THE EFFECTS OF OUTCOME REVERSALS ON CHILDREN'S CONDITIONAL DISCRIMINATION, EQUIVALENCE, AND REINFORCER-PROBE PERFORMANCES

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ABSTRACT

Previous studies have shown that class-specific reinforcers are critical not only to the establishment but also to the maintenance of conditional discriminations. However, this effect has yet to be tested with humans. In Experiment 1, normally capable children were trained to perform two arbitrary conditional discriminations (AB and AC) with class-specific reinforcers. Selections of B1, B2, or B3 given A1, A2, or A3, respectively, produced R1, R2, or R3, respectively. Upon mastery, the reinforcement contingencies were reversed such that selections of B1, B2, or B3 given A1, A2, or A3, respectively, now produced R2, R3, or R1, respectively. Next, selections of C1, C2, or C3 given A1, A2, or A3, respectively, produced R1, R2, or R3, respectively; but again, upon mastery, the reinforcement contingencies were reversed such that selections of C1, C2, or C3 given A1, A2, or A3, respectively, now produced R3, R1, or R2. In contrast to the findings of previous studies, most participants (six out of nine) showed no decline in accuracy on their conditional discrimination performances following training with reversed outcomes. In experiment 2, reflexivity, symmetry, and equivalence probes were administered to evaluate the formation of stimulus classes A1B1C1, A2B2C2, and A3B3C3. In addition, participants completed reinforcer probes in order to ascertain whether the class-specific reinforcers had become class members. Four of the eight participants performed positively on tests for equivalence, but we found little evidence of the reinforcers becoming class members. Experiment 3, which was conducted with the same stimuli used to complete Experiments 1 and 2, was a replication of those studies without outcome reversals. Six of the seven participants performed positively on tests for equivalence. Moreover, for three of these participants, arranging class-consistent reinforcement contingencies brought reinforcer-probe performances more closely in line with the original equivalence classes. Experiment 4 was a replication of

Experiment 3 with novel stimuli. All three of the participants performed positively on tests for equivalence and the reinforcer-probe performances of two of these participants indicated the expansion of the equivalence classes to include reinforcers. Implications are discussed.

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CHAPTER 1. INTRODUCTION

How does learning occur? Scientists concerned with the experimental analysis of behavior contend that even relatively complex behaviors arise from a few simple and observable behavioral processes. Most familiar to us are those identified by Skinner (e.g., 1938, 1953) as operant reinforcement, simple discrimination, and conditional discrimination from among others. The most basic analytic unit is the two-term response-reinforcement unit known as operant reinforcement, followed by the three-term unit or simple discrimination, which entails that a response must occur in the presence of a particular stimulus in order to produce a reinforcer. A conditional discrimination is a four-term contingency consisting of the following elements: two antecedent stimuli, a response, and a consequence. Learning a conditional discrimination entails making a choice between at least two stimuli where that choice or discrimination is conditional upon the presence of another stimulus (Catania, 1998). For example, consider a mother who would like to teach her child the written referents that correspond to an apple and pear. She first shows the child an index card containing the printed word, *apple*, along with two pictures, one of an apple and the other of a pear. For this particular trial, choosing the picture of the apple would be reinforced, while choosing the picture of the pear would not be reinforced. In contrast, when presented with an index card containing the printed word, *pear*, choosing the picture of the pear would be reinforced, while choosing the picture of the apple would not be reinforced. Correct selections on both trial types would indicate that the child had learned one arbitrary-conditional discrimination. Such behavior (i.e., word-picture matching) is indicative of reading comprehension (e.g., Sidman, 1971, 1994).

Some Pioneering Research in Stimulus Equivalence

The First Experiment

In attempt to ascertain the minimum instruction necessary to establish reading comprehension, Sidman (1971) taught a 17-year-old boy with severe mental retardation a series of conditional discriminations which entailed training the participant to correctly select 20 printed three-letter words conditionally upon hearing their spoken referents (i.e., auditory-receptive reading). Prior to training, the participant was capable of selecting pictures that corresponded to their spoken referents (i.e., auditory comprehension) and of correctly naming pictures aloud (i.e., picture naming). However, he was unable to match printed words to their corresponding representational pictures (i.e., reading comprehension) and incapable of selecting the appropriate printed words upon hearing them spoken. Although training word-object or word-picture matching is customary procedure for teaching elementary children rudimentary reading comprehension, the participant in this study was only explicitly trained in auditory receptive reading. However, at the study's conclusion, the participant, previously thought to be incapable of transferring auditory-visual stimulus relations to purely visual relations, demonstrated reading comprehension of some 20 words, a phenomenon known today as stimulus equivalence. Because the participant was never explicitly trained in reading comprehension, these relations are considered to be emergent. The emergence of such performances is indicative of the formation of stimulus-equivalence classes. Stimulus-class members, although physically dissimilar, are mutually interchangeable.

A Systematic Replication

Sidman and Cresson (1973) conducted a similar study in an effort to provide additional support for previous studies that suggested the efficacy of auditory-visual learning in generating relatively basic reading comprehension skills in mentally retarded children. Using a procedure analogous to that employed in the aforementioned study, Sidman and Cresson taught two severely retarded boys, ages 18 and 19, auditory comprehension and auditory receptive reading. Participants were first taught word-word identity matching using 20 printed words. All words consisted of one syllable and were three characters long. Examples include the words *cat* and *cow*. Next, upon hearing each dictated sample word, participants were taught to select one of six variations of its appropriate picture. This task provided a measure of auditory comprehension, a skill that normally precedes visual comprehension or reading. Participants were then given a series of tests to measure any marked improvement in reading comprehension. Results indicated that auditory comprehension development alone was not enough to generate reading comprehension. Following this conclusion, the experimenters sought to replicate the results of a previous study conducted by Sidman (1971) using a similar paradigm with children more severely retarded than the original subject. Participants were taught conditional discriminations AB and AC with the A stimulus set consisting of 20 dictated words, the B stimulus set consisting of 20 corresponding pictures, and the C stimulus set consisting of 20 printed words. Subsequent testing was conducted to evaluate the emergence of AC, selecting the printed-word comparisons (C) that corresponded to the dictated-word samples (A), indicative of auditory receptive reading; the emergence of BC, selecting the picture choices (B) that corresponded to the picture samples (C), indicative of one form of reading comprehension; and CB, the reverse of the previously mentioned reading comprehension task. After learning the baseline conditional discriminations, both participants appeared to display significant transfer from learned auditory-visual stimulus equivalences to the purely visual equivalences that underlie reading comprehension.

The results of these studies discredited the previously accepted notion that individuals with mental retardation were simply incapable of achieving transfer from auditory comprehension to reading comprehension. Thus, previous problems in demonstrating reading comprehension in individuals with mental retardation were likely the result of ineffective teaching methods. Further, for the first time, the utility of stimulus-equivalence methodology had revealed itself, culminating in a rapid growth in research dedicated to understanding the processes that govern stimulus equivalence.

Stimulus-Equivalence Methodology

Studies concerning stimulus equivalence generally begin with teaching participants at least two interrelated, arbitrary conditional discriminations (e.g., *a*R*b* and *b*R*c*). This initial phase comprises baseline training and is commonly held to be the basis for the emergence of equivalence-class formation (Pilgrim, Chambers, & Galizio, 1995). Match-to-sample procedures, now a mainstay in laboratory studies of stimulus equivalence, are typically applied to train baseline discriminations, while subsequently providing for equivalence testing. A match-to-sample trial consists of presenting a participant with one of at least two possible sample stimuli, and then requiring the participant to make an observing response towards the stimulus (e.g., touching the stimulus). Following the appropriate observing response, the participant is presented with at least two additional stimuli simultaneously, commonly referred to as comparison stimuli. Next, the participant is required to select one of the comparison stimuli. Selections of the comparison stimulus designated as correct yield a reinforcer (e.g., candy), while selections of those designated as incorrect do not.

For example, consider a child who has been taught, using a match-to-sample procedure, to match the printed numeral *1* (Sample Stimulus A1) to the printed word *one* (Comparison Stimulus B1) and alternatively, to match the printed numeral *2* (Sample Stimulus A2) to the printed word *two* (Comparison Stimulus B2). Now suppose, in addition to learning AB, the child was also taught BC. Note that B stimuli are common to both conditional discriminations, that is, AB and BC are interrelated. Teaching the second conditional discrimination is accomplished in a manner procedurally identical to that employed to teach the first conditional discrimination. This might entail, for example, teaching the child to match the printed word *one* (Sample Stimulus B1) to the printed word *uno* (Comparison Stimulus C1) and alternatively, to match the printed word *two* (Sample Stimulus B2) to the printed word *dos* (Comparison Stimulus C2). Acquisition of AB and BC is demonstrative of the minimum baseline training requisite for equivalence testing.

Testing for Equivalence

According to Sidman and Tailby (1982), a conditional relation that tests positive for reflexivity, symmetry, and transitivity, in the absence of instruction or differential reinforcement, is an equivalence relation. Thus, probing for the emergence of these essential properties is critical to stimulus-equivalence methodology. Equivalence probes consist of reflexivity, symmetry, and transitivity trials presented in extinction.

Reflexivity

Determining if a conditional relation, R, is reflexive, can be accomplished through the application of a relatively simple test for identity matching. Proof of reflexivity would be evident if, after learning AB and BC as in the example provided above, the child is then able to match each stimulus to itself. For instance, upon presentations of the printed numeral *1* (Sample Stimulus A1), selections of the same image from among several printed numerals (i.e., matching A1 to A1) would offer proof of reflexivity. Matching A2 to A2, B1 to B1, and B2 to B2 during subsequent reflexivity probes would provide additional support for the emergence of reflexive relations.

