) was required, and that generalization to new cases was required. Generalized identity-matching (reflexivity) was required when X was present, generalized oddity-matching when Y was present, and transitivity when Z was present. The remaining 25% of the trials tested for symmetry of the relations trained when Z was present. Testing was ended when the subject scored at least 46/48 for two consecutive sessions, or if performance did not change more than 2/48 over two sessions.

Results

Training

Overall performance on each session for both subjects is depicted in Figure 16. S23 performed at criterion on Task 1 in 12 sessions. On Task 2, identity performance fell to 70.8% and came to 100% in three sessions. Her performance on oddity fluctated greatly between 33.3% and 66.7%, while performance on arbitrary matching ranged from 50% to 75%. Performance on both oddity and arbitrary matching peaked between sessions 17 and 19, but then fell sharply. Two sessions of arbitrary matching alone increased performance to 86.7% and 95%. When returned

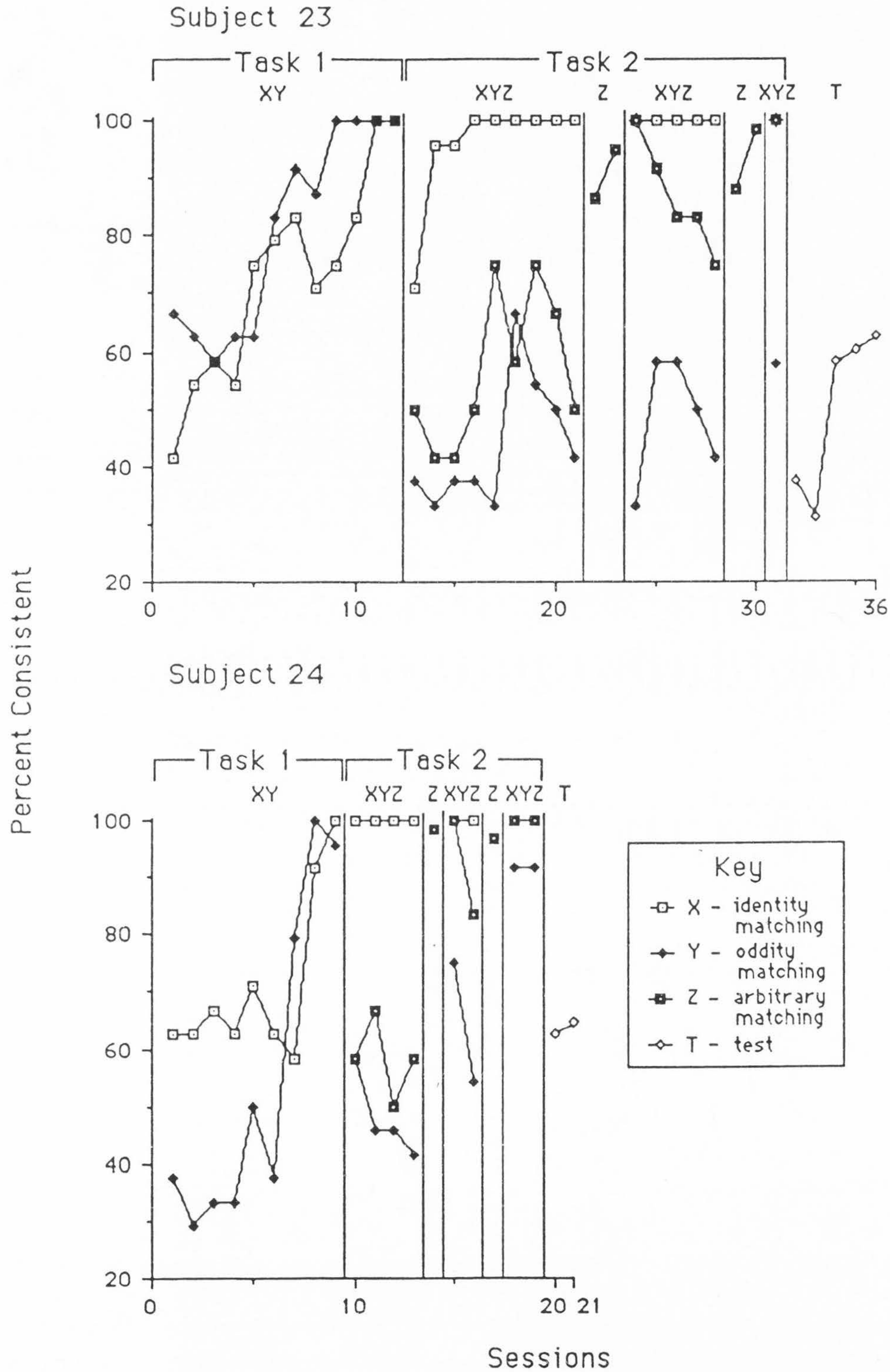


Figure 16. Percentage of correct reponses for each session and phase of Experiment 4A.

to Task 2, the performance of S23 on identity remained at 100%, while performance on arbitrary matching rapidly fell from 100% to 75%. Performance on oddity fluctuated between 33.3% and 58.3%. Two more sessions of arbitrary matching only produced scores of 88.3% and 98.3%. On a final session of Task 2, S23 performed at 100% on both identity and arbitrary matching and performed at 58.3% on oddity. Testing was begun before the performance on arbitrary matching could fall again.

S24 performed at criterion on Task 1 in 9 sessions. Her identity performance remained at 100%, while oddity performance declined from 58.3% to 41.7%. Performance on arbitrary matching varied between 50% and 66.7%. One session of arbitrary matching alone was presented and S2 scored 98.3%. When returned to Task 2, identity performance again remained at 100% while performance on oddity and arbitrary matching dropped sharply. Another session of arbitrary matching alone resulted in a score of 96.7%. On the return to Task 2 for two sessions, performance on both identity and arbitrary matching was at 100%, and performance on oddity was at 91.7%. Since the behavior seemed to be stable, testing was begun.

Testing

S23 scored 37.5% and 31.3% on the first two sessions of testing, and her scores then increased to between 58.3% and 62.5%. A closer look at the data reveals that performance on the first two testing sessions was largely random (See Table 37). The only consistent pattern seemed to be a bias towards responding towards identity regardless of the context present. Starting with Session 34, S23 consistently chose the identical comparison when the contextual

Table 37

Results on Generalization Test for S23*

11/15/88 - Session 32

Contextual Stimulus	X		Y		Z			
Sample Stimulus	C1	C2	C1	C2	C1	C2	B1	B2
Co:								
A1	1	2	2	1	2	1	2	1
A2	0	0	1	0	0	0	0	1
B1	1	2	3	2	0	2	3	0
B2	0	1	0	1	0	0	1	3
C1	2	1	0	2	3	1	0	1
C2	2	0	0	0	1	2	0	0

11/15/88 - Session 33

Contextual Stimulus	X		Y		Z			
Sample Stimulus	C1	C2	C1	C2	C1	C2	B1	B2
Co:								
A1	2	1	2	1	2	2	3	2
A2	1	0	1	0	0	0	1	0
B1	2	1	1	1	0	2	0	2
B2	1	2	1	2	1	0	1	0
C1	0	2	0	2	2	1	0	1
C2	0	0	1	0	1	1	1	1

11/15/88 - Session 34

Contextual Stimulus	X		Y		Z			
Sample Stimulus	C1	C2	C1	C2	C1	C2	B1	B2
Co:								
A1	0	0	3	1	0	1	2	0
A2	0	0	0	2	1	1	0	1
B1	0	0	3	2	0	1	3	2
B2	0	0	0	1	0	0	0	2
C1	6	0	0	0	4	2	0	1
C2	0	6	0	0	1	1	1	0

11/16/88 - Session 35

Contextual Stimulus	X		Y		Z			
Sample Stimulus	C1	C2	C1	C2	C1	C2	B1	B2
Co:								
A1	0	0	3	1	1	2	3	1
A2	0	0	0	0	0	1	0	0
B1	0	0	3	2	0	1	3	2
B2	0	0	0	2	1	0	0	2
C1	6	0	0	1	2	1	0	1
C2	0	6	0	0	2	1	0	0

11/16/88 - Session 35

Contextual Stimulus	X		Y		Z			
Sample Stimulus	C1	C2	C1	C2	C1	C2	B1	B2
Co:								
A1	0	0	3	1	2	2	3	1
A2	0	0	0	0	1	0	0	0
B1	0	0	3	1	0	2	2	2
B2	0	0	0	2	2	0	1	0
C1	6	0	0	2	1	2	0	2
C2	0	6	0	0	0	0	0	1

Ideal Performance

Contextual Stimulus	X		Y		Z			
Sample Stimulus	C1	C2	C1	C2	C1	C2	B1	B2
Co:								
A1	0	0	0	2	3	0	3	0
A2	0	0	2	0	0	3	0	3
B1	0	0	0	2	3	0	0	0
B2	0	0	2	0	0	3	0	0
C1	6	0	0	2	0	0	3	0
C2	0	6	2	0	0	0	0	3

* Number of times each comparison chosen in the presence of each sample stimulus and each contextual stimulus.

stimulus for identity (X) was present. S23 consistently demonstrated an equivalence class of A1-B1-C1 when the contextual stimulus (Y) for oddity was present and the sample was C1. However, when the sample was C2, she chose randomly among the nonidentical comparisons. S23 never chose an identical comparison when Y was present. When the contextual stimulus for arbitrary matching was present (Z) and the sample was B1, S23 16/18 times chose A1 or B1. Responses seemed to be mostly random when any other sample was present until the last session, when S23 consistently chose according to oddity given Z as context and C2 as sample.

S24 scored 62.5% and 64.6% on two sessions of testing. She responded according to identity when X was present, and according to oddity when Y was present, although she did have some trouble when Y and C1 were present on the first session (See Table 38). When Z was present, S24 nearly always chose correctly on symmetry trials, and nearly always chose the identical comparison on transitivity trials. She responded this way on 49/60 cases over the two sessions. The primary exception which accounts for 5 of the 11 deviations was that S2 chose the odd comparison when B1 was the sample on transitivity trials.

Following completion of the experiment, each subject was debriefed. Both subjects stated that they were to pick "the same" stimulus when X was present. Both subjects said that when Y was present, they were not to pick the comparison identical to the sample, but they were not sure on what basis to choose the correct comparison. Neither subject could describe the relations controlled by Z.

Table 38

Results on Generalization Test for S24*

10/19/89 - Session 20

	Contextual Stimulus X		Y		Z			
	Sample Stimulus C1	C2	C1	C2	C1	C2	B1	B2
Co:								
A1	0	0	2	2	3	1	3	1
A2	0	0	2	0	0	2	0	3
B1	0	0	1	2	0	0	1	0
B2	0	0	1	0	0	0	1	2
C1	6	0	0	2	3	1	0	0
C2	0	6	0	0	0	2	1	0

10/19/89 - Session 21

	Contextual Stimulus X		Y		Z			
	Sample Stimulus C1	C2	C1	C2	C1	C2	B1	B2
Co:								
A1	0	0	0	2	3	0	3	1
A2	0	0	2	0	0	3	1	3
B1	0	0	0	2	0	0	0	0
B2	0	0	2	0	1	0	1	2
C1	6	0	0	2	2	1	0	0
C2	0	6	2	0	0	2	1	0

*Number of times each comparison chosen in the presence of each sample stimulus and each contextual stimulus.