Symmetry

To determine if a conditional relation, R, is symmetric, the experimenter must present baseline comparison stimuli as sample stimuli and thus, baseline sample stimuli as comparison stimuli. This permits the experimenter to gauge whether or not the baseline relations hold under conditions in which the sample and comparison stimuli change functions. Proof of symmetry would be evident if, after learning AB and BC, upon presentations of the printed word *one* (Sample Stimulus B1), the child is then able to select the printed numeral *1* (Comparison Stimulus A1) from among several printed numerals (i.e., matching B1 to A1). Matching B2 to A2, C1 to B1, and C2 to B2 during subsequent symmetry probes would provide additional support for the emergence of symmetric relations.

Transitivity

Proof of transitivity would be evident if, after learning AB and BC, when presented with the printed numeral *1* (Sample Stimulus A1), the child is then able to select the printed word *uno* (Comparison Stimulus C1) from among several printed Spanish number words (i.e., matching A1 to C1). Similarly, upon presentations of the printed numeral *2* (Sample Stimulus A2), a child who is then able to correctly select the printed word *dos* (Comparison Stimulus C2) from among several printed Spanish number words (i.e., matching A2 to C2), has demonstrated transitivity. Thus, in this case, positive tests for reflexivity, symmetry, and transitivity would provide the necessary criteria for demonstration of the establishment of equivalence classes A1B1C1 and A2B2C2.

Equivalence

It is also possible to evaluate symmetry and transitivity concurrently. Such a test has been referred to as a test for equivalence or a combined test for equivalence. Proof of equivalence would be evident if, after learning AB and BC, when presented with the printed word *uno* (Comparison Stimulus C1), the child is then able to select the printed numeral *1* (Sample Stimulus A1) from among several printed numerals (i.e., matching C1 to A1). Depending on the prevailing training structure, a combined test may be the only means by which to assess transitivity. That is, testing solely for transitivity is not possible under all circumstances. If, for instance, a child has been taught AB and AC, rather than AB and BC, proof of transitivity simultaneously yields proof of symmetry. Thus, it is not possible to test for one without the other.

Why Study Stimulus Equivalence?

Verbal Behavior

The possibility that stimulus equivalence is germane to verbal behavior and category formation has fueled research efforts in stimulus equivalence for over thirty years. Thus, a great deal of modern thought regarding the processes that govern verbal behavior and the ways in which it should be characterized stem from researchers working in the area of stimulus equivalence (e.g., Hayes, Fox, Gifford, Wilson, Barnes-Holmes, & Healy, 2001; Horne & Lowe, 1996; Sidman, 1994). Sidman has argued that stimulus equivalence is a key determinant in the use of such expressions as *meaning*, *symbol*, *referent*, and *rule governed* (Sidman, 1992, p. 20) and that stimulus equivalence is a prerequisite to linguistic behavior (Sidman, 1994). Others have suggested that stimulus equivalence is the defining property of symbolic behavior (e.g., Dugdale & Lowe, 1990, p.115). Invariably, there are gaps and conflicting ideas in our understanding of exactly how stimulus equivalence relates to language. Even so, considerable progress has been made and current behavior analysts are more enthusiastic then ever about the research area of stimulus equivalence.

Application

Education

Equivalence procedures offer a tremendous advantage in terms of teaching efficiency, seemingly minimizing input while simultaneously maximizing output. For example, merely training AB and BC establishes the prerequisite for the emergence of the following stimulus relations: AA, BB, CC, BA, CB, AC, and CA. For this reason, equivalence procedures are especially advantageous and have proven to be particularly effective in teaching individuals with MR and language limitations a variety of skills, namely, reading comprehension (e.g., Sidman, 1971, 1973). Moreover, when traditional teaching approaches prove futile, methods derived from equivalence research may offer some useful alternatives (e.g., Stromer, Mackay, & Stoddard, 1992).

Clinical

Some researchers (e.g., Hayes & Wilson, 1993) have suggested that stimulus equivalence can play a significant role in the development of a variety of psychological disorders (e.g., anxiety and depression), and therefore, potentially in their treatment. For example, those who view stimulus equivalence as a fundamental behavioral process that underlies language and other symbolic behavior, contend that verbal stimuli attain their psychological function through their involvement in an equivalence relation with the events they represent (Dougher & Hackbert, 1994). In this way, verbal statements may come to exert stimulus control over one's behavior. This effect has been demonstrated in the laboratory when verbal statements are used in the induction of mood states (e.g., Velten, 1968). Fortunately, equivalence classes can be brought under contextual control. Thus, research involving stimulus equivalence and its potential benefits in clinical settings, though limited at this time, may offer a promising alternative to treating psychological disorders.

Emergent Behavior

In addition to stimulus equivalence, a vast array of significant phenomena (e.g., symbolic behaviors) is characterized by emergent behavior. Yet, until recently, emergent, or creative behaviors were often regarded as non-reproducible and thus, impossible to study (Sidman, 1971). Clearly, this is no longer the case. Time and again equivalence procedures have proven to be a reliable and effective tool in the production and observation of emergent behaviors in the carefully controlled domain that is the scientific laboratory. Researchers no longer have to speculate about what gives rise to novel behaviors or waste precious resources waiting for them to materialize.

On the Origins of Stimulus Equivalence

What exactly is responsible for generating equivalence relations? The scientific community has offered several plausible theories. Three prominent theoretical explanations exist concerning the origins of stimulus equivalence. Proponents of the major theories include Horne and Lowe with their naming account (e.g., 1996), Hayes et al. with their relational frame account (e.g., Hayes et al., 2001), and Sidman with his reinforcement contingency account (e.g., 2000).

Equivalence and Naming

Horne and Lowe (1996) have suggested that verbal behavior, specifically naming, is critical to the establishment of stimulus-equivalence relations. In other words, they see naming as a prerequisite for equivalence. Moreover, Horne and Lowe argue that equivalence is no more than an outcome resulting from the relation that exists between multiple stimuli via a common name. Therefore, equivalence is but one example of emergent behavior made possible by naming.

Horne and Lowe (1996) have chosen the term *name* to indicate a basic behavioral unit and have carefully described what leads to naming and how it may give rise to stimulus equivalence. In order to establish what actually constitutes an instance of naming, one must consider both speaker and listener behavior. Naming involves both, in that the speaker is able to respond as a listener to his or her own speaking. Thus, naming is a circular or bidirectional relation that is directly trained. For example, a child seeing an object (e.g., a bottle of juice), saying “juice,” hearing his own utterance, and then seeing or attending to the object again, represents such a bidirectional relation.

In the natural environment a child learns to assign common names to groups of objects through the verbal community. Ultimately, via a common name, these groups of objects become functional and even equivalent stimulus classes. Horne and Lowe (1996) contend that this process occurs through one of two mechanisms. One mechanism involves the child assigning a common name, either overtly or covertly, to several different stimuli. The result is the formation of an equivalence class comprised of any number of stimuli related by a common name. Another possibility involves the child learning a sequence of verbal responses. This occurs when the child assigns a different name to each member of a class and learns intraverbal relations among names of the stimulus-class members. Emitting the name of any stimulus within a class comes to control the emission of others within that same class and this, in turn, allows for correct comparison selection.

Equivalence and Derived Relational Responding

Proponents of the Relational Frame Theory postulate that stimulus relations held to be emergent are actually learned (Hayes et al., 2001). Learned and abstracted relational responding occurs when an organism responds based on relational rather than absolute characteristics of stimuli. Multiple exemplar training, initially based on the absolute properties of stimuli, allows for the abstraction of a multitude of relations. Equivalence relations are but one example of such relational responding. A child who has been taught, for example, that an elephant is bigger than a cat would initially have to guess if asked to indicate which they believed to be smaller: the elephant or the cat. However, following enough pairings of the relational frames that are *bigger than* and *smaller than* with a variety of stimuli, the child would eventually be able to derive the *smaller than* relation given the *bigger than* relation when asked the same question in reference to novel stimuli. Further, if the child has truly learned to derive the *smaller than* relation given the *bigger than* relation, he/she should be able to apply this frame in circumstances where the novel stimuli do not include the absolute properties of *bigger than*. An organism's ability to demonstrate evidence of transformation of stimulus functions once a relation is learned is perhaps the most critical defining feature of Relational Frame Theory. Further, once responding is brought under contextual control, contextual cues should provide the necessary means to allow for an organism to arbitrarily apply an abstracted relational frame to any given stimuli. In short, relational frame theorists contend that equivalence relations represent only one of many types of relations that may be abstracted and applied in accordance with the prevailing context.

Equivalence and the Reinforcement Contingency

According to Sidman (2000), the reinforcement contingency, and that alone, provides the prerequisite for demonstrating stimulus equivalence. Moreover, equivalence is an automatic outcome of the reinforcement contingency. Equivalence relations represent an automatic outcome in the sense that they are not explicitly trained. Further, Sidman contends that equivalence is a fundamental stimulus function not derivable from more simple behavioral processes.

The reinforcement contingency produces analytic units (e.g., two-term, three-term, four-term contingencies, etc.), but Sidman suggests that an additional outcome of the reinforcement contingency is the emergent analytic units that comprise an equivalence relation; that is, the new, yet predictable, conditional discriminations that humans perform on equivalence tests. Further, Sidman maintains that equivalence relations consist of the “ordered pairs of all positive elements that participate in the contingency” (p. 128). For example, given a conditional discrimination, the equivalence class would potentially consist of the conditional stimulus, the discriminative stimulus, the response, and the reinforcer. However, although initially the equivalence relation does include all elements of the contingency, as Sidman points out, this is often only temporarily the case. This is presumably the case for training procedures that employ a common reinforcer (i.e., providing a single reinforcer for all correct responses irrespective of the antecedent stimuli). For example, if trained to perform AB and AC via a single reinforcer, the common element (i.e., the reinforcer) will cause the stimuli to collapse into one, large equivalence class. Thus, all A, B, and C stimuli would become equivalent to one another. For Sidman’s theory to hold, if the two possible outcomes of the reinforcement contingency should come into discord, the analytic unit must assume priority over the equivalence-class formation. If this occurs, the common reinforcer must drop out of the equivalence relation. However, when no such conflict exists, the equivalence relation does include all elements of the contingency, as has been confirmed by numerous studies that have employed outcome-specific reinforcers or class-specific reinforcers (Dube & McIlvane, 1995; Dube, McIlvane, Mackay, & Stoddard, 1987; Dube, McIlvane, Maguire, Mackay, & Stoddard, 1989; McIlvane, Dube, Kledaras, de Rose, & Stoddard, 1992). While traditional conditional-discrimination procedures utilize a single reinforcer to train stimulus-stimulus relations (i.e., sample-comparison relations), employing class-specific reinforcement entails providing a reinforcer specific to each stimulus-stimulus relation (e.g., selecting Comparison B1 given Sample A1 produces Reinforcer 1, while selecting Comparison B2 given Sample A2 produces Reinforcer 2).

Class-Specific Reinforcement

It is not uncommon to speak of reinforcers in terms of the strengthening function they serve in establishing conditional discrimination behaviors. However, discrimination-training procedures utilizing class-specific reinforcement have yielded several additional noteworthy and reliable effects. As a result, much attention has been given to the examination of how class-specific reinforcement procedures influence the nature of conditional relations.

Indeed, a number of studies have demonstrated that class-specific reinforcement procedures facilitate acquisition of conditional discriminations in both animals (e.g., Carlson & Wielkiewicz, 1976) and humans (e.g., Schomer, 2001). Moreover, it has been reported in the animal literature that specific reinforcer relations are critical to the maintenance of conditional discrimination behaviors (Honig, Matheson, & Dodd, 1984; Peterson & Trapold, 1980, 1982; Peterson, Wheeler, & Armstrong, 1978). Finally, it has been shown that class-specific reinforcers often play a substantial role in the formation of stimulus-equivalence classes, more so for humans (e.g., Dube et al., 1987), but in a few instances for animals as well (e.g., Kastak, Schusterman, & Kastak, 2001).

Effects on Acquisition of Conditional Discrimination

In 1970, Trapold conducted one of the first experiments designed to examine the effects of class-specific reinforcement on the acquisition of conditional discriminations. During the first experiment in this two-part study, 24 experimentally naive rats were randomly assigned to one of two groups Experimental (E) or Control (C), prior to conditional-discrimination training. Each trial began with the onset of either a tone or clicker. Seconds later subjects were presented with two retractable levers. Depressing the right bar was designated correct on tone trials and depressing the left bar on clicker trials. Incorrect responses were never reinforced. For half of the subjects in Group E, correct responses to the tone were reinforced with food and correct responses to the clicker were reinforced with sucrose. The stimulus-reinforcer relations were the exact opposite for the remaining subjects. For subjects in Group C, a single reinforcer followed correct responses to the tone and clicker. Half of all subjects in this condition received food following all correct responses, while the remaining subjects received sucrose following correct responses. Though all subjects performed fairly well across both conditions, subjects trained with class-specific reinforcement (Group E) learned the discrimination task more quickly. An analysis of variance revealed a significant main effect of difference between groups ($p < .01$). Further, upon a comparison to each of the separate control conditions, Group E scores were shown to be significantly superior in both cases ($p < .05$ for Group C food condition; $p < .001$ for Group C sucrose condition).

In the second experiment, sixteen experimentally naive rats were exposed to stimulus pairings of the tone and clicker stimuli with either food or sucrose (pretraining) prior to conditional-discrimination training. Next, subjects were randomly assigned to one of two groups, Facilitation (F) or Interference (I). During conditional-discrimination training for subjects in Group F, the stimulus-reinforcer relations were consistent with those in place during pretraining. For subjects in Group I, however, the stimulus-reinforcer relations were exactly the opposite of those in place during pretraining. As the author had predicted, Group F learned the discrimination task at an accelerated rate compared to Group I.

Litt and Shreibman (1981) observed a similar effect on the conditional-discrimination peformances of humans. Using three different reinforcement procedures, five nonverbal autistic boys were taught two-choice receptive label discriminations with a variety of novel objects. Prior to the experiment, reinforcer assessment tests were conducted to determine the edible reinforcer of most salience (i.e., most highly preferred) to each individual child. Moreover, a less salient, but equally desirable pair of edible reinforcers was determined on an individual basis. Next, all participants underwent conditional-discrimination training in one of three conditions: a stimulus-specific reinforcer condition (class-specific), a salient reinforcer condition, or a varied reinforcer condition. Barring the reinforcement procedure, the task across all three conditions was identical. On any given trial, two novel objects were positioned in front of the participant and the experimenter instructed the participant to "Give me____" (stimulus object). In both the stimulus-specific reinforcer and varied reinforcer conditions, correct responses produced either one of two reinforcers determined to be of equal desirability to the participant. For participants in the stimulus-specific reinforcer condition, correct responses were followed by a reinforcer specific to the stimulus; that is, the sample stimulus reliably predicted the outcome. In contrast, for participants in the varied reinforcer condition, both sample stimuli were associated with each outcome equally. Moreover, for participants in the salient reinforcer condition, all correct responses produced a single reinforcer, the reinforcer predetermined to be most salient for each child. Individual and statistical analyses suggested that both the stimulus-specific reinforcer and the varied reinforcer conditions yielded superior performance compared to that of the salient reinforcer condition. These results undermine the findings of previous studies (e.g., Stark, Giddan, & Meisel, 1968), which suggest that it is in fact the salience of reinforcement that is responsible for the enhanced rates of acquisition observed with class-specific reinforcement. Further, the stimulus-specific reinforcer condition proved to be the most facilitative followed by the varied reinforcer and the salient reinforcer conditions, respectively, eliminating the possibility that it was simply the use of multiple reinforcers rather than class-specific reinforcers that was responsible for the differences in acquisition rates.

During another relevant study, in examining the arbitrary conditional-discrimination performances of 14 normally developing children, ages 4 to 10, Schomer (2001) observed the facilitative effect of class-specific reinforcement. Participants were randomly assigned to one of two groups. Eight participants received conditional-discrimination training with class-specific reinforcers, while the remaining six received conditional-discrimination training with a single reinforcer. All training, which entailed teaching participants to match abstract shapes to one another, was conducted on computers equipped with specialized match-to-sample software (Dube, 1991). Correct responses for participants in the class-specific reinforcer group were followed by one of three corresponding computer-generated auditory-visual displays. Correct responses for participants in the single reinforcer group, however, always yielded a single computer-generated auditory visual display consisting of multicolored stars. Participants trained with class-specific reinforcers readily acquired baseline conditional discriminations. In contrast, participants trained with a single reinforcer showed no signs of acquisition. Nonetheless, during subsequent training with class-specific reinforcers, all six of the participants exhibited a trend towards acquisition within five sessions and met criterion quickly thereafter.

Effects on Maintenance of Conditional Discrimination

In the animal literature, at least one additional noteworthy effect has been reported regarding the function of reinforcers. That is, in addition to their facilitative effect on conditional discrimination acquisition, at least in some instances, class-specific reinforcers appear to be critical not only to the establishment but also to the maintenance of conditional discrimination behaviors (Honig et al., 1984; Peterson & Trapold, 1980, 1982; Peterson et al., 1978).

Peterson et al. (1978) conducted one of the first experiments designed to investigate whether reinforcers play a fundamental role in the maintenance of conditional discriminations. Using a delayed match-to-sample procedure, four pigeons were trained to perform a two-choice conditional discrimination. Subjects were taught to select comparison stimuli, either a vertical line or a horizontal line, conditionally upon the presentation of either a red or a green sample stimulus. For two subjects, selections of the horizontal line in the presence of a red light were followed by water, while selections of the vertical line in the presence of a green light were followed by food. For the other two subjects, selections of the horizontal line in the presence of the red light were followed by food, while selections of the vertical line in the presence of the green light were followed by water. Incorrect responses produced no reinforcement and delayed the onset of the next trial by 5 s. Training during this particular phase continued for at least 12 sessions and until subjects performed at 90% or above accuracy on three consecutive sessions. Next, the stimulus-reinforcer relations were reversed so that the stimulus-stimulus relations that had previously yielded food now yielded water. Likewise, the stimulus-stimulus relations that had previously yielded water now yielded food. Performance averaged 95% correct (range 89%-100%) on the session immediately preceding outcome-reversal training. Interestingly, on the first session of outcome-reversal training performance averaged 75% correct (range 65%-85%). Moreover, within six sessions all subjects were performing at chance level, or very close to it, though after the original training procedure was reinstated, performances recovered. For all four subjects, chance performance during outcome-reversal training appeared to be due to the development of a preference for the comparison stimulus that yielded food.