Discussion

An attempt was made to train two subjects to perform three different types of matching tasks based upon the presence of a contextual stimulus. Both subjects learned to perform identity matching, and one subject learned to perform oddity matching. While both subjects learned to perform arbitrary matching, neither demonstrated stimulus equivalence. On the portion of the test which examined equivalence, one subject (S24) responded correctly to symmetry trials but not transitivity trials, and one subject (S23) responded mostly randomly.

The lack of control may be traced to the training procedure. The training procedure was a three-comparison matching task. During oddity trials, two of the comparisons were correct and one was incorrect. The subjects reported being confused and unsure of what they were supposed to do on oddity trials. During the debriefing following the experiment, both subjects were surprised to hear that either stimulus was correct. They reported being distressed that they could not find **the** correct answer.

Both also had difficulty learning the arbitrary matching task, and required separate training. An examination of Figure 16 indicates that correct responding to oddity and arbitrary matching seemed to correspond in direction, though oddity performance was lower in all but one point. Stimulus equivalence may have been disrupted because the subjects were unsure of the role of incorrect comparisons, or because the confusion with oddity carried over into a confusion with excluding stimuli from a class. That is, B1 and C1 may go with A1, but that does not mean B2 and C2 do not. Similarly, if they were unsure about what constitutes a correct response besides identity, then they would have no reason to generalize any relations beyond the directly trained ones.

Speculation aside, the results indicate that once learned, identity is quite stable, and that oddity and arbitrary matching may interact. However, in order to demonstrate the desired results, the role of oddity training needs to be established before testing, and perhaps before equivalence training.

EXPERIMENT 4B

In Experiment 4A a number of difficulties were found. First, the subjects had difficulty learning the oddity task with three comparisons. There was no particular correct stimulus, although there was a particular incorrect stimulus. Either of the nonidentical stimuli were considered correct, and the subjects found the task confusing. Second, addition of the arbitrary matching disrupted oddity performance for both subjects. Third, the confusion between oddity and arbitrary matching probably led to the poor performance on the test sessions. In Experiment 4B, the subjects were taught each type of matching separately, in hopes of reducing confusion. Also, a two-comparison procedure was used with the oddity and the initial identity training in order to make the nature of the oddity task more clear.

Method

Subjects

Two subjects were recruited from the undergraduate statistics psychology class at Utah State University. One was a male aged 24 and one was a female aged 21. They were given class points for participating in the research, and bonus points were given for completing the experiment.

Apparatus

The same apparatus as in Experiment 4A was used.

Procedure

General Procedures. The same general procedures as in Experiment 4A were used with the following exceptions. The experimental tasks were presented in either two-comparison or three-comparison formats (See Figure 17). Tasks with two comparisons lasted for 40 trials, and tasks with three comparisons lasted for 48 trials. Two to seven sessions for a total of 40-50 minutes each day were conducted 2 days a week.

Training. Training involved the same types of procedures as in Experiment 4A. The primary difference was that the training was broken down into more tasks in Experiment 4B. Trial types for the first three tasks are depicted in Table 39. Task 1 was a two-comparison identity-matching task, in which the relations A1-A1, B1-B1, A2-A2, and B2-B2 were trained. Task 2 was a two-comparison oddity-matching task, in which the subject was trained to respond away from the comparison identical to the sample.

On Task 3, identity and oddity trials were mixed 50/50. A two-comparison task was used because of the difficulty inherent in training oddity using three-comparisons: two different and therefore correct answers are present. Due to the simplicity of the tasks, each task was presented until the subject was correct on at least 38/40 trials for one session.

Upon completion of the third task, each subject was presented with Task 4, which was a three-comparison identity-matching task. This step was taken so the subjects would not relate the identity-matching task to only two-comparison tasks. Tables 34 and 35 (Experiment 4A)

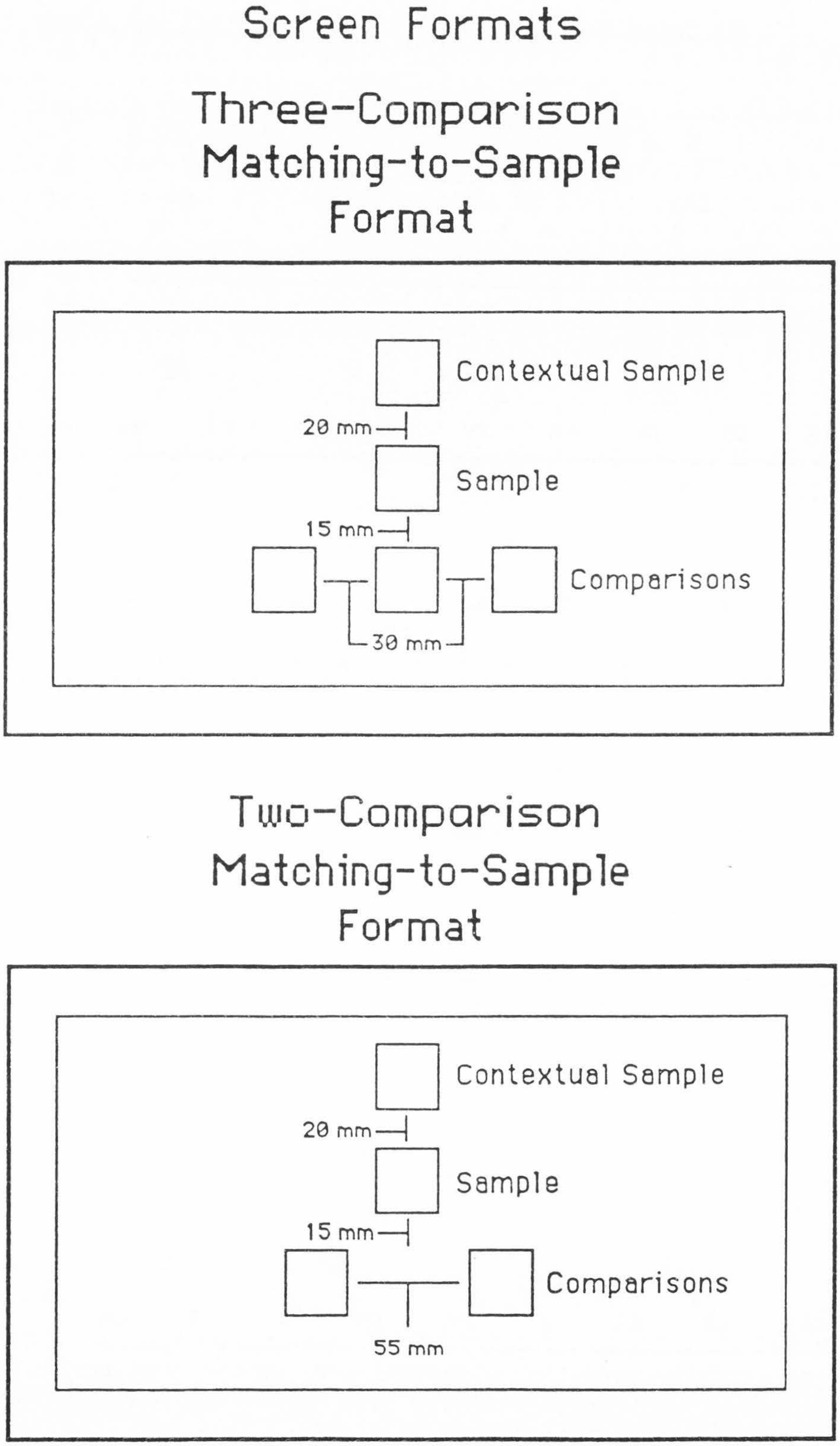


Figure 17. On-screen formats for the matching-to-sample tasks in Experiment 4B.

Table 39

<u>Trial Types for Two-Comparison Tasks on Experiment 4B</u>

Identity

1. X	2. X	3. X	4. X	5. X
A1	A1	A1	A1	A1
/	/	/	/	/
A1 B1	A1 C1	A1 A2	A1 B2	A1 C2
6. X	7. X	8. X	9. X	10. X
B1	B1	B1	B1	B1
/	/	/	/	/
B1 A1	B1 C1	B1 A2	B1 B2	B1 C2
11. X	12. X	13. X	14. X	15. X
A2	A2	A2	A2	A2
/	/	/	/	/
A2 A1	A2 B1	A2 C1	A2 B2	A2 C2
16. X	17. X	18. X	19. X	20. X
B2	B2	B2	B2	B2
/	/	/	/	/
B2 A1	B2 B1	B2 C1	B2 A2	B2 C2

Oddity

1. Y	2. Y	3. Y	4. Y	5. Y
A1	A1	A1	A1	A1
\	\	\	\	\
A1 B1	A1 C1	A1 A2	A1 B2	A1 C2
6. Y	7. Y	8. Y	9. Y	10. Y
B1	B1	B1	B1	B1
\	\	\	\	\
B1 A1	B1 C1	B1 A2	B1 B2	B1 C2
11. Y	12. Y	13. Y	14. Y	15. Y
A2	A2	A2	A2	A2
\	\	\	\	\
A2 A1	A2 B1	A2 C1	A2 B2	A2 C2
16. Y	17. Y	18. Y	19. Y	20. Y
B2	B2	B2	B2	B2
\	\	\	\	\
B2 A1	B2 B1	B2 C1	B2 A2	B2 C2

present individual trial types for Tasks 4, 5, and 6. When the subject completed two consecutive sessions of 46/48 correct, Task 5 was presented which was a three-comparison arbitrary matching procedure. Each subject was taught four conditional relations: A1-B1, A1-C1, A2-B2, A2-C2.

When the subject scored at least 46/48 for two sessions, the last training task (Task 6) began. The subjects were presented with a 50/50 mix of identity and arbitrary matching trials. Upon completion of two consecutive sessions of at least 46/48 correct, testing began.

Testing. The test was identical to that used in Experiment 4A. Testing was ended when the subject scored at least 46/48 for two consecutive sessions. Separate testing for symmetry and transitivity also occurred. Tests were comprised of 50% trained (Z) relations and 50% symmetrical or transitive relations. Trial types are shown in Table 40. Sessions were 48 trials long, and were repeated until at least two consecutive sessions of 46/48 correct occurred.

Results

Identity/Nonidentity Training

Performances across sessions for each subject are shown in Figure 18. Both subjects scored perfectly on the first session of identity (Task 1). They scored 39/40 on the first session of oddity (Task 2), both having missed the first trial in the session. S26 was presented one additional session each of Tasks 1 and 2 since she had not participated for five days. She scored at least 39/40 on both sessions and performed at criterion for the combined task in three sessions.