Peterson and Trapold (1980) used class-specific reinforcers to teach 16 pigeons to perform a two-choice conditional discrimination via a delayed match-to-sample procedure. Subjects were required to key-peck choice stimuli conditionally upon the presentation of a color cue or sample. Once a high level of correct responding was achieved, subjects were exposed to non-contingent delivery of reinforcers following sample presentations. For half the subjects (Same Group), the sample stimulus-reinforcer relations were identical to those previously established. For the remaining subjects (Opposite Group), the sample stimulus-reinforcer relations were exactly the opposite. Upon the completion of nine sessions, subjects again underwent conditional-discrimination training. For all subjects, the outcomes were the reverse of what they had been in the original conditional discrimination problem. Additionally, for half of each of the above groups, the stimulus-reinforcer relations remained the same as in the original conditional discrimination problem (i.e., Same/Original Group and Opposite/Original Group) and for the other half of each group; the stimulus-reinforcer relations were reversed (i.e., Same/Reversal Group and Opposite/Reversal Group). For the Opposite/Reversal Group, the original stimulus-stimulus relations were readily disrupted and subjects conformed quickly to the new conditional discrimination contingencies. Subjects in the Same/Reversal and Opposite/Original groups initially did very poorly when exposed to the new contingencies, but gradually improved over a number of sessions. Subjects in the Same/Original Group initially performed the conditional-discrimination task at a fairly high level of accuracy, but performance rapidly deteriorated to chance. However, this group also eventually achieved high levels of accurate responding after a number of sessions. Exposing subjects to non-contingent, reversed outcomes following conditional-discrimination training had a profound effect on choice responses. Opposite Group subjects performed much more accurately when the stimulus-reinforcer relations in the second conditional discrimination problem were the reverse of those in the original conditional discrimination problem, versus when they remained the same. This finding is likely attributable to the pairing of samples with reversed outcomes. Additionally, the effects of outcome-reversal training were evident in the deterioration of accurate responding found in the Same/Original Group. For this group, reversing the outcomes while maintaining the original stimulus-stimulus relations disrupted accurate responding, as was the case in the aforementioned study conducted by Peterson et al. (1978).

In 1982, Peterson and Trapold observed a similar effect. Sixteen pigeons were taught two two-choice conditional discriminations with a delayed match-to-sample procedure. One was red/green identity matching where subjects were taught to match each stimulus to its self (i.e., red to red and green to green). The other entailed teaching subjects to select comparison stimuli, either a vertical line or a horizontal line, conditionally upon the presentation of either a red or a green sample stimulus. Pecking the vertical line was denoted as correct following the presentation of a red light and pecking the horizontal line was denoted as correct following the presentation of a green light. Correct selections were followed by either a 3 s access to grain or a 0.75 s tone contingent on the subject's assignment to one of two groups of eight. For subjects in the Congruent Group, the sample reliably predicted the outcome. Subjects in this group were further divided into two groups of four. One group received food following correct responses on trials in which the sample stimulus was red and the tone following correct responses on trials in which the sample stimulus was green. For the other group, the stimulus-reinforcer relations were the exact opposite. For subjects in the Incongruent Group, each sample was associated with each outcome equally. That is, the outcome that followed a particular sample stimulus (red or green) on color-choice trials was opposite that of the outcome that followed that same sample stimulus (red or green) on line-choice trials. Correctly selecting the red comparison stimulus during identity-matching trials yielded food, as did correctly selecting the horizontal comparison stimulus. Conversely, correctly selecting the green comparison stimulus during identity-matching trials yielded the tone, as did correctly selecting the vertical comparison stimulus. Following from the results, it is clear that subjects in the Congruent Group learned both baseline conditional discriminations to a much higher degree of accuracy (roughly 100% vs. 80% for the Incongruent Group) as indicated by a significant main effect of group, $F(1, 14) = 94.54$, $p < .001$.

During Phase Two of this experiment, the reinforcement procedure was reversed for the two groups. During the reversal, the sample reliably predicted the outcome for the Incongruent Group as it had before the reversal for the Congruent Group. Conversely, the sample was associated with each outcome equally for the Congruent Group, as it had been before the reversal for the Incongruent Group. A significant group main effect, $F(1, 14) = 261$, $p < .001$, indicated a difference between groups following the reversal. Performance on both conditional discriminations for subjects in the Incongruent Group increased to a level similar to that attained by subjects in the Congruent Group during baseline (roughly 100%). For subjects in the Congruent Group, however, performance on both conditional discriminations deteriorated. While performance on the line problem decreased over about 12 sessions to around 80% accuracy, interestingly, performance on the color problem decreased much more quickly (within the first reversal session) and more significantly (to roughly 60% accuracy). Further research is needed to elucidate this difference.

A study conducted by Honig et al. (1984) found more evidence of this effect. Via delayed match-to-sample training, three groups of pigeons learned to perform two conditional discriminations. Subjects were taught to select a vertical line following the presentation of either a green or blue light and to select a horizontal line following the presentation of either a red or white light. Correct responses were reinforced with either food or water depending on the trial type. For subjects in the Consistent Group, correctly selecting the vertical and horizontal line consistently yielded food and water, respectively. For subjects in the Inconsistent Group, correctly selecting the vertical line following the presentation of the green light yielded food, while correctly selecting the vertical line following the presentation of the blue light yielded water. The reinforcement relations were exactly the opposite for correct selections of the horizontal line. For subjects in the Random Group, correct selections of the vertical and horizontal line were followed randomly and equally often by either food or water. Acquisition for subjects in the Consistent Group was faster and more pronounced than that of subjects in either the Inconsistent or Random Groups.

During the second phase of the experiment, reinforcement contingencies (but not discriminative contingencies) were changed for the blue-white conditional discrimination. For subjects in the Consistent Group, correct responses were now reinforced inconsistently. In contrast, for subjects in the Inconsistent and Random Groups, correct responses were now reinforced consistently. Following the transition, performance of subjects previously in the Consistent Group dramatically deteriorated. Interestingly, performance on both conditional discriminations declined even though reinforcement contingencies only changed for one of the conditional discriminations. In contrast, performance of subjects previously in the Inconsistent and Random Groups slightly improved following the transition. Additionally, after the previous reinforcement procedure was reinstated for the Consistent Group, though not immediately, all subjects demonstrated marked improvement in their performance.

Effects on Equivalence-Class Formation

Until recently, the primary focus of studies involving stimulus-class formation has been the stimulus-stimulus relations demonstrated in match-to-sample procedures (e.g., Sidman & Tailby, 1982). In the case of the conditional discrimination, the stimulus-stimulus relations of interest involve the conditional and discriminative stimuli, or the sample and comparison stimuli as they are referred to in match-to-sample procedures. While this level of analysis may be sufficient for some experiments, this is not always the case, particularly for studies that do not involve a single defined response or reinforcer. When conditional-discrimination training requires class-specific responses (i.e., differential responding to the discriminative stimuli) or involves the use of class-specific reinforcers, further analysis is paramount to determine what role, if any, these elements play in stimulus-class formation. To date, few studies have considered the role of the response due to the procedural difficulties inherent to experiments of this nature; however, a number of studies have investigated the role of the reinforcer in equivalence-class formation (e.g., Ashford, 2001; Dube et al., 1987; Schenk, 1994).

A relevant study conducted by Kastak et al. (2001) showed that nonhuman animals, specifically, California sea lions, are capable of demonstrating equivalence classes. In the first experiment, two California sea lions were taught a series of two-choice simple discriminations. Stimulus pairs consisted of one letter and one number. Correct responses (i.e., a nose poke on the appropriate choice stimulus) produced a tone accompanied by a fish, while incorrect responses produced the vocal signal "no." Depending on the phase, correct responses produced either random reinforcement (i.e., correct responses produced a tone and either one of two fish irrespective of the antecedent stimulus) or class-specific reinforcement (i.e., correct responses produced either a high or low pitched tone and a specific fish). Following acquisition of all discriminations, the reinforcement contingencies were reversed so that selections of stimuli previously designated as incorrect now produced a reinforcer. Conversely, selections of stimuli previously designated as correct no longer produced a reinforcer. Training in this phase continued until subjects again met criterion. The reinforcement contingencies were alternated several more times in this fashion, and responses on the first trial following each reversal were of particular interest to the experimenters. Eventually, during training phases that employed class-specific reinforcement, both subjects began to respond in a manner consistent with the contingencies in place within only a few trials following each reversal. Interestingly, performances consistently declined during training phases that employed random reinforcement.

In the second experiment, the sea lions were tested to see if the functional classes established via the simple-discrimination reversal procedure would provide for conditional discriminations in a match-to-sample procedure. During the first phase of Experiment Two, a match-to-sample procedure and class-specific reinforcers were employed to establish a baseline of familiar conditional discriminations with a subset of stimuli used in a previous experiment (Schusterman & Kastak, 1993). Transfer tests containing novel combinations of letter or number stimuli were then administered to evaluate whether the functional classes, established during Experiment One, would transfer to a match-to-sample procedure. On transfer test trials, the selection of a letter or number conditionally upon the presentation of another letter or number, respectively, produced a class-specific reinforcer. Subjects' performance on each initial novel conditional discrimination served as the primary measure of transfer. Overall, performances on transfer tests were indicative of the transfer of class members to conditional discriminations.

The final experiment was conducted to determine if equivalence relations could be established via functional class members that share common stimulus and reinforcer relations. During the first phase of Experiment Three, a new letter and number was added to the existing functional classes. Subsequent testing documented the emergence of untrained relations between the new stimuli and the remaining members of each functional class. Next, additional tests were conducted to evaluate whether similar reinforcer relations between novel stimuli and equivalence class members would provide for class expansion to include the novel stimuli. Simple discrimination training was conducted with the training stimuli utilized in Experiment Two. For one sea lion, when selections of letter stimuli were designated as correct, correct responses produced a class-specific tone and capelin; and when selections of the number stimuli were designated as correct, correct responses produced a different class-specific tone and herring. For the other sea lion, the reinforcing contingencies were exactly the opposite. On test trials, both subjects learned to make selections based on the reinforcer produced by the positive functional class. Further, during the final round of testing, training stimuli utilized in the second experiment were combined with functional classes to produce novel conditional discriminations. Both subjects learned to match training stimuli to the functional class member that shared a common reinforcer on a majority of test trials.

A series of experiments conducted with humans (Dube et al., 1987) documented similar findings regarding reinforcers and equivalence classes. For example, after conditional-discrimination training with class-specific reinforcement, participants' performances on subsequent reinforcer probes (see below) were flawless suggesting that reinforcers can become equivalence class members. Further, additional findings suggested that stimulus-equivalence classes could be expanded solely on the basis of stimulus-reinforcer relations. During the first experiment, two mentally retarded adults, ages 23 and 43, were taught identity matching with two sets of stimuli, each containing two printed symbols (S1 and S2), two objects (O1 and O2), and two food items (F1 and F2). Correct selections of S1, O1, and F1 were consequated with F1, while correct selections of S2, O2, and F2 were consequated with F2. Additional baseline training, again conducted with class-specific reinforcement, introduced an additional set of stimuli (stimuli N1 and N2, representing two dictated names) and documented either NS and OS (Participant 1) or NO and OS (Participant 2) conditional discriminations. For Participant 1, correct matches of S1 to N1 and S1 to O1 yielded F1, while correct matches of S2 to N2 and S2 to O2 yielded F2. For Participant 2, correct matches of O1 to N1 and S1 to O1 yielded F1, while correct matches of O2 to N2 and S2 to O2 yielded F2. During subsequent equivalence tests, performance on symmetry and transitivity probes was class consistent. In addition to the traditional equivalence probes, participants received reinforcer probes. On reinforcer probe trials, reinforcers were presented as samples or comparisons. For both participants, performance on reinforcer probes was class consistent, indicating that the reinforcers had become class members.

During the second experiment, two novel objects (X1 and X2) were included in identity-matching trials. Correct selections of X1 and X2 were followed by F1 and F2, respectively. Although X stimuli were never displayed in conjunction with the S, O, or N stimuli, additional tests showed that the classes had in fact expanded to include X stimuli. Next, the reinforcement contingencies for all X stimuli were reversed so that correct selections of X1 and X2 were now followed by F2 and F1, respectively. All other contingencies remained as before. Subsequent testing documented the disruption of previous X stimulus-class membership for both participants though, eventually, their performances became consistent with the reversed contingencies.

During a systematic replication of their previous work, Dube et al. (1989) showed that reinforcers without explicitly established match-to-sample functions could become stimulus-class members. Two moderately mentally retarded males, ages 20 and 14, were taught identity matching with two sets of arbitrary stimuli (A1, B1, C1, D1 and A2, B2, C2, D2). Correct selections of A1, B1, C1, and D1 were consequated with R1, while correct selections of A2, B2, C2, and D2 were consequated with R2. Additional baseline training documented AB and BC conditional discriminations. Correct selections of B1 and C1 given A1 and B1, respectively, were followed by R1, while correct selections of B2 and C2 given A2 and C2, respectively, were followed by R2. During subsequent testing, both participants demonstrated equivalence classes A1B1C1 and A2B2C2. Moreover, although D stimuli were never displayed in conjunction with A, B, or C stimuli, additional tests showed that the classes had in fact expanded to include D stimuli yielding equivalence classes A1B1C1D1 and A2B2C2D2.

Next, the experimenters reversed the outcome for all D stimuli so that correct selections of D1 and D2 were now followed by R2 and R1, respectively. All other contingencies remained as before. Additional testing documented the disruption of previous D stimulus-class membership following the reversal. Given that the reinforcers were devoid of explicitly developed sample or comparison functions, and that class disruption followed the reversal, these results strongly indicate that the stimulus-reinforcer relations were indeed responsible for the expansion of stimulus classes to include D stimuli.

Ashford (2001) examined the role of the reinforcer in the equivalence performances of four developmentally disabled children. Using a match-to-sample procedure, participants were taught to perform either AB and AC conditional discriminations or AB and CD conditional discriminations. Correct responses produced both a class-specific primary reinforcer and a class-specific conditioned reinforcer. All participants demonstrated the conditional discriminations rapidly, and during subsequent testing, performance on reflexivity and symmetry probes was class consistent. For the participants trained to perform the two unrelated conditional discriminations (AB and CD), testing for the emergence of transitivity or equivalence was not possible. However, for participants trained to perform AB and AC conditional discriminations, performance on equivalence probes proved to be class consistent, thus, documenting the formation of stimulus-classes A1B1C1, A2B2C2, and A3B3C3. Following baseline training, reinforcer probe testing was conducted to assess whether the primary and conditioned reinforcers had become independent class members. Of the participants that had received AB and CD baseline training, only one responded class consistently on class-formation probes, indicating that for that participant, the class-specific reinforcers acted as nodes for class membership across the unrelated conditional discriminations. Both the participants that had received AB and AC baseline training performed class consistently on reinforcer probe tests. Moreover, the reinforcer-probe performances of all three of these participants indicated that both the class-specific primary and conditioned reinforcers had become equivalence-class members. Next, participants begin identity-matching training with new stimuli (E and F). Correct responses on these trials produced either only a class-specific primary reinforcer or a class-specific, auditory-visual conditioned reinforcer. After the participants met acquisition on these trials, they were exposed to class-expansion probes, followed by sound probes, to assess for membership of the auditory component of the conditioned reinforcers. All participants quickly met acquisition criteria on class-expansion probes, suggesting that the individual elements of the class-specific reinforcers had acted as nodes for class membership following identity-matching training. These results, as well as those of the previously mentioned studies, indicate that reinforcers can act as fully functioning class members.

Purpose of the Present Study

As mentioned earlier, previous studies have demonstrated that outcome-specific reinforcers facilitate acquisition of conditional discrimination in both animals (e.g., Carlson & Wielkiewicz, 1976) and humans (e.g., Schomer, 2001). Moreover, studies conducted with pigeons have shown that stimulus-reinforcer relations are critical to the maintenance of conditional discriminations (Honig et al., 1984; Peterson & Trapold, 1980, 1982; Peterson et al., 1978). Yet, to date, no study has examined the effects of outcome-reversals on the conditional discrimination and equivalence performances of humans. Experiment 1 of the present study was designed in an effort to determine whether class-specific reinforcers are critical to the maintenance of conditional discriminations in humans, specifically children. Using class-specific reinforcement, AB and AC conditional-discrimination training was conducted in 4 phases. Upon mastery of the AB conditional discrimination, the stimulus-reinforcer relations were reversed and performance was closely monitored for possible signs of disruption. Next, AC conditional-discrimination training was conducted, and again upon mastery, the stimulus-reinforcer relations were reversed as performance was monitored for disruption. Experiment 2 was conducted in an effort to examine how exposure to outcome-reversal training would effect equivalence-class formation. Studies have shown that class-specific reinforcers play a substantial role in the formation of stimulus-equivalence classes (e.g., Dube et al., 1987; Kastak et al., 2001). Reflexivity, symmetry, and equivalence probes were administered to evaluate equivalence-class formation following the outcome reversals. Further, in addition to the traditional probes for class formation, participants completed a series of reinforcer probes in order to ascertain whether the reinforcers became class members. Experiment 3 was conducted to see if the reinforcers would join the classes if participants repeated Experiments 1 and 2 without outcome reversals. Experiment 4 was conducted with a new set of experimental stimuli to determine whether consequential stimuli would join equivalence classes that had no history of outcome reversals.

CHAPTER 2. GENERAL METHOD

Setting and Materials

Testing was conducted in a quiet room located on school grounds five days a week or as often as permitted given absences and unforeseen schedule conflicts. Participants were encouraged to complete one to three sessions daily. Upon completion, participants received a primary reinforcer (e.g., a gummy fruit) and were permitted to select a sticker to place on a prize chart. Each time they earned five stickers on their prize chart, participants were allowed to select a toy from a prize box containing an assortment of age-appropriate toys. All participants were recruited through parent-permission packets (see Appendix A).

Apparatus and Stimuli

Participants were tested on either a Macintosh desktop or portable computer equipped with match-to-sample software (Dube, 1991). All training and testing was conducted using one of three sets of experimental stimuli (see Figure 1). Experimental stimuli were abstract black line drawings, approximately 1 in. by 1 in., presented against a white background. Table 1 shows experimental stimulus sets assigned to each participant during Experiments 1-4. Consequential stimuli were one of two sets of three flashing computer-generated auditory-visual displays, which were presented across the entire computer screen (see Figure 1). Unless otherwise indicated, all training was conducted using Consequential Stimulus Set 1.

General Procedure

Each match-to-sample trial began with the presentation of a sample stimulus, which appeared in the middle of the computer screen. Participants were required to make an