Table 40

Trial Types for the Separate Symmetry and Transitivity Tests on Experiment 4B

Symmetry

1. Z	2. Z	3. Z	4. Z	5. Z	6. Z
C1	C1	C1	C2	C2	C2
/	/	/	/	/	/
A1 C1 A2	A1 C1 B2	A1 C1 C2	A2 C2 A1	A2 C2 B1	A2 C2 C1
7. Z	8. Z	9. Z	10. Z	11. Z	12. Z
B1	B1	B1	B2	B2	B2
/	/	/	/	/	/
C1 B1 A2	C1 B1 B2	C1 B1 C2	C2 B2 A1	C2 B2 B1	C2 B2 C1

Transitivity

1. Z	2. Z	3. Z	4. Z	5. Z	6. Z
C1	C1	C1	C2	C2	C2
/	/	/	/	/	/
B1 C1 A2	B1 C1 B2	B1 C1 C2	B2 C2 A1	B2 C2 B1	B2 C2 C1
7. Z	8. Z	9. Z	10. Z	11. Z	12. Z
B1	B1	B1	B2	B2	B2
/	/	/	/	/	/
A1 B1 A2	A1 B1 B2	A1 B1 C2	A2 B2 A1	A2 B2 B1	A2 B2 C1

Training Baseline

1. Z	2. Z	3. Z	4. Z	5. Z	6. Z
A1	A1	A1	A1	A1	A1
/	/	/	/	/	/
B1 A1 A2	B1 A1 B2	B1 A1 C2	C1 A1 A2	C1 A1 B2	C1 A1 C2
7. Z	8. Z	9. Z	10. Z	11. Z	12. Z
A2	A2	A2	A2	A2	A2
/	/	/	/	/	/
B2 A2 A1	B2 A2 B1	B2 A2 C1	C2 A2 A1	C2 A2 B1	C2 A2 C1

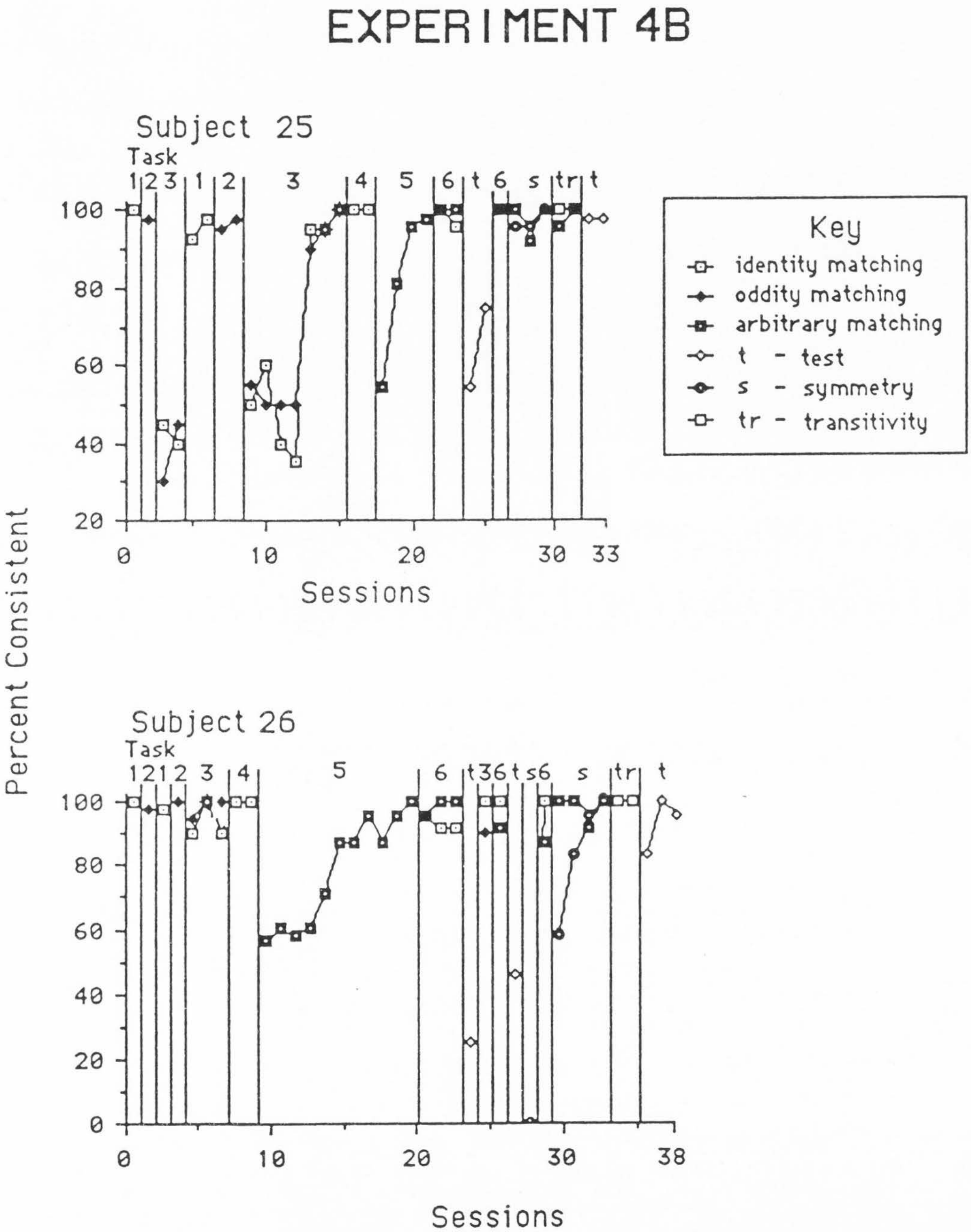


Figure 18. Percentage of correct responses for each session and phase of Experiment 4B.

She scored perfectly on two sessions of the three-comparison identity task (Task 3).

S25 performed poorly on the combined identity/oddity task (Task 3) with scores of 15/40 and 17/40. He was returned to Tasks 1 and 2, and demonstrated good performance on each. Four sessions of the combined task were presented, and he scored between 17/40 and 21/40, well within the chance levels of a two-comparison procedure of 50/50. On Session 13 a verbal prompt was used. He was questioned by the experimenter why his choice was correct or incorrect for the first three trials. On Trial 1 (Y-incorrect) he responded that he did not know.

On Trial 2 (X-correct) he responded that the correct comparison was the same as the sample. On Trial 3 (Y-incorrect) he did not respond, but immediately started the next trial. On Trial 4 (Y-correct) he responded that the correct comparison was different from the sample. He scored 37/40 on that session, and two of the errors were made on the first three trials. He missed two on the next session, and then scored perfectly on the last session of Task 3 and on two sessions of Task 4.

Arbitrary Matching Training

S25 performed at criterion (46/48) on arbitrary matching (Task 5) in four sessions, and scored at criterion in two sessions on the combined identity-arbitrary matching (Task 6). S26 scored between 27/48 and 29/48 for four sessions of Task 5. On the next day she came, the trial types were presented in blocks (all four of trial type 1, then all four of trial type 2, etc.) in the hope that doing so would make the tasks easier (Saunders & Spradlin, 1989). The location of the comparisons on the screen was still varied at random. Her score increased from 34/48 to 46/48 on the next four sessions. The order was then presented randomly, and she performed at criterion in three sessions. She scored 46/48 on two sessions of Task 6. She was given an additional session of Task 6 since she missed both instances of a trial type, and again scored 46/48.

Testing

Detailed results on the tests are depicted in Table 41 for S25 and Table 42 for S26. Both subjects experienced difficulty on the test. S25 scored 15/48 and 36/48, and S26 scored 12/48 and 22/48. S25 scored perfectly on identity trials, but did poorly on oddity and arbitrary matching trials. She was presented another session of Task 6 and scored perfectly.

S26 responded entirely to identity regardless of context. She was presented a session of the combined identity-oddity task and a session of the combined identity-arbitrary matching task. She performed at 38/40 on the first and 46/48 on the second. Another session of the test was presented, and she again scored perfectly on identity trials, but nearly randomly on the other trials.

The amount of generalization required was assumed to be too great, so the symmetry and transitivity trials were presented separately. S25 performed at criterion in three sessions on symmetry trials, and in two sessions on transitivity trials. S26 again responded entirely to identity when presented the symmetry trials. A

Table 41

Results on Generalization Test for S25

10/19/89 - Session 24

	Contextual Stimulus X		Y		Z			
	Sample Stimulus C1	C2	C1	C2	C1	C2	B1	B2
Co:								
A1	0	0	1	0	3	2	3	2
A2	0	0	2	3	0	0	0	0
B1	0	0	0	0	3	2	0	2
B2	0	0	1	3	0	1	0	0
C1	6	0	0	0	0	1	3	1
C2	0	6	2	0	0	0	0	1

10/19/89 - Session 25

	Contextual Stimulus X		Y		Z			
	Sample Stimulus C1	C2	C1	C2	C1	C2	B1	B2
Co:								
A1	0	0	2	1	3	0	3	0
A2	0	0	1	0	0	2	0	2
B1	0	0	2	2	3	1	2	1
B2	0	0	1	2	0	3	0	1
C1	6	0	0	1	0	0	1	0
C2	0	6	0	0	0	0	0	2

10/26/89 - Session 32

	Contextual Stimulus X		Y		Z			
	Sample Stimulus C1	C2	C1	C2	C1	C2	B1	B2
Co:								
A1	0	0	0	1	3	0	3	0
A2	0	0	2	0	0	3	0	3
B1	0	0	0	2	3	0	0	0
B2	0	0	2	0	0	3	0	0
C1	6	0	0	2	0	0	3	0
C2	0	6	2	1	0	0	0	3

10/26/89 - Session 33

	Contextual Stimulus X		Y		Z			
	Sample Stimulus C1	C2	C1	C2	C1	C2	B1	B2
Co:								
A1	0	0	0	2	3	0	3	0
A2	0	0	2	0	0	3	0	3
B1	0	0	0	2	3	0	0	0
B2	0	0	2	0	0	2	0	0
C1	6	0	0	2	0	1	3	0
C2	0	6	2	0	0	0	0	3

* Number of times each comparison chosen in the presence of each sample stimulus and each contextual stimulus.