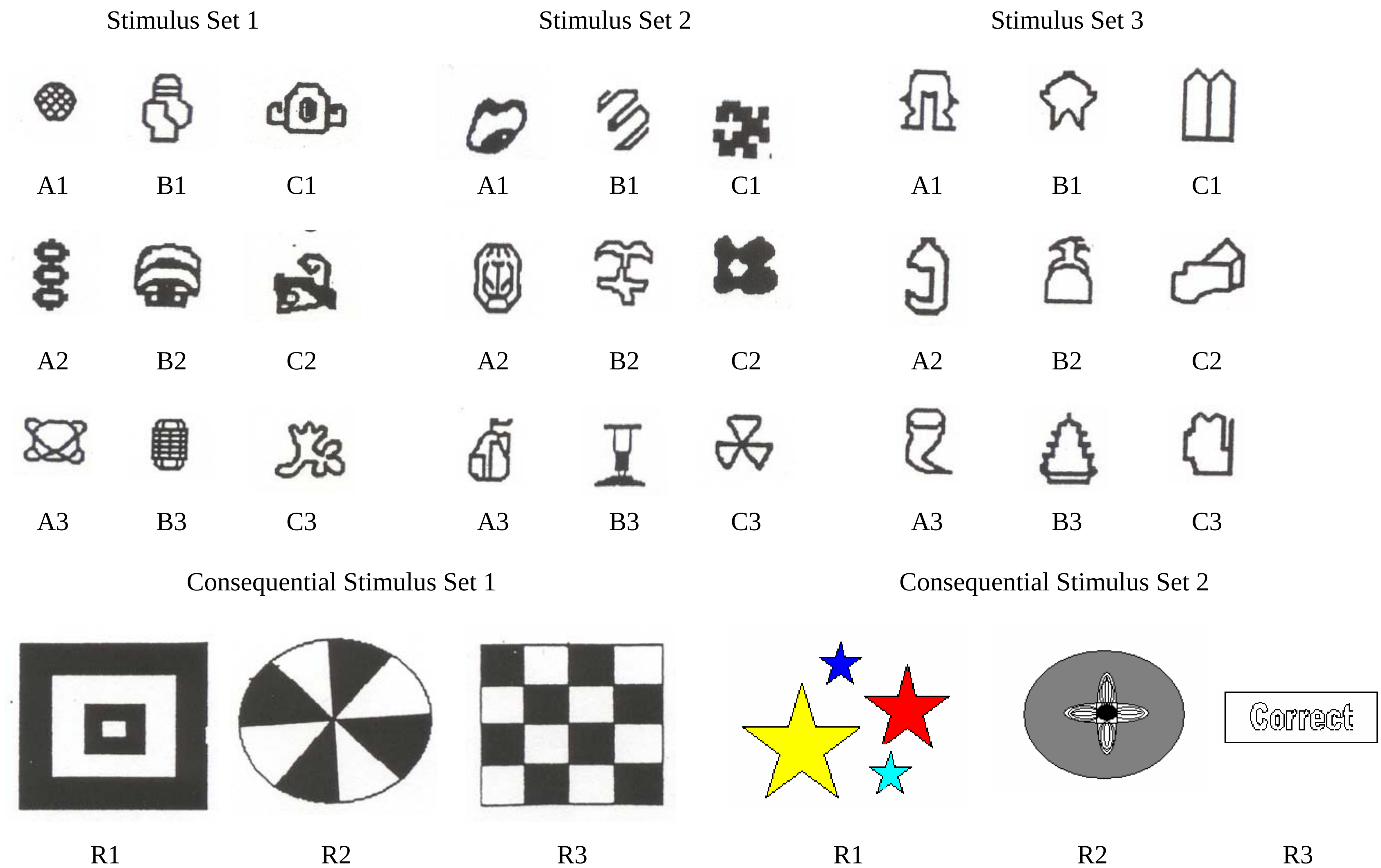


Figure 1. Experimental and consequential stimuli.

Table 1

Experimental Stimulus Sets Utilized by Each Participant

Participant	Experiment	Experimental stimulus sets
AJ	1	1
AM	1	1
AS	1	1
BG	1	1
BM	1	3
BP	1	1
BS	1	1, 2, and <u>3</u>
	2 and 3	3
DF	1	1
DP	1 and 2	<u>2</u>
DS	1	1
DW	1	1
GM	1, 2, and 3	<u>2</u>
	4[1]	3
GR	1	<u>1 and 3</u>
	2 and 3	3
JM	1	1
LK	1	1
LR	1, 2, and 3	<u>2</u>

Table 1 cont.

Participant	Experiment	Experimental stimulus sets
LR2	1	1
LS	1	1
LT	1	3
MH	1, 2, and 3	<u>1</u>
	4[1]	3
PL	1	2
SB	1	3
ST	1	1 and <u>2</u>
TG	1	1
TK	1, 2, and 3	<u>2</u>
ZM	1,2, and 3	<u>1</u>
	4[1]	3

Note. Underlined values indicate the experimental stimulus set utilized during mastery of Phase 1 of Experiment 1.
[1]Training was conducted using Consequential Stimulus Set 2.

observing response to the sample stimulus (i.e., depressing the mouse while the cursor was located over the sample stimulus) in order to produce the three comparison stimuli. Comparison stimuli appeared simultaneously, one each in three corners of the screen (i.e., simultaneous matching). Sessions were programmed such that: (1) each sample stimulus was presented equally often and no more than twice in a row, (2) each comparison stimulus was presented equally often and did not appear in the same location more than twice in a row, and finally (3) each comparison stimulus was presented in each location equally often and was designated correct equally often. Further, in a given trial block, each trial type was presented in a quasi-random sequence. On trials in which consequences were not programmed, responses were followed by a black computer screen for 1.5 s before the presentation of the next trial. On trials in which consequences were programmed, selecting a comparison stimulus designated as correct yielded one of three computer-generated auditory-visual displays (i.e., R1, R2, R3), while selecting a comparison designated as incorrect yielded an auditory buzz and a blank computer screen. Following the presentation of either consequence, the screen went blank for 1.5 s prior to the next trial presentation. Paper tally sheets (see Appendices B-C) were utilized to ensure that participants attended to each presentation of the consequential stimulus such that upon each presentation, participants were required to produce a tally mark under a 1.5 in. by 1.5 in. representation of the computer-generated display.

CHAPTER 3. EXPERIMENT 1

Method

Participants

Twenty-six normally capable children, 10 girls and 16 boys, began the experiment. All were experimentally naïve when the study began. Eight participants (MH, ZM, BS, DP, GR, TK, LR, and GM) completed all phases of the study and one (Participant ST) completed all but the last. The remaining 17 participants either withdrew from the school that served as the testing site, or required such extensive training that time did not permit them to complete the study. Data will not be reported for children who completed fewer than ten sessions (Participants AJ, AM, and PL). As shown in Table 2, children were aged from 3 years10 months to 8 years 7 months at the start of the study and most scored within the normal range on the Peabody Picture Vocabulary Test (PPVT).

Stimuli

Training and testing were conducted using one of three sets of experimental stimuli (see Figure 1). Table 1 shows the experimental stimulus set used by each participant.

Procedure

Prior to beginning the experiment, participants received mouse training, which consisted of the experimenter providing assistance with manipulating, pointing, and clicking the mouse, during an age-appropriate computer game. Next, using a match-to-
sample procedure and class-specific consequences, participants began arbitrary three-choice conditional-discrimination training. Training took place over five phases (see below) and each baseline-training session, or trial block, consisted of 24 match-to-sample trials. Sessions alternated between one of two versions that differed only in order of trial

Table 2

Participants' Gender, Age, and Peabody Picture Vocabulary Test (PPVT) Age Equivalent

Participant	Experiment	Gender	Age on first session (years/months)	PPVT (years/months)
AJ	1	F	4/4	—
AM	1	M	5/1	—
AS	1	F	3/10	3/3
BG	1	F	4/0	3/5
BM	1	M	4/10	5/0
BP	1	M	4/4	4/1
BS	1, 2, and 3	F	8/7	8/5
DF	1	M	4/1	5/8
DP	1 and 2	M	4/9	4/7
DS	1	M	3/10	4/11
DW	1	M	4/0	5/4
GM	1, 2, and 3	M	7/3	7/2
GR	1 and 2	M	6/2	5/5
JM	1	M	4/6	4/5
LK	1	F	4/11	—
LR	1, 2, and 3	M	4/8	5/3
LR2	1	M	4/9	2/8
LS	1	M	4/4	4/10
LT	1	F	4/6	3/9

Table 2 cont.

Participant	Experiment	Sex	Age on first session (years/months)	PPVT (years/months)
MH	1, 2, 3, and 4	F	4/5	4/5
PL	1	F	4/8	—
SB	1	F	4/1	4/5
ST	1	F	4/8	4/4
TG	1	M	4/3	—
TK	1, 2, and 3	M	8/1	8/8
ZM	1, 2, 3 and 4	M	4/1	4/10

Note. Dashes indicate that PPVT age equivalent was not obtained.

presentation. During the first two phases of baseline training, trial blocks consisted of AB conditional-discrimination trials. During the third and fourth phases of baseline training, trial blocks consisted of AC conditional-discrimination trials. The final phase of baseline training involved the presentation of trial blocks composed of both AB and AC conditional-discrimination trials (12 AB and 12 AC) intermixed in a random order. Table 3 shows the composition of trial blocks for each baseline-training phase.

Specialized training was provided in the following instances: when a participant failed to acquire the AB conditional-discrimination problem within a reasonable number of sessions, or when a participant showed evidence of a particular pattern of responding consistent with a form of stimulus control other than that intended by the experimenter (e.g., a position or stimulus preference). The specific type and sequence of interventions was determined on an individual basis.

Training Sequence

Phase 1: AB (Original) Training

A1, A2, or A3 served as sample stimuli and B1, B2, and B3 served as comparison stimuli. Selections of B1, B2, or B3 conditionally upon A1, A2, or A3, respectively, produced R1, R2, or R3, respectively. Mastery criterion was set at three consecutive sessions at 90% accuracy or above.

Phase 2: AB Outcome-Reversal Training

As with the first phase of AB training, A1, A2, or A3 served as sample stimuli and B1, B2, and B3 served as comparison stimuli. However, the contingencies were altered in the following manner: Selections of B1, B2, or B3 conditionally upon A1, A2, or A3, respectively, now produced R2, R3, or R1, respectively. Mastery criterion was set at two

Table 3

Session Composition for Baseline Training

Training phase	Reinforcement density	Trial type	No. trials
AB	100%	A1: B1, B2, B3	8
		A2: B2, B3, B1	8
		A3: B3, B1, B2	8
AC	100%	A1: C1, C2, C3	8
		A2: C2, C3, C1	8
		A3: C3, C1, C2	8
AB/AC MIX	100%	A1: B1, B2, B3	4
		A2: B2, B3, B1	4
		A3: B3, B1, B2	4
		A1: C1, C2, C3	4
		A2: C2, C3, C1	4
		A3: C3, C1, C2	4
AB/AC MIX	75%	A1: B1, B2, B3	4
		A2: B2, B3, B1	4
		A3: B3, B1, B2	4
		A1: C1, C2, C3	4
		A2: C2, C3, C1	4
		A3: C3, C1, C2	4

Table 3 cont.