Table 42

Results on Generalization Test for S26

10/19/89 - Session 24

	X		Y		Z			
	C1	C2	C1	C2	C1	C2	B1	B2
Co:								
A1	0	0	0	0	0	0	0	0
A2	0	0	0	0	0	0	0	0
B1	0	0	0	0	0	0	6	0
B2	0	0	1	0	0	0	0	5
C1	6	0	5	0	6	0	0	0
C2	0	6	0	6	0	6	0	1

(Contextual Stimulus: X, Y, Z; Sample Stimulus: C1 C2 C1 C2 C1 C2 B1 B2)

10/19/89 - Session 27

	X		Y		Z			
	C1	C2	C1	C2	C1	C2	B1	B2
Co:								
A1	0	0	0	1	1	1	1	1
A2	0	0	1	1	0	0	0	0
B1	0	0	1	2	2	1	2	1
B2	0	0	2	1	1	1	1	2
C1	6	0	0	1	1	1	1	1
C2	0	6	2	0	1	2	1	1

10/26/89 - Session 36

	X		Y		Z			
	C1	C2	C1	C2	C1	C2	B1	B2
Co:								
A1	1	0	1	0	3	0	2	0
A2	0	0	2	2	0	2	0	3
B1	0	0	0	0	3	1	0	0
B2	0	0	2	2	0	3	0	0
C1	5	0	0	2	0	0	3	0
C2	0	6	1	0	0	0	1	3

10/26/89 - Session 37

	X		Y		Z			
	C1	C2	C1	C2	C1	C2	B1	B2
Co:								
A1	0	0	0	2	3	0	3	0
A2	0	0	2	0	0	3	0	3
B1	0	0	0	2	3	0	0	0
B2	0	0	2	0	0	3	0	0
C1	6	0	0	2	0	0	3	0
C2	0	6	2	0	0	0	0	3

10/26/89 - Session 38

	X		Y		Z			
	C1	C2	C1	C2	C1	C2	B1	B2
Co:								
A1	0	0	0	2	3	0	3	0
A2	0	0	2	0	0	3	0	3
B1	0	0	0	2	3	0	0	1
B2	0	0	2	0	0	2	0	0
C1	6	0	0	2	0	1	3	0
C2	0	6	2	0	0	0	0	2

*Number of times each comparison chosen in the presence of each sample stimulus and each contextual stimulus.

session of Task 6 was presented, and then symmetry was retested. S26 scored at 45/48 on the training and came to criterion on symmetry in four sessions. She scored perfectly on two sessions of transitivity. The complete test was then readministered to both subjects. S25 made only one inconsistent response in the two sessions. S26 made 8 inconsistencies on the first session, none on the second, and two on the last.

During the debriefing, both subjects could state that X indicated that they were to pick the same stimulus as the sample. However, both had difficulty describing the relations under the control of Y and Z. When S25 was given the list of stimuli, he was able to show how they went together. S26 was also able to indicate what the contingencies were with the stimulus list, but was very slow and hesitant.

Discussion

Two subjects were trained to perform different types of matching tasks based on the presence of contextual stimuli. Identity and oddity matching generalized to novel stimuli, and arbitrary matching training resulted in the establishment of two three-member stimulus classes. The results provide support for the notion that contextual stimuli can control whether people will group stimuli into classes or not.

The subjects again had difficulty with the oddity task. S26 required an additional session of XY training after the first test, and reported that she had forgotten what the contextual stimulus Y signalled. S25 had difficulty when identity and oddity were combined in the same session. He was apparently not attending to the contextual stimulus, and was responding based on the feedback given for the last trial. If he was correct, then he responded in the same way on the next trial. If he was incorrect, he responded in the opposite way on the next trial.

S26 had difficulty with the arbitrary matching. The prior exposure to oddity and identity matching biased her to respond according to physical characteristics, which does not work on arbitrary matching. When the task was broken down into the individual trial types, and presented in blocks so that she received a number of corrections on the same trial type, she was able to learn the task.

On the test, the subjects were again unclear as to what to do. S26 demonstrated a response of choosing based on identity if unsure. On the premise that too much generalization was required, the test was broken down so that equivalence could be tested first. Both subjects demonstrated symmetry and transitivity. Upon return to the test, oddity performance improved when performance on symmetry and transitivity improved.

One difficulty with the training procedure is that C1 and C2 were used as comparisons in the identity and oddity training. Since neither C1 or C2 served as samples, trial types with C1 or C2 as comparisons were not conditional discriminations. What this means is that because C1 and C2 were never related to a stimulus, they were never correct comparisons, and subjects could have learned simply to choose away from them.

GENERAL DISCUSSION

Fifth-Term Control

Experiments 1A and 1B demonstrated that fifth-term control can be established, provided systematic replication of prior research on contextual control (e.g., Bush et al., 1989; Fucini, 1982; Hayes et al., in press; Kennedy & Laitinen, 1988; Lazar & Kotlarchyk, 1986; Serna 1987; Wulfert & Hayes, 1988), and demonstrated that the function of a contextual stimulus can be transferred to neutral stimuli via stimulus equivalence paradigm procedures (Hayes et al., in press; Lazar & Kotlarychk, 1986; Wulfert & Hayes, 1988). These experiments set the stage for further analysis of fifth-term control (Sidman, 1986) and its usefulness in predicting and controlling development of complex stimulus classes such as those found in language.

Classes of words used in natural settings are not usually simple, mutually exclusive groups of stimuli, but tend to overlap or "intersect" as in the metal/liquid example. The element "mercury" is a member of both the classes of liquids and of metals, but not all liquids are synonymous with all metals. Rarely are there single stimuli controlling natural language classes. For example, a child may have learned to differentiate between plants and animals and then learns that the words "beast" and "creature" are synonymous with the word, "animal". Greater efficiency results if the new words also control the stimuli in the subordinate class in the same manner as does the word, "animal". These results indicate the potential robustness of stimulus equivalence procedures for the description of the development of complex stimulus classes.

Transfer of Function

Transfer of various stimulus functions has been accomplished at least three times previously (i.e., Hayes et al., in press; Lazar & Kotlarychk, 1986; Sigurdardottir, Green, & Saunders, 1990; Wulfert & Hayes, 1988). In the Lazar and Kotlarchyk (1986) and Wulfert and Hayes (1988) studies, novel stimuli were made equivalent to a class of equivalent stimuli whose function was to determine the ordering of responses. The novel stimuli thereafter also controlled the ordering of responses. Sigurdardottir et al. (1990) extended the results of Lazar and Kotlarchyk (1986) by using a longer sequence, adding distractor stimuli, and carefully testing for equivalence based on order. In the Hayes et al. (in press) study, novel stimuli were made equivalent to stimuli that functioned as conditioned reinforcers or as discriminative stimuli. Thereafter, the novel stimuli also functioned as conditioned reinforcers or as discriminative stimuli.

In the present study, novel stimuli made equivalent to contextual stimuli thereafter controlled the conditional relations controlled by the contextual stimuli. In each of these experiments, stimuli that previously had no function were made functional via procedures that led to stimulus equivalence. The potential generality of transfer of function should only be limited by the number of different functions that stimuli might possibly serve (e.g., eliciting, reinforcing, discriminative, etc.), and suggests another important utility of stimulus equivalence procedures. Transfer of function via stimulus equivalence can be used for generalization of a learned stimulus function to novel situations (stimuli) without retraining in each situation. Also, the control of behaviors by certain stimuli can be transferred to new stimuli, which would provide an effective method for generalization of behavior to new situations.

Sixth-Term Control

Experiment 2 demonstrated that Sidman's (1986) hierarchical analysis can be extended to at least six terms. The questions that arise from the demonstration are (1) whether the effect is real or due to stimulus compounding; and (2) whether the effect is relevant to everyday life or is merely a laboratory phenomenon. Both issues are critical to the hierarchical approach. Sidman has expressed concern over the possibility of stimulus compounding (Sidman et al., 1989) and others have suggested that a hierarchical analysis is not necessary and is explainable by stimulus compounding (Delprato, 1987; Thomas & Schmidt, 1989). The transfer of function demonstrated by Experiments 1A, 1B, and 2 lends support to the notion that the sample stimuli are not compounded, since the function tranferred to the novel stimuli was strictly that of the stimuli to which they were related. The fact that the function was manifested immediately upon testing without any prior experience also weakens the stimulus compounding position.

Hierarchical control essentially describes a complex logical if-then relation. To the extent that such logical relations exist in the everyday world, hierarchical control does also. Early computer programming languages were based on the use of the If-Then statement to make decisions, for example, if X is the case, then do Y. The limitations of the statement quickly became apparent when a number of conditions needed to be examined at once or in a sequence. The "If-Then-Else, If and/or If Then, and If Then If Then Else" statements were created to simplify programming and cut down on the explosion of program size due to the number of "If Then" statements. These more complex statements are identical to higher-order contingencies; for example, the BASIC language statement "If X1 Then If A1 Then If B1 Then B1 Else C1" describes the leftmost fifth-term contingency illustrated in Figure 1. That such statements are commonly used in programming can be used as evidence that hierarchical situations do exist in the real world, or at least can be conceptualized as such.

An everyday example of a six-term contingency is that of linguistics: Consider a listener hearing the words "knot" or "not" who must then write down the correct word. In written language, an additional cue in the form of the presence or absence of the letter "k" makes the discrimination easier. However, the listener is dependent upon the context of the word usage. An additional level can compound matters by considering the listener bi-lingual German/English. If German is spoken, and the context is "tying", the word is "Knot", but if the context is "poverty", the word is "Not". If English is spoken, and the context is "tying", the word is "knot", but if the context is "absence" or "negation", the word is "not".

Experiment 2 demonstrated that transfer of function can take place via equivalence at the sixth-term level. Such a finding is important since it systematically replicates earlier work which used fourth-term or fifth-term contingencies (e.g., Hayes et al., in press; Lazar & Kotlarchyk, 1986; Wulfert & Hayes, 1988). Together, all these studies indicate that the basic findings of equivalence apply at a number of different levels from simple matching-to-sample to complex hierarchical tasks.

Limits on Combinations of Classes

Experiments 3A, 3B and 3C point out a critical limit with equivalence procedures. If a class is related to two different classes, and a subject is forced to choose between the two different classes, even a contextual stimulus will not prevent ambiguity (cf. Bush et al., 1989; Fucini, 1982). S3 of Experiment 3C demonstrated that the difficulty can be surmounted via the use of verbal behavior in the form of self-generated rules (Hayes, 1989), but she was the only one of six subjects in Experiments 3A and 3C to actually do so. What verbal behavior the other eight subjects in Experiment 3A, 3B, and 3C might have used is unknown. None reported the use of rules; however, the subjects' verbal report may not accurately describe their covert verbal behavior.

The findings of these three experiments may have important implications for teaching. Some combinations of stimuli apparently cannot be taught, or can be taught only with great difficulty. However, a slight change in procedures can greatly facilitate learning. If Experiment 3B was altered so that M1 and M3 and the associated relations were taught at the same time, and M2 and M4 were taught at the same time, the subjects likely would not learn the relations. Merely the order of training is altered, and the difficulty of the task increases dramatically.

Other possibilities exist which could conceivably change the difficulty of the training as dramatically. Errorless procedures could be attempted that would reduce the difficulty of training by ensuring that each set of conditional discriminations were mastered before introducing more relations. Perhaps subjects could have learned the relations in Experiment 3A if each logical step was carefully taught in such a way that equivalence was apparent. What those procedures might be requires further study.

Fields and Verhave (1987) suggest two basic sets of parameters for training that may also affect ease of acquisition. Directionality of training, or which stimuli serve as samples and comparisons may be important. They suggested that generalization of new relations may be easier depending on the manner of presentation of the stimuli during training. For example, if two relations are trained: A-B, B-C and the potential derived relations A-C, C-A are tested, the relation A-C might be easier to learn than the relation C-A because in the former both stimuli had served in the same roles as sample and comparison. That is, A had been the sample and C a comparison in prior training, while in the case of C-A, both stimuli are serving in an unfamiliar role. Even though subjects had never seen A-C together before, their familiarity with the trained roles could conceivably make the test task much easier than C-A, in which the pairing is novel, and the stimuli appear in roles they have never been in before.