Training phase	Reinforcement density	Trial type	No. trials
AB/AC MIX	50%	A1: B1, B2, B3	4
		A2: B2, B3, B1	4
		A3: B3, B1, B2	4
		A1: C1, C2, C3	4
		A2: C2, C3, C1	4
		A3: C3, C1, C2	4

Note. Trial types are listed with the sample stimulus first, followed by the three comparison stimuli. Correct comparisons are those immediately following the sample.

consecutive sessions at 90% accuracy or above and, in effort to ensure that participants had made sufficient contact with the new contingencies, participants were required to complete at least five sessions before advancing to the next phase of training. That is, for a participant to advance after completing exactly five sessions, accuracy must have been at or above 90% on their fourth and fifth sessions. In cases were any disruption in accuracy was evident, however, participants completed ten sessions.

Phase 3: AC (Original) Training

A1, A2, or A3 served as sample stimuli and C1, C2, and C3 served as comparison stimuli. Selections of C1, C2, or C3 conditionally upon A1, A2, or A3, respectively, produced R1, R2, or R3, respectively. Mastery criterion was set at three consecutive sessions at 90% accuracy or above.

Phase 4: AC Outcome-Reversal Training

As with the first phase of AC training, A1, A2, or A3 served as sample stimuli and C1, C2, and C3 served as comparison stimuli. However, the contingencies were altered in the following manner: Selections of C1, C2, or C3 conditionally upon A1, A2, or A3, respectively, now produced R3, R1, or R2, respectively. Mastery criterion was set at two consecutive sessions at 90% accuracy or above with the stipulation that participants had to complete at least five sessions before advancing to the next phase of training. That is, for a participant to advance after completing exactly five sessions, accuracy must have been at or above 90% on their fourth and fifth sessions. In cases were any disruption in accuracy was evident, however, participants completed ten sessions.

Phase 5: AB/AC-Mixed Training

AB/AC-mixed training consisted of sessions with both AB and AC conditional-discrimination trials randomly intermixed. The reinforcement procedure for each conditional discrimination was consistent with that employed during outcome-reversal training (see Table 4). AB/AC-mixed training was conducted at 100%, 75%, and 50% reinforcement density, in that order. Responses on trials programmed to produce no consequences were followed by a black computer screen for 1.5 s before the presentation of the next trial. Half of the trials that did not include a consequence were AB trials and half were AC trials. Mastery criterion at each reinforcement density of AB/AC-mix training was set at two consecutive sessions at 90% accuracy or above.

Specialized Training

Identity-Matching Procedure

Identity-matching training was conducted with the A and B stimulus sets. On A identity-matching sessions, selections of A1, A2, or A3 conditionally upon presentations of A1, A2, or A3, respectively, produced R1, R2, or R3, respectively. On B identity-matching sessions, selections of B1, B2, or B3 conditionally upon presentations of B1, B2, or B3, respectively, produced R1, R2, or R3, respectively. Mixed-identity sessions included an even mix of both A and B identity-matching trials. Participants were required to achieve 90% accuracy or above on at least one A identity-matching session, one B identity-matching session, and one mixed-identity session (in that order). Each of the identity training session types included 24 trials.

Correction Procedure

During AB training trials, a correction procedure (e.g., Sidman, 1971) was used in which a correct response was required before the next trial was presented. Thus, trials on which the participant selected an incorrect comparison were repeated (i.e., trial-rerun

Table 4

Outcome-Reversal Training Arrangement

Training phase	Trial type	Reinforcement
AB	A1:B1	R2
	A2:B2	R3
	A3:B3	R1
AC	A1:C1	R3
	A2:C2	R1
	A3:C3	R2

Note. Trial types are listed with the sample stimulus first, followed by its corresponding comparison stimulus.

correction). Each incorrect response increased the total number of trials in the current session by one. Sessions did not exceed 36 trials.

Delayed-Cue Procedure

During AB training trials, a delayed-cue procedure (e.g., Peterson et al., 1978) was used in which the comparison stimuli designated as incorrect disappeared from the screen after a specified amount of time had elapsed (e.g., 10 s). For example, although Comparison Stimuli B1, B2, and B3 initially appeared following an observing response to Sample Stimulus A1, Comparison Stimuli B2 and B3 would disappear after a specified amount of time, thus allowing only for the selection of Comparison Stimulus B1. During delayed-cue sessions, the delay between the presentation of all comparison stimuli and the disappearance of the comparison stimuli designated as incorrect increased by .5 s with each correct response and decreased by .5 s with each incorrect response until a minimum delay of .1 s was reached. Delay times ranged from 5- 30 s and were increased as needed (e.g., when participants showed evidence of delaying responses until incorrect comparisons disappeared). Delayed-cue sessions were either presented consecutively or in alternation with standard training sessions. Delayed-cue sessions included 24 trials.

Two-Comparison Procedure

A two-choice conditional-discrimination training procedure was utilized either to simplify the discrimination learning task or when participants demonstrated a pattern of responding consistent with a position or stimulus preference. When, for example, a participant was consistently selecting the stimulus located in a specific position of the screen, irrespective of the sample stimulus displayed, the experimenter would program the session so that the preferred position was never occupied. If, however, a participant was consistently choosing the same comparison stimulus, irrespective of the sample stimulus presented, the experimenter would program the session to eliminate that particular comparison stimulus as a choice. Two-comparison sessions contained 24 trials.

Symbolic-Line Drawing

Following an observing response to the sample stimulus, participants were instructed to trace a line from the sample to the comparison of their choice to make a selection (in place of mouse clicking).

General Instructions

Prior to beginning an AB training session the participant was provided with the following instructions: "The purpose of this game is to try and find the ones that go together." Additionally, for the first five trials of the session, the experimenter pointed to the sample and stated, "Pick the one that goes with this one."

Explicit Instructions

For the first five trials of an AB training session, the experimenter pointed first to the sample (e.g., A1) and then to its corresponding comparison (e.g., B1) and stated, "This one goes with this one."

Naming Procedure

Participants were taught to tact samples A1, A2, and A3 as Kif, Vek, and Zog, respectively (see, for example, Lowe, Horne, Harris, & Randle, 2002). During echoic training, the experimenter placed three index cards containing pictures of stimuli A1, A2, and A3 in front of the participant, and said; "Look at this. It is a [Kif]. Can you say [Kif]?" If the child produced the correct response, the experimenter responded, "Yes, it is a [Kif]! Good job!" If the child produced an inaccurate response or remained silent, the experimenter pointed to the target stimulus and said, “This is a [Kif]. Can you say it? Following echoic training, participants were tested on their ability to tact the samples (tact training). The experimenter placed three index cards containing pictures of each sample stimulus in front of the participant, pointed to the target stimulus, and asked, “What is this? Can you tell me what this is?” Feedback for both accurate and inaccurate responses was identical to that provided during echoic pre-training. Both echoic training and tact training sessions contained 18 trials arranged in predetermined quasi-random order. Each sample stimulus was presented on a total of six trials per session. Mastery criterion was set at five of six correct responses for each target stimulus.

Primary Class-Specific-Reinforcement Procedure

Prior to beginning match-to-sample training, reinforcer-preference testing (for a detailed description of this procedure see Ashford, 2001) was conducted to determine three food items of equal preference. During match-to-sample training, selecting a comparison stimulus designated as correct yielded one of three computer-generated auditory-visual displays (i.e., R1, R2, R3) as well as a corresponding primary reinforcer (i.e., PR1, PR2, PR3).

Results

Eight participants (MH, ZM, BS, DP, GR, TK, LR, and GM) completed all phases of the experiment and one (Participant ST) completed all but Phase 5. For participants who did not master Phase 1, refer to Table 5 for number of baseline sessions completed and highest scores achieved, and to Table 6 for each individual’s exact sequence of specialized-training conditions and number of sessions in each. The remainder of this section will focus on participants who completed the critical experimental phases of this experiment.

With the exception of Participant MH (see Figure 4), no child mastered AB training in fewer than ten sessions. All remaining participants received specialized training to facilitate

Table 5

Baseline of Participants Who Did Not Master AB Training

Participant	Stimulus set	Initial AB training: No. sessions completed	Initial AB training: Highest score	Additional AB training: No. sessions completed	Additional AB training: Highest score
BP	1	10	56		
SB[a]	3	15	50		
BM[a]	3	12	72		
TG	1	9	44		
JM	1	10	46	15[b]	50
DS	1	11	44		
LS	1	10	50		
BG	1	10	61		
LK	1	10	33		
AS	1	10	44		
DF	1	10	50		
DW	1	11	50		
LR2	1	10	61	11[b]	67
LT	3	14	38	13[c]	46

[a]Training was conducted with primary class-specific reinforcement. [b]Additional AB training (included line drawing with general instructions) occurred following identity sessions. [c]Training included naming.

Table 6

Sessions Completed in Specialized Training by Participants Who Did Not Master AB Training

Participant	2 Comparisons	Identity Matching	Delayed Cue/ 2 Comparisons					Correction Procedure	
			5s.	10s.	15s.	20s.	30s.	3 Comparisons	2 Comparisons
BP	1/15			2/2	3/1	4/10[b]			
SB[a]		7[c]							
BM[a]		9							
TG	4								
JM		1/14[cd]						2/12[e]	3/4[e]
DS	1/28	8/6	3/2[b]	4/1	5/2	6/5[b]	7/2[b]		2/12
LS	4								
BG	1/12, 6/7[c]	5/12[c]	2/1	3/2	4/7				
LK	7								
AS	1/25	8/8	3/4	4/2	5/2	6/2	7/6[b]		2/10
DF	1/10	6/6	2/2[f]	3/2[f]	4/1	5/5			
DW	1/33	7/10[c]	3/3	4/3	5/1	6/6[b]			2/2

Table 6 cont.