In terms of larger classes, Fields and Verhave (1987) suggest that nodality, or to how many stimuli a sample is related during training, may also be important. For example, with a six-member class, one stimulus may serve as the sample throughout training and the other five are related to it: A-B, A-C, A-D, A-E, A-F. On the other hand, each of the stimuli may be related to only two other stimuli, and four of the six will serve as both sample and comparison: A-B, B-C, C-D, D-E, E-F. These issues may significantly improve training procedures by improving test performances and reducing training times, and require further research.

Contextual Control of Matching Performances

In Experiments 4A and 4B, subjects were trained to perform various matching tasks based on the presence of contextual stimuli. In Experiment 4B the subjects were able to demonstrate generalized performance of oddity, identity (reflexivity), symmetry and transitivity after appropriate training. The generalization task was overwhelming and needed to be broken down, but was eventually performed.

Two major conclusions can be drawn from these results. Identity matching seems to be very robust and even sometimes preferred because it is easy and perhaps most familiar to adult humans. Steele and Hayes (1988) found that subjects trained on a series of arbitrary-matching tasks failed to perform on an identity-matching task. Their results are likely due to a contextually controlled bias of responding based on arbitrary matching for two reasons. First, Experiment 4B demonstrated that a context based on type of procedure can control the kind of matching performed. Second, Experiment 4A and 4B also demonstrated that arbitrary matching apparently is partially based on choosing away from identity, and thus becomes an incompatible response (cf., Stromer & Osborne, 1982). Therefore, no conclusive results have indicated that reflexivity is not necessary for equivalence to develop.

Another conclusion which can be drawn from the results of Experiments 4A and 4B is that oddity and equivalence are linked somehow, perhaps with reference of what to do with incorrect stimuli. In training, the correct response during oddity was any nonidentical stimulus. However, on the test, the correct response to oddity was a nonclass member, not any nonidentical stimulus. Before the separate equivalence testing, the subjects both chose any nonidentical stimulus. After the subjects demonstrated equivalence, they chose only nonclass members (cf. Dixon et al., 1983). Perhaps the prior oddity training interfered with the formation of equivalence on the first test, since the behavior of choosing stimuli which later were to become class members had been reinforced. In essence, what the subjects were learning during oddity was that these two stimuli are not the same. S2 may have had difficulty during equivalence training because she was then told to put stimuli together which she had learned did not go together. Maybe the formation of equivalence could have been facilitated if oddity training did not use future class members as correct comparisons.

The problem of overlap in Experiments 3A, 3B, and 3C may be related in some way to the problems that arose with the use of three comparisons with the oddity task in Experiment 4A. In both cases there was a situation in which there was no single right answer. In the case of Experiment 4A, the confusion occurred within the individual trial, and in Experiments 3A, 3B, and 3C, the confusion occurred between contexts (e.g., Group 1 went with Group 2 and Group 1 also went with Group 3). The possibility still exists that the ambiguity of the lack of a single correct answer may have led to confusion in both cases. In Experiments 3A, 3B, and 3C, the use of a contextual stimulus was still not enough to clarify the relations, although separating the conditions over time was.

Methodological Issues

Acquisition

Some of the experiments, particularly 3A and 4A revealed difficulties with the training and testing tasks. Subsequent experiments or subjects who participated later typically had an easier time. These difficulties were inferred to be largely functions of the procedures. In many cases, the difficulties seemed due to the programming errors experienced by the earlier subjects. Shortening session times and lowering criteria for performance between Experiment 1A and Experiment 1B did not cause difficulties, and seemed to decrease the aversiveness of the tasks. Given the difficulties of establishing fifth-term control reported in the literature (Bush et al., 1989; Kennedy & Laitinen, 1988; Serna, 1987), the demonstration that fifth-term control can be readily established enhances the usefulness of fifth-term control as both an explanatory device and as a teaching method.

Breaking down tasks into smaller, more manageable sizes helped in both training and testing. The tactic was used in both Experiments 3A and 4B with training with success, and in Experiment 4B with testing. Saunders and Spradlin (1989) also used the method with success, and found that doing so was the only effective way of training with subjects who had difficulty learning the relations. A number of other methodological adjustments could possibly make the formation of stimulus classes easier and less time consuming. Finding such shortcuts could make the procedures much more relevant and useful for classroom applications. The use of errorless techniques and verbal prompting could improve performance.

Class structure

Experiments 1A, 1B, and 2 utilized minimum sized classes in order to examine the simplest cases of higher-order control. Given the small size of the classes, two groups of two stimuli always were related, regardless of conditional stimuli. No matter how the stimuli were grouped, two groups of two stimuli would always remain together. Also, because of the small pool of stimuli, the samples during training were also used as incorrect comparisons, even though they could be excluded since they were never correct. This again was unavoidable.

These procedures led to a possible confound in terms of exclusion. Subjects may have learned to respond away from certain relations rather than to respond based on the experimenter-defined contingencies. Harrison and Green (in press) found that subjects could learn to perform on test trials strictly by noting which combinations of stimuli occur more often. A sample stimulus may occur more often with the correct comparison than with incorrect comparisons programmed to appear randomly, and subjects learn to relate the stimuli which appear together consistently. The following section will address the role of exclusion in this dissertation.

Exclusion

Exclusion of A1 and A2 during four-term training only occurred when two three-member classes were trained, but not when four three-member classes were trained. Why this should be the case is not clear. Perhaps learning the conditional relations is easier than learning a number of unrelated rules about the stimuli. Also, the later experiments were very complex, and an exclusion strategy would have required memorizing far more relations than that involved in simply learning the experimenter-defined contingencies.

The exclusion of A1 and A2 during Experiments 1A, 1B, and 2 probably made the acquisition of the training phases easier, but did not likely have much effect on class formation given subject responses during testing. Subjects could not exclude A1 and A2 during symmetry testing because both stimuli were used as correct comparisons on symmetry probe trials. Subjects did choose A1 and A2 during testing, and did so on trained relations as well. The subjects did not exclude A1 or A2 during transitivity testing. Although A1 and A2 could be excluded during training, they could not be excluded during testing, and subjects did not do so. Harrison and Green (in press) found that subjects learned to respond based on extraneous cues in those cases in which derived performances developed gradually. The subjects in this dissertation performed with little difficulty in most testing tasks, which indicates that exclusion of A1 and A2 played little role in the acquisition of stimulus classes.

The permanent combination of B1-C1 and B2-C2 during Experiments 1A, 1B, and 2 was probably not significant. Only one subject of seven was found to exclude the pairs during training and none during testing. Results from Experiments 3A, 3B, and 3C indicate that subjects tend to learn a group of individual relations during training and sort them out into classes during testing. The subjects generally did not learn any more complex rules than the exclusion of single stimuli. Trials in which A1 or A2 were incorrect comparisons or B1-C1 or B2-C2 were both incorrect comparisons were not performed more successfully during testing than any other trial configurations. Exclusion apparently did not play a significant role in the acquisition of stimulus classes. However, the subject requires further research to clarify the role of exclusion in class formation.

Verbal reports

The subjects' verbal reports provide additional insight into the role of verbal mediation on the formation of stimulus classes. They generally could not describe the relations involved without aid of a prop; that is, the stimulus list. The major exception was when subjects learned three member classes without contextual control. One subject could, (S3 in Experiment 3C) but used self-generated verbal behavior considerably throughout experiment, which may have been the only way to complete it successfully. Some of the other subjects reported using various verbal aids such as names, rhymes, etc. None of the others did so consistently; that is, had names for all the stimuli. The conclusion can be drawn on the basis of these experiments that verbal behavior is not necessary for the formation of stimulus classes, but can be very helpful. Verbal rules, names, etc. are not necessary, and several subjects reported not using such. However, when the tasks became more and more complex, subjects became more likely to resort to verbal tactics according to their self-report.

Perhaps a reason humans developed verbal behavior was to make the task of organizing large amounts of stimuli easier. In fact, a major role of contextual stimuli in language may be to serve as labels for classes. The following argument might be made, which provides a behavioral account similar to some of Piaget's views on language (Piaget, 1932, 1980). When first learning language, children learn that words are equivalent with objects and action. They learn a large number of four-term relations. At some point, enough relations are learned that equivalence can occur, and classes are formed. Children learn to group stimuli differently depending on the context, and five-term relations are learned. A great leap in language development comes when the fifth-term becomes verbal (i.e., a word is used to describe a class) because language is then no longer just a group of symbols associated with various objects, but can be used to control the stimulus classes. At this point, a child can not only use language as a referent, but can use language to describe language, and can form his/her own rules.

Verbal instructions were kept to a minimum during the experimental situation, but how they interact with stimulus class formation is of importance, since so much everyday learning is instructional. There is much superstitious lab lore concerning methodology. In these experiments, subjects performed well on sessions comprised of 50% to 100% test probes. Fading feedback was not found to be necessary. On the other hand, why Experiment 3A should have failed is not obvious a priori. Much methodological work is necessary, and demonstration research is still valuable for finding the limits.

Conclusions

The experiments comprising this dissertation provide an analysis of the development of higher-order stimulus control in humans. Subjects were able to arrange stimuli into classes based upon hierarchical levels of contextual stimuli. Experiments 1A, 1B, and 2 were demonstrations of the viability of higher-order stimulus control. Experiments 3A, 3B, and 3C examined some of the factors which affect class formation and hierarchical control, particularly in terms of order of training. Whether higher-order control is established level-by-level or all at once does not seem to make much difference in contrast to the findings of Kennedy and Laitinen (1988). However, certain groupings of stimuli can be easily learned, as in Experiment 3B, while other groupings can be very difficult, as in Experiments 3A and 3C. Experiments 4A and 4B demonstrated that context is a factor in class formation, and examined some of the factors that affect the role of context on how stimuli are related.

The results of these experiments are of theoretical value, as they demonstrate that higher-order control can be established, and provide evidence supporting hierarchical control rather than stimulus compounding. They are also of theoretical value since they provide evidence that context plays a role in class formation. A number of empirical issues are raised as well. The roles of exclusion and oddity on class formation are related issues that need to be addressed in further research. The precise nature of higher-order relations needs to examined more closely, and the role of verbal behavior in class formation (and indeed all operant behavior) needs to be investigated. In addition, the results have some applied implications. Some arrangements of stimuli are impossible, or at least very difficult to learn. At the present, how to recognize potential difficulties is not possible, beyond the general notion of overlap of stimulus classes. What variables control ease of learning is important for teaching concepts at any level.

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APPENDICES

Appendix A

Consent Form and Human Subjects Approval

INFORMED CONSENT

Expansion of Contextual Control of Stimulus Classes

This experiment involves learning relations between various arbitrary stimuli. You will be asked to learn to match correctly various groups of stimuli shown on a computer monitor. Each session will consist of 48-64 trials, and will last for approaximately 15 minutes. You will be asked to participate at least two to three times a week for about an hour each time. The experiment will take 3-8 weeks to complete, depending on regularity of attendance, and what conditions you are in. You may recieve up to 40 PSY 101 class points for attendance and successful performance, and 10 bonus points are available for completing the experiment.

The above named treatment is the ONLY experimental manipulation that will be made. If, for the clarity of some point raised by the outcome data, the experimenter wishes to change or add a treatment condition, this will be discussed with you before such a change or addition is made. Participation is solely on a volunteer basis, and if at any time you wish to terminate your participation, you are fully at liberty to do so. You will receive whatever class points you have earned up to that point.

The data on your performance will be kept in coded form and will be available only to the experimenter. These data may be written up for publication in professional journals any may be presented at professional meetings, or for educational purposes. After the data have been analyzed and the results written as a research report, a copy of the report will be made available to you upon your request.

I UNDERSTAND THE PURPOSES AND PROCEDURES OF THIS EXPERIMENT AND AGREE TO VOLUNTARILY PARTICIPATE IN THIS EXPERIMENT.

____
Participant's Signature

____
Experimenter's Signature

Date: __________________

OMB No. 0925-0631

DEPARTMENT OF HEALTH AND HUMAN SERVICES

PROTECTION OF HUMAN SUBJECTS
ASSURANCE/CERTIFICATION/DECLARATION

☐ ORIGINAL ☒ FOLLOWUP ☐ EXEMPTION (previously undesignated)

☒ GRANT ☐ CONTRACT ☐ FELLOW ☐ OTHER

☒ New ☐ Competing continuation ☐ Noncompeting continuation ☐ Supplemental

APPLICATION IDENTIFICATION NO. *(if known)*

1 R01 HD 21389-01A1

POLICY: A research activity involving human subjects that is not exempt from HHS regulations may not be funded unless an Institutional Review Board (IRB) has reviewed and approved the activity in accordance with Section 474 of the Public Health Service Act as implemented by Title 45, Part 46 of the Code of Federal Regulations (45 CFR 46—as revised). The applicant institution must submit certification of IRB approval to HHS unless the applicant institution has designated a specific exemption under Section 46.101(b) which applies to the proposed research activity. Institutions with an assurance of compliance on file with HHS which covers the proposed activity should submit certification of IRB review and approval with each application. (In exceptional cases, certification may be accepted up to 60 days after the receipt date for which the application is submitted.) In the case of institutions which do not have an assurance of compliance on file with HHS covering the proposed activity, certification of IRB review and approval must be submitted within 30 days of the receipt of a written request from HHS for certification.

1. TITLE OF APPLICATION OR ACTIVITY

Stimulus Equivalence and Conditional Discriminations

2. PRINCIPAL INVESTIGATOR, PROGRAM DIRECTOR, OR FELLOW

J. Grayson Osborne

3. FOOD AND DRUG ADMINISTRATION REQUIRED INFORMATION *(see reverse side)*

4. HHS ASSURANCE STATUS

☒ This institution has an approved assurance of compliance on file with HHS which covers this activity.

#M-1152 Assurance identification number ________ IRB identification number

☐ No assurance of compliance which applies to this activity has been established with HHS, but the applicant institution will provide written assurance of compliance and certification of IRB review and approval in accordance with 45 CFR 46 upon request.

5. CERTIFICATION OF IRB REVIEW OR DECLARATION OF EXEMPTION

☐ This activity has been reviewed and approved by an IRB in accordance with the requirements of 45 CFR 46, including its relevant Subparts. This certification fulfills, when applicable, requirements for certifying FDA status for each investigational new drug or device. *(See reverse side of this form.)*

August 17, 1987 Date of IRB review and approval. *(If approval is pending, write "pending." Followup certification is required.)*
(month/day/year)

☒ Full Board Review ☐ Expedited Review

☐ This activity contains multiple projects, some of which have not been reviewed. The IRB has granted approval on condition that all projects covered by 45 CFR 46 will be reviewed and approved before they are initiated and that appropriate further certification *(Form HHS 596)* will be submitted.

☐ Human subjects are involved, but this activity qualifies for exemption under 46.101(b) in accordance with paragraph ________ *(insert paragraph number of exemption in 46.101(b), 1 through 5)*, but the institution did not designate that exemption on the application.

6. Each official signing below certifies that the information provided on this form is correct and that each institution assumes responsibility for assuring required future reviews, approvals, and submissions of certification.

APPLICANT INSTITUTION	COOPERATING INSTITUTION
NAME, ADDRESS, AND TELEPHONE NO. Research Information Office Utah State University Logan, Utah 84322-1450 (801) 750-6924	NAME, ADDRESS, AND TELEPHONE NO.
NAME AND TITLE OF OFFICIAL *(print or type)* D. Kim Openshaw, Chair	NAME AND TITLE OF OFFICIAL *(print or type)*
SIGNATURE OF OFFICIAL LISTED ABOVE *(and date)* [signature] 8-17-87	SIGNATURE OF OFFICIAL LISTED ABOVE *(and date)*

HHS 596 (Rev. 1/82)

(If additional space is needed, please use reverse side under "Notes.")

Appendix B

Instructions Given to Subjects

At the first session, subjects were seated in front of the computer monitor. The experimenter turned the monitor on, requested the subject to pick up the joystick, and said, "To begin the session, press the button on the joystick nearest the apple." When the first (contextual) stimulus appeared on the monitor, the subject was told, "To indicate that you've seen the stimulus, press the button." The sample then appeared, and the subject was told to again press the button if they asked. The comparisons then appeared. The subject was then told, "Choose the stimulus on the bottom that goes with the two stimuli above. Move the joystick left or right to position the cursor under the stimulus you think is correct. If you are correct, the computer will say 'Correct' and will give you a point. If you are not correct, the screen will go blank, and then it will show the same trial again. It will do this until you get the trial right. When you do, the computer will say 'Correct', but you will not get a point. You must get it right the first time to get points. There are 80 trials each session."

If the subject asked questions about how the stimuli went together, the experimenter replied to the effect that there was a consistent order, but that s/he must find out for him/herself. The experimenter remained in the same room on the opposite side of a partition. Several subjects asked questions about the nature of the experiment and the relation between the stimuli during the course of the experiment. The experimenter responded that he could not discuss the questions at that time, because that might spoil the experiment but would explain everything when the experiment was completed.

When end-of-trial feedback was reduced, the subjects were told before they began, "I'm going to make things a little harder. I'm not going to give you feedback on whether you were correct on every trial, OK?"

When testing began, the subjects were told, "Today I'm going to test you to see what you've learned. I'm going to show you some new things, and because it's a test, I can't give you any feedback."

At the start of Phase 2, the subjects were told that they were going to start something new. If the subjects asked whether they were supposed to press the button as before, the experimenter responded, "Yes". No other instructions were given. During end-of-trial feedback reduction, and symmetry and transitivity testing, the same instructions as used for Phase 1 were given.

When the subjects were ready for the contextual class test, they were told, "OK, we're going to do something new now. There will be three levels on the screen again." No other instructions were given.

Appendix C

Debriefing Procedures

When the subjects completed the experiment, they were shown line drawings of the stimuli arranged randomly in a single column and asked how they went together. If the subject had difficulty, or did not describe all the relations, they were prompted. If the subjects did not volunteer names for the stimuli, they were asked if they had their own names for the stimuli.

The subjects were then shown the figure illustrating the experiment design for their experiment (e.g., Figure 1 for Experiment 1A), and the experimental procedures were explained. For those subjects who did not successfully complete the procedures (such as those in Experiment 3A), they were told that their failures indicated faulty procedures which required revision rather than personal inadequacy on their part.

Following the explanation of the procedures, they were told how many points they had earned in the experiment, and reminded that they could if they desired, obtain a write-up of the results by contacting the experimenter.

Appendix D

Exclusion Evidence for Experiments 3A, 3B, and 3C

Table 43

Number of Times Each Stimulus Is Chosen As An Incorrect Comparison for Each Subject Each Session in Experiment 3A

S14						Incorrect Comparisons						
Session	A1	B1	C1	A2	B2	C2	A3	B3	C3	A4	B4	C4
1	0	1	2	2	2	3	0	4	2	3	0	2
2	0	0	1	0	0	0	0	0	0	0	0	1
3	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	3	1	1	2	1	0	2	0
5	0	0	0	0	5	0	0	3	0	1	0	1
6	2	0	1	0	1	2	4	5	2	0	1	1
7	0	1	0	0	1	1	0	1	1	2	0	0
8	3	0	0	0	2	1	0	2	0	0	1	0
9	0	0	0	0	0	0	0	0	0	0	1	0
10	0	0	0	0	0	2	0	1	1	0	0	1
11	0	0	0	0	1	1	0	1	1	2	0	0
12	2	1	2	0	1	2	1	3	0	0	1	0
13	0	0	0	0	4	0	0	3	1	1	0	1
14	1	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0
16	0	2	0	0	0	0	0	0	0	0	0	1
17	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	1	1	0	0	1	0	0	0	1
20	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0
22	3	4	0	3	3	0	3	4	2	4	1	7
23	2	0	0	1	4	1	3	4	4	3	2	5
24	0	1	0	0	0	0	0	0	0	0	0	1
25	0	0	0	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0	0	0	0
28	3	3	0	1	1	2	3	3	3	4	5	2
29	4	4	0	4	2	2	0	0	0	0	0	0
30	2	6	0	4	2	2	0	0	0	0	0	0
31	4	6	0	2	3	2	0	0	0	0	0	1
32	0	0	0	0	0	0	0	0	0	0	0	0
33	0	0	0	0	0	0	0	0	0	0	0	0

(table continues)

Table 43 (continued)

S15						Incorrect Comparisons						
Session	A1	B1	C1	A2	B2	C2	A3	B3	C3	A4	B4	C4
1	1	2	4	1	3	4	4	3	0	4	1	0
2	0	0	0	0	4	3	0	0	0	1	0	2
3	0	0	3	0	0	3	0	0	0	0	1	0
4	0	0	3	0	0	0	0	0	0	1	1	0
5	0	0	1	0	0	0	0	0	0	1	0	0
6	0	0	2	0	0	0	0	0	0	0	0	0
7				INDIVIDUAL TRIAL DATA LOST								
8	1	0	5	0	3	3	0	0	1	4	0	1
9	0	1	2	2	2	1	0	1	0	5	0	1
10	2	0	5	0	1	1	2	4	1	2	0	2
11	1	0	3	0	0	2	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	1	0
13	0	0	1	1	0	4	0	0	0	1	1	0
14	0	0	1	0	0	0	0	0	0	1	0	0
15	0	0	0	0	0	1	0	0	0	0	0	0
16	0	1	1	1	0	2	1	0	0	0	1	0
17	0	1	0	0	0	7	2	0	0	1	1	0
18	1	0	0	0	0	6	1	0	0	1	0	0
19	0	1	1	1	0	3	1	0	0	0	1	0
20	0	0	0	0	0	0	0	0	0	0	0	0
21	0	1	1	0	0	2	0	0	0	0	0	0
22	1	0	0	0	0	1	0	0	0	0	0	0
23	0	0	0	0	0	2	0	0	0	0	0	0
24	0	0	1	0	0	0	0	0	0	0	0	1
25	0	0	0	0	0	0	0	0	0	0	0	0
26	5	6	0	1	3	2	1	0	4	3	1	0
27	4	7	0	0	2	4	0	2	2	2	1	0
28	0	0	3	0	0	1	0	0	0	0	1	0
29	1	0	2	0	0	1	0	0	0	0	1	0
30	0	0	0	0	0	0	0	0	0	0	0	0
31	0	0	2	0	0	0	0	0	0	0	0	0
32	4	5	0	3	2	5	0	2	1	2	5	0
33	4	7	0	2	4	5	1	0	0	3	0	0
34	3	7	0	2	2	5	0	2	0	2	2	0
35	0	0	0	0	0	0	0	0	0	0	0	0
36	0	0	0	0	0	0	0	0	0	0	0	0

(table continues)

Table 43 (continued)

S16	Incorrect Comparisons											
Session	A1	B1	C1	A2	B2	C2	A3	B3	C3	A4	B4	C4
1	2	3	5	1	3	8	1	5	4	0	4	2
2	4	1	0	3	5	5	1	1	4	4	2	2
3	2	0	2	1	4	3	1	1	8	2	4	2
4	0	2	1	3	3	4	4	4	4	6	0	0
5	0	5	1	1	4	2	0	1	4	4	1	3
6	1	3	3	1	3	1	1	0	1	4	0	1
7	0	0	0	0	3	0	0	0	0	1	0	0
8	3	1	1	0	5	0	1	1	2	1	0	0
9	2	0	2	0	1	3	0	1	0	3	0	0
10	0	1	2	0	0	3	0	0	0	0	0	1
11	1	1	2	0	1	1	0	0	0	0	0	0
12	0	1	3	0	3	1	0	0	0	0	0	0
13	0	2	1	0	0	0	0	0	0	1	0	0
14	0	0	1	0	0	0	0	0	0	0	0	0
15	0	3	0	0	0	2	0	0	0	0	0	0
16	0	2	1	0	3	3	0	0	1	0	0	0
17	0	0	2	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	1	0	0	1	0	0	0	0	1	0
20	0	0	0	0	0	0	0	1	0	0	0	0
21	1	0	2	0	2	1	0	4	5	0	0	0
22	1	1	1	0	0	2	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	2	0	0	0
24	0	0	0	0	0	1	0	0	1	0	0	0
25	0	0	2	0	0	1	0	0	0	0	1	1
26	0	0	1	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0	0	0	0
28	3	7	0	3	5	3	1	2	5	4	1	1
29	2	7	0	2	3	4	1	3	5	5	2	1
30	0	0	2	0	0	1	0	1	1	0	0	0
31	0	0	1	0	1	0	0	0	1	0	0	0
32	0	0	0	0	0	0	0	0	0	0	0	0
33	0	0	0	0	1	0	0	0	0	0	0	0
34	3	5	0	2	3	2	1	3	3	8	6	0
35	3	3	0	2	2	1	5	2	1	2	5	7
36	0	2	0	0	1	0	0	0	0	1	4	4
37	0	4	0	0	0	1	0	0	1	0	3	4
38	0	0	1	1	2	0	0	0	1	0	1	4
39	0	0	1	0	1	1	0	0	0	0	1	0
40	0	1	0	0	0	0	0	0	0	1	1	0
41	0	1	0	0	0	0	0	0	0	0	0	1
42	4	7	0	4	5	2	0	5	3	1	0	3
43	3	6	0	4	2	3	3	3	3	1	2	3
44	0	3	0	2	1	2	1	0	1	3	3	4
45	0	1	0	4	0	2	1	0	1	0	2	4

Table 44

Number of Times Each Stimulus Is Chosen As An Incorrect Comparison for Each Subject Each Session in Experiment 3B

S17	Incorrect Comparisons											
Session	A1	B1	C1	A2	B2	C2	A3	B3	C3	A4	B4	C4
1	0	2	3	1	1	5	6	3	5	1	3	5
2	0	5	2	0	2	0	3	0	0	3	2	0
3	1	3	0	0	0	0	0	0	0	0	2	2
4	0	1	2	0	0	0	0	0	0	0	1	0
5	0	2	1	0	0	0	0	0	0	0	1	3
6	0	1	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0
10	0	1	1	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	2	0	1	0	0	0	1	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0
15	1	0	1	0	0	0	9	8	10	0	0	0
16	0	0	0	0	0	0	10	8	9	0	0	0
17	2	0	0	0	0	0	6	9	8	0	0	0
18	0	0	0	0	0	0	11	12	7	0	0	0
19	1	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
21	3	0	1	3	0	1	0	4	1	2	3	1
22	3	1	0	2	0	0	0	2	4	1	1	2
23	1	0	2	2	0	1	0	2	2	3	2	0
24	0	0	1	0	0	0	1	2	0	0	2	0
25	0	0	0	0	0	0	0	0	0	1	0	0
26	0	0	0	0	0	0	0	0	0	0	0	0
27	6	4	6	4	6	5	2	3	2	5	2	2
28	1	0	0	0	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	2	0	1	0	1	0	1	1	0
31	1	0	1	0	0	0	0	0	0	0	0	0
32	5	4	4	1	4	5	1	1	0	5	3	4
33	4	4	3	3	4	2	3	3	3	3	2	4
34	0	0	0	1	0	1	1	3	1	0	1	1
35	0	0	0	0	0	0	0	0	0	0	0	0
36	0	1	0	1	0	2	1	1	1	1	1	0
37	0	0	0	0	0	0	0	0	0	1	0	0
38	2	2	1	0	0	0	1	1	0	0	1	1
39	0	0	1	0	0	0	0	0	0	0	0	0
40	1	1	0	0	0	0	0	0	0	0	1	0

(table continues)

Table 44 (continued)

S17						Incorrect	Comparisons					
Session	A1	B1	C1	A2	B2	C2	A3	B3	C3	A4	B4	C4
41	0	0	0	0	0	0	0	0	0	0	0	0
42	0	0	0	0	0	0	0	0	0	0	0	0
43	0	1	1	0	0	0	0	0	0	2	1	3
44	1	2	0	0	0	0	0	0	0	1	1	0
45	0	3	2	0	0	0	0	0	0	1	2	1
46	0	1	0	0	0	0	0	0	0	0	1	0
47	0	0	0	0	0	0	0	0	0	1	0	0

S18						Incorrect	Comparisons					
Session	A1	B1	C1	A2	B2	C2	A3	B3	C3	A4	B4	C4
1	3	2	6	1	4	7	6	4	3	4	0	3
2	2	3	4	3	2	3	6	5	3	3	2	4
3	4	2	4	7	2	6	0	6	4	3	2	3
4	6	1	2	3	8	4	3	5	5	4	2	2
5	5	3	5	1	10	2	1	4	4	3	1	1
6	0	3	2	3	3	0	2	5	2	3	1	1
7	1	1	0	1	0	2	0	0	0	1	0	3
8	1	3	1	1	1	1	0	5	0	4	0	0
9	0	0	0	0	0	2	0	0	0	0	1	0
10	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	1	1	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	1	0	1
14	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	4	0	1	0	0	0	1	0	1	0
16	0	1	0	0	0	0	1	0	0	0	1	0
17	0	0	0	0	0	0	0	0	0	0	0	1
18	0	2	1	0	0	0	0	0	0	3	1	0
19	0	0	0	0	0	0	0	0	0	1	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
21	6	0	0	1	0	0	1	1	0	1	0	0
22	2	1	0	0	0	0	0	2	1	0	1	0
23	3	1	0	2	1	0	0	0	0	0	1	0
24	0	0	0	0	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0	0	0	0
28	0	3	1	1	1	0	1	1	2	1	1	0
29	1	0	0	0	0	0	0	0	0	0	0	0
30	0	1	0	0	0	0	0	0	0	0	1	0
31	0	1	0	2	5	2	0	0	1	0	1	1
32	1	1	1	1	2	1	0	1	0	1	1	1
33	0	0	0	1	2	1	1	1	1	0	0	0
34	1	0	0	0	2	1	0	1	1	0	0	0
35	0	1	0	1	0	2	0	1	1	0	1	2

(table continues)

Table 44 (continued)

S18 Session	Incorrect Comparisons A1	B1	C1	A2	B2	C2	A3	B3	C3	A4	B4	C4
36	0	1	1	0	1	1	0	0	2	0	1	2
37	0	0	0	1	1	1	0	2	1	1	0	0
38	0	0	1	2	0	5	1	1	3	0	0	1
39	0	0	0	0	0	3	0	0	3	0	0	0
40	0	0	0	0	0	1	0	0	3	0	0	0
41	0	0	0	0	0	0	0	0	0	0	0	0
42	0	0	0	1	0	1	0	0	0	0	0	0
43	0	0	0	0	0	1	0	0	0	0	0	0
44	1	0	0	2	1	0	1	2	0	0	1	0
45	0	1	0	0	0	1	0	0	0	0	0	0
46	0	0	0	0	0	0	1	1	0	0	0	0
47	1	0	0	0	0	0	0	0	0	0	0	0
48	0	0	0	0	0	0	0	0	0	0	0	0

S19 Session	Incorrect Comparisons A1	B1	C1	A2	B2	C2	A3	B3	C3	A4	B4	C4
1	1	1	1	1	6	5	2	2	7	4	5	0
2	0	2	2	2	1	2	0	7	1	1	0	1
3	0	0	3	0	0	5	0	5	2	4	2	3
4	0	2	3	0	3	4	0	3	3	1	3	6
5	1	2	0	0	0	0	0	1	2	1	2	3
6	1	0	0	0	0	0	0	0	0	0	1	0
7	1	1	0	0	0	0	1	0	0	0	0	0
8	0	0	1	0	0	0	1	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0
10	1	0	1	1	1	0	1	1	0	0	0	0
11	0	0	1	0	1	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0
13	1	0	2	0	1	0	0	1	1	0	2	0
14	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	1
17	0	0	0	0	0	0	0	0	0	1	0	0
18	0	2	1	1	2	1	1	3	0	1	2	1
19	1	0	0	4	0	0	0	4	1	0	2	1
20	0	0	1	0	1	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0
22	5	5	6	3	8	4	6	6	5	8	1	8
23	1	0	2	2	0	0	0	0	0	0	0	0
24	0	0	1	0	0	0	0	0	0	0	0	0
25	5	3	6	6	3	4	1	5	2	4	3	4
26	4	4	6	6	2	4	6	3	6	4	6	4
27	3	2	2	4	2	2	2	3	4	2	3	3
28	3	3	4	2	5	2	3	4	3	2	1	4

Table 45

Number of Times Each Stimulus Is Chosen As An Incorrect Comparison for Each Subject Each Session in Experiment 3C.

S20	Incorrect Comparisons											
Session	A1	B1	C1	A2	B2	C2	A3	B3	C3	A4	B4	C4
1	3	3	1	4	6	3	4	2	6	3	3	2
2	1	1	3	2	2	3	1	2	4	9	2	6
3	2	1	3	0	3	2	5	3	3	3	2	1
4	0	1	0	2	0	0	1	6	1	2	1	2
5	0	1	2	0	0	0	0	1	0	2	2	0
6	0	0	1	0	0	0	0	0	0	0	0	3
7	0	0	0	0	0	0	0	0	0	1	0	1
8	0	0	0	0	0	0	0	0	0	0	0	0
9	0	1	0	0	0	0	0	0	0	2	1	1
10	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	1
12	0	1	0	0	0	0	0	0	0	1	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	2	0	0	0	0	0	1	0
15	0	0	0	4	1	0	0	0	0	0	2	0
16	0	0	0	0	3	1	0	0	0	0	0	0
17	0	0	0	0	0	1	0	0	0	1	1	0
18	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	4	5	5	3	3	3	0	0	2
20	0	0	0	8	6	5	1	4	0	2	3	6
21	0	0	0	9	11	8	0	2	2	5	1	4
22	0	0	0	5	9	5	2	5	2	2	2	6
23	5	0	4	2	2	1	1	1	0	0	0	0
24	2	0	1	2	0	2	0	0	1	0	0	0
25	3	1	1	1	0	1	0	0	0	0	0	0
26	3	0	0	0	0	0	0	0	0	0	0	0
27	0	0	0	2	0	1	0	0	0	0	0	0
28	7	7	11	4	4	0	0	0	0	0	0	0
29	9	11	10	2	2	1	9	1	1	6	2	3
30	10	8	8	2	3	5	3	5	4	7	3	3
31	12	12	7	5	5	3	3	4	3	2	1	2
32	0	0	1	2	3	2	0	0	0	0	0	0
33	1	2	1	0	0	0	0	0	0	0	0	0
34	3	0	0	0	0	0	0	0	0	0	0	0
35	5	12	11	1	2	3	2	4	4	4	3	1
36	9	11	7	4	2	4	4	2	4	5	3	2
37	13	8	9	4	1	2	3	5	2	2	4	2
38	15	9	8	4	2	2	1	3	6	5	2	2

(table continues)

Table 45 (continued)

S21 Session	A1	B1	C1	A2	B2	C2	A3	B3	C3	A4	B4	C4
	Incorrect Comparisons											
1	4	0	3	1	3	3	4	4	5	5	1	0
2	1	2	4	0	3	0	3	0	0	2	0	0
3	1	0	0	0	0	0	0	0	0	2	0	0
4	0	0	1	0	0	0	0	0	0	1	0	0
5	1	1	0	0	0	0	0	0	0	0	1	0
6	1	0	0	0	1	0	0	0	0	0	1	0
7	0	1	0	0	1	1	0	0	0	3	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0
9	0	1	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	1	0	0	0	1	0	6	1
11	0	0	0	0	1	0	0	2	1	0	0	0
12	0	0	0	0	0	0	0	0	1	0	0	0
13	0	0	0	0	2	0	0	0	1	0	0	2
14	0	0	0	0	0	0	0	1	0	0	0	0
15	0	0	0	0	0	0	0	1	0	0	0	0
16	0	0	0	3	6	6	4	6	4	0	0	0
17	0	0	0	4	5	4	0	4	7	11	5	5
18	0	0	0	4	3	7	3	5	6	5	3	5
19	0	0	0	7	4	2	3	6	3	10	3	9
20	0	0	0	0	0	0	1	0	1	0	0	0
21	0	0	1	0	0	1	0	0	0	0	0	0
22	7	19	5	2	2	1	3	5	3	2	5	4
23	10	13	10	2	3	3	2	6	2	2	2	2
24	14	9	6	3	2	3	5	3	2	3	3	3
25	11	10	6	3	4	3	4	2	5	2	1	5
26	1	0	1	0	0	1	0	0	0	0	0	0
27	10	7	8	3	2	3	5	5	1	3	5	3
28	6	14	9	2	3	2	6	2	2	6	3	1
29	11	10	8	0	2	2	7	2	1	4	4	4
30	6	10	10	0	1	1	4	2	5	3	7	4

S22

Session	A1	B1	C1	A2	B2	C2	A3	B3	C3	A4	B4	C4
	Incorrect Comparisons											
1	0	3	2	0	0	4	2	0	4	0	2	0
2	1	0	0	0	0	0	0	0	0	0	0	1
3	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	1	0	0	0	0	0	0	0	1	0
7	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	1	0	0	0	1	0	0	0	1
9	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	1	1	1	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0
12	1	1	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0
14	11	6	10	2	2	1	8	1	1	6	2	3
15	0	0	0	0	0	1	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	1	0	0	0	2	0	0	0	0	1
18	0	0	0	1	0	0	0	0	0	0	0	0
19	0	0	1	0	0	0	1	0	0	0	0	0
20	0	0	1	0	1	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	1	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	1	0	0	1	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0

Vita

Michael B. Gatch

Educational Background

Doctorate of Philosophy, Utah State University, June, 1990
Major: Psychology, Analysis of Behavior
Minor: Statistics
Dissertation: An Experimental Analysis of Higher-Order Stimulus Control in Humans.
Chair: J. Grayson Osborne

Master of Arts, University of Houston--Clear Lake, May, 1985
Major: Behavioral Sciences, Specialization: Behavior Analysis/Behavioral Medicine.
Thesis: Signal Detection Analysis of Biofeedback.
Chair: Hilary Jo Karp, Ph.D.

Bachelor of Arts, The University of Chicago, June, 1983
Major: Behavioral Sciences.
Research Supervisor: Israel Goldiamond, Ph.D.

Academic Awards

Omicron Delta Kappa National Honor Society, December, 1984.

Who's Who in American Universities & Colleges, January, 1985.

Graduate School Honor Roll, Utah State University, Fall, 1986.

Grants/Financial Awards

Behavioral Science Scholarship, University of Houston--Clear Lake, August 1983, August 1984. $200, plus out-of-state tuition remission.

Graduate Student Fellowship, Utah State University, Competition-all incoming graduate students, September, 1985, $5000, plus out-of state tuition waiver.

Graduate Student Scholarship, Utah State University, College of Education, Competition-all graduate students in College of Education, January, 1989, $1000.

Teaching Experience

Supervised teaching

University Teaching Apprenticeship, PSY 380, Introduction to Educational and Psychological Statistics, Dr. J. Grayson Osborne, Instructor. Fall, 1985.

University Teaching Apprenticeship, PSY 101, General Psychology, Dr. Richard Powers, Instructor. Fall, 1986.

University Teaching Apprenticeship, PSY 345, Perception and Psychophysics, Dr. Carl Cheney, Instructor. Winter, 1988.

University Teaching Apprenticeship, PSY 510, History and Systems of Psychology, Dr. Carl Cheney, Instructor. Spring 1989.

Sign Language Lab Assistant, ComD 338, Sign Language Practicum, ComD 430, Yvonne Clark, Instructor. Fall, 1986. Utah State University.

Assistantships

Teaching Assistantship, PSY 101, General Psychology, 1986-1987.

Teaching Assistantship, PSY 140, Analysis of Behavior: Basic Processes, 1987-1988, 1988-1989.

Teaching Assistantship, PSY 366, Educational Psychology, 1989-1990.

Courses taught unsupervised

PSY 440 Analysis of Behavior--Learning, Motivation, & Emotion. Fall, 1986, Utah State University--Extension, Tooele.

PSY 101 General Psychology, Spring 1988, Utah State University--Extension, Tooele.

PSY 101 General Psychology, Spring 1990, Utah State University--Extension, Tooele.

PSY 140 Analysis of Behavior--Basic Processes, Spring 1988, Utah State University--Extension, Tooele.

Psy 345 Perception and Psychophysics, Spring 1989, Utah State University--Extension, Moab.

Previous Clinical Experience

Uta Halee Girl's Village, Omaha, Nebraska, July-September 1985. Supervisor:Peg Miller, M.S.W. Responsibilities: Resident Advisor--administer ongoing therapy, advise residents, serve as adult role-model, assist residents in making short and long-term goals, write monthly staffing reports, assist in formation of care plans for residents.

PSY 738, Analysis of Behavior Internship. Two quarters of practicum experience, Clinical Services, Developmental Center for Handicapped Persons, Utah State University, Winter and Spring, 1990.

Community Service

Volunteer, American Cancer Society's Great American Smokeout. Provided and manned an "Advice Table", Fall 1984.

Sunday school teacher, Logan First Presbyterian Church, Logan, Utah, October, 1986-April, 1987. Taught senior high age.

Member, Board of Trustees, Logan First Presbyterian Church, Logan, Utah, July, 1989-December, 1989.

Member, Board of Session, Logan First Presbyterian Church, Logan, Utah, January, 1990-present.

Volunteer, Special Olympics.

Publications and Research Presentations

Gatch, M. B. (1985). Signal detection analysis of biofeedback. Paper presented at the annual convention of the Association for Behavior Analysis, Columbus, Ohio.

Gatch, M. B. & Crossman, E. K. (1987). Conservation of session time in mixed Fixed-Ratio schedules. Poster presented at the annual convention of the Association for Behavior Analysis, Nashville, Tennessee.

Osborne, J. G., & Gatch, M. B. (1987). Stimulus equivalence and reading by hearing-impaired preschool children. Poster presented at the annual convention of the Association for Behavior Analysis, Nashville, Tennessee.

Gatch, M. B., & Osborne, J. G. (1988). Class formation of contextual stimuli and contextual control of complex classes. Poster presented at the annual convention of the Association for Behavior Analysis, Philadelphia, Pennsylvania. (Received Certificate of Merit).

Gatch, M. B., & Osborne, J. G. (1989). Sixth-term control of stimulus classes. Poster presented at the annual convention of the Association for Behavior Analysis, Milwaukee, Wisconsin.

Gatch, M. B., & Osborne, J. G. (1990). Contextual control of identity matching, non-identity matching and class formation. Poster presented at the annual convention of the Association for Behavior Analysis, Nashville, Tennessee.

Gatch, M. B., & Osborne, J. G. (1990). Extension of a contextual class via stimulus equivalence. Poster presented at the annual convention of the Association for Behavior Analysis, Nashville, Tennessee.

Publications

Gatch, M. B., & Osborne, J. G. (1989). Transfer of contextual stimulus function via equivalence class development. Journal of the Experimental Analysis of Behavior, 51, 369-378.

Osborne, J. G., & Gatch, M. B. (1989). Stimulus equivalence and receptive reading by hearing-impaired preschool children. Language, Speech and Hearing Services in Schools, 20, 63-75.

Membership in professional societies

Member, Houston Association for Behavior Analysis (February 1984-July 1985).
Student Member, Association for Behavior Analysis (May 1984-Present).

Computer Consulting Experience

Experience in writing behavioral programming in BASIC on Rockwell AIM-65, TRS-80, CBM, Apple II and IBM computers.

Designed and constructed wiring for computer run operant chambers for Dairy Science department, Utah State University, February 1987.

Wrote BASIC language programs for IBM computer control of animal operant equipment, Department of Psychology, Utah State University, January, 1989.

Professional References

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Birth date: July 22, 1961
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