Participant	2 Comparisons	Identity Matching	Delayed Cue/ 2 Comparisons					Correction Procedure	
			5s.	10s.	15s.	20s.	30s.	3 Comparisons	2 Comparisons
LR2	4/11[eg], 5/6[g]	1/15[d]						2/8[e]	3/8[e]

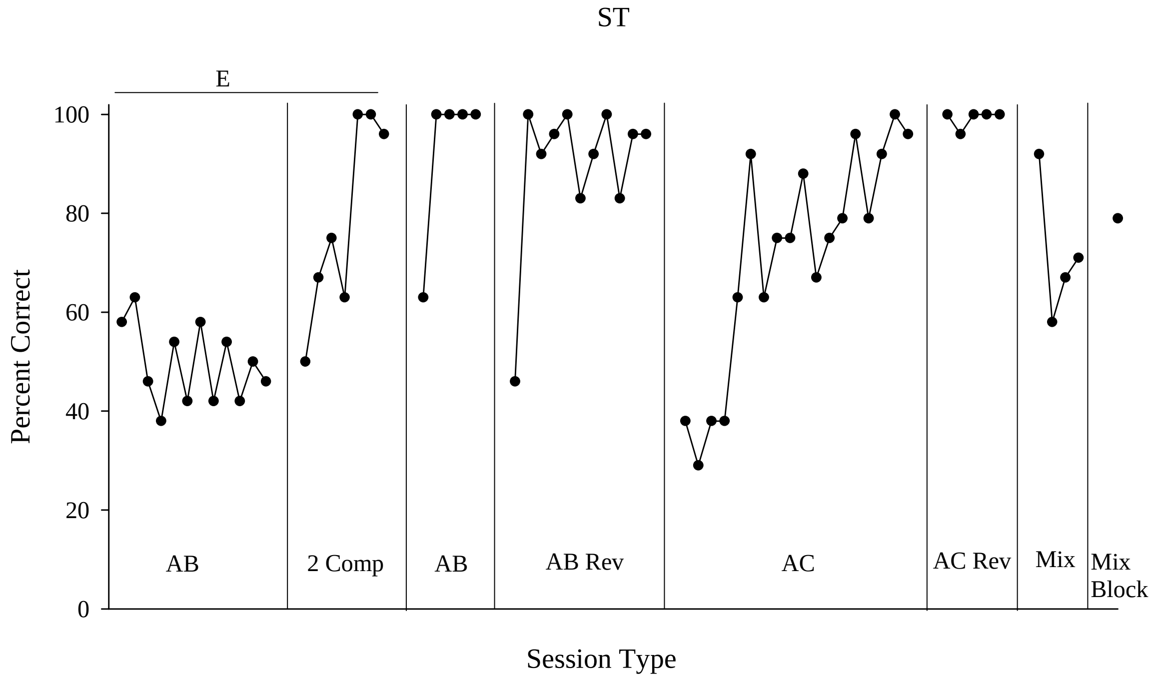
Note. Values to the left of slashes indicate the order in which specialized-training sessions were conducted. Values to the right of slashes indicate number of sessions completed. Underlined values indicate specialized-training conditions that were mastered.
[a]Training was conducted with class-specific edibles. [b]Training consisted of alternating sessions with and without delayed cue.
[c]Training was conducted with line drawing. [d]Training included general instructions. [e]Training included explicit instructions.
[f]Training included three-comparion trials. [g]Training included naming.

AB acquisition. Three participants (DP, ST, and GR) showed some disruption during either one or both phases of outcome-reversal training; thus their performances during AB acquisition and outcome-reversal sessions will be discussed in some detail below (see Figures 2-3). Mixed-AB/AC training will only be discussed when specialized training was implemented.

Participants Who Showed Disruption

Participant ST

Refer to Figure 2. Although Participant ST received training with Stimulus Set 1 prior to mastering AB training with Stimulus Set 2, only data collected during training with Stimulus Set 2 are presented. For Participant ST, AB training with Stimulus Set 2 was initially conducted with explicit instructions (i.e., the last intervention used during training with Stimulus Set 1). Following 12 AB sessions with scores that differed only slightly from chance, Participant ST received two-comparison sessions in conjunction with explicit instructions before mastering AB training. Of all participants, ST showed the greatest degree of disruption during outcome-reversal training (AB outcome reversals only). During the first session of AB outcome-reversal training, ST’s accuracy declined drastically (to 46%) but returned to baseline by the following session. Participant ST continued to show some moderate disruption throughout AB outcome-reversal training, however no disruption was evident during AC outcome-reversal training. Due to decline in accuracy during AB/AC-mixed training, ST was placed on mixed AB/AC block training (i.e., sessions consisting of 12 AB trials followed by 12 AC trials). On her first session of mixed-block training, an error analysis revealed that all errors occurred on AB trials. Further testing was not permitted, as ST withdrew from the school after one



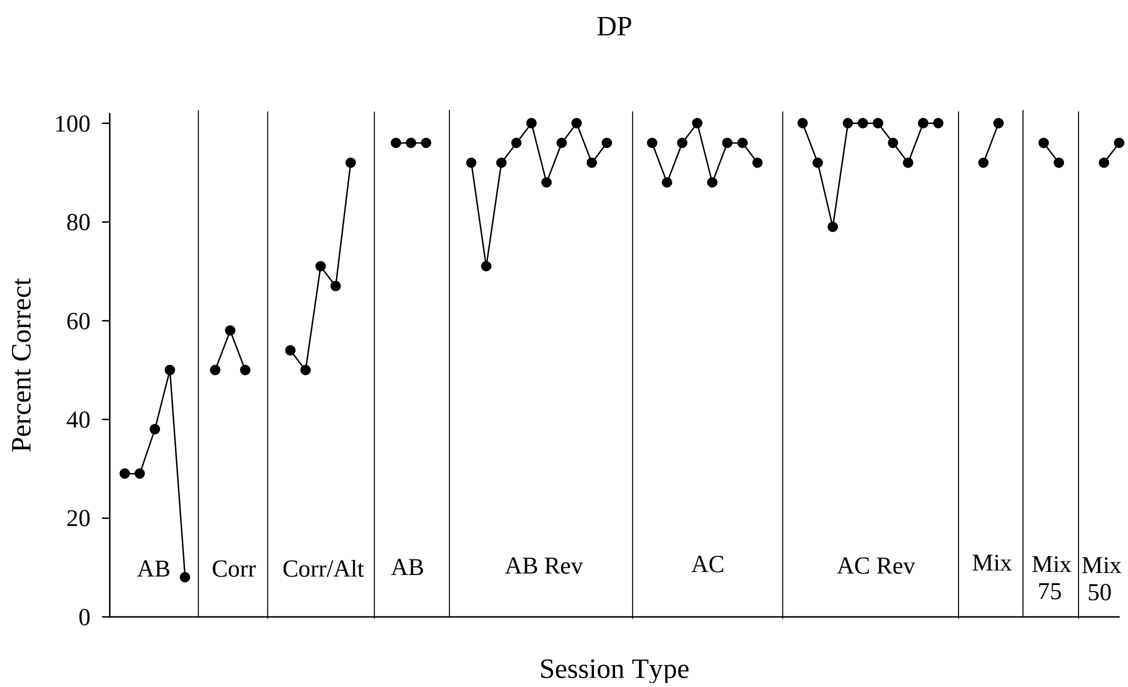
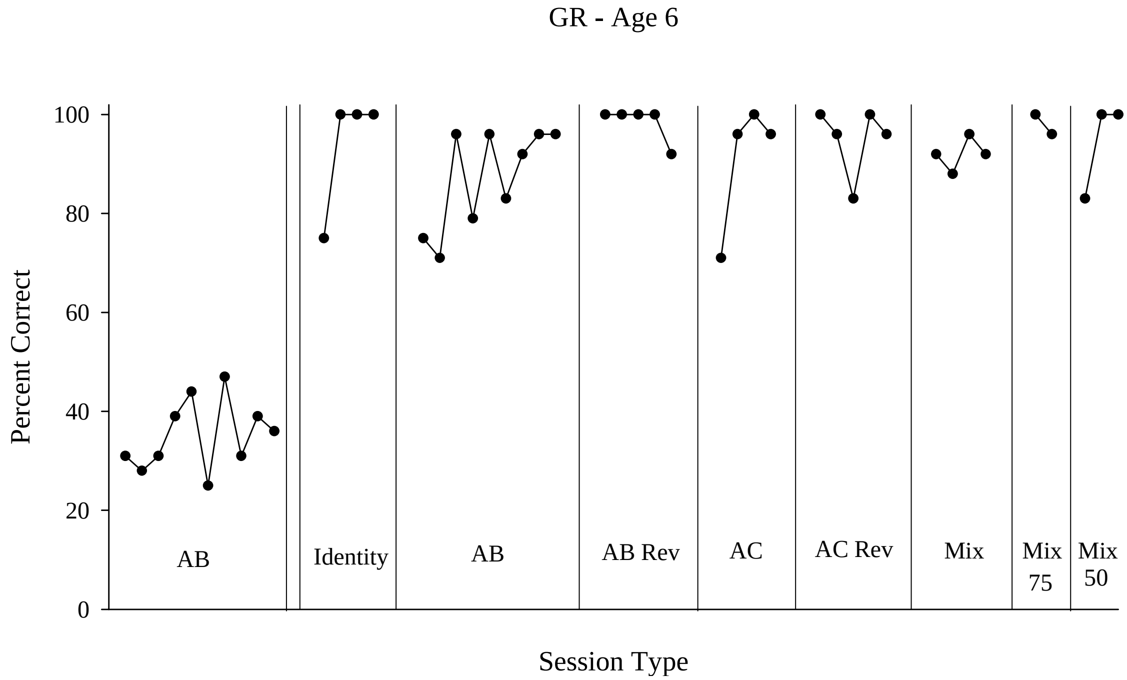


Figure 2. Baseline training for Participants ST and DP during Experiment 1. Data points under the horizontal line labeled E indicate sessions in which the participant received explicit instructions.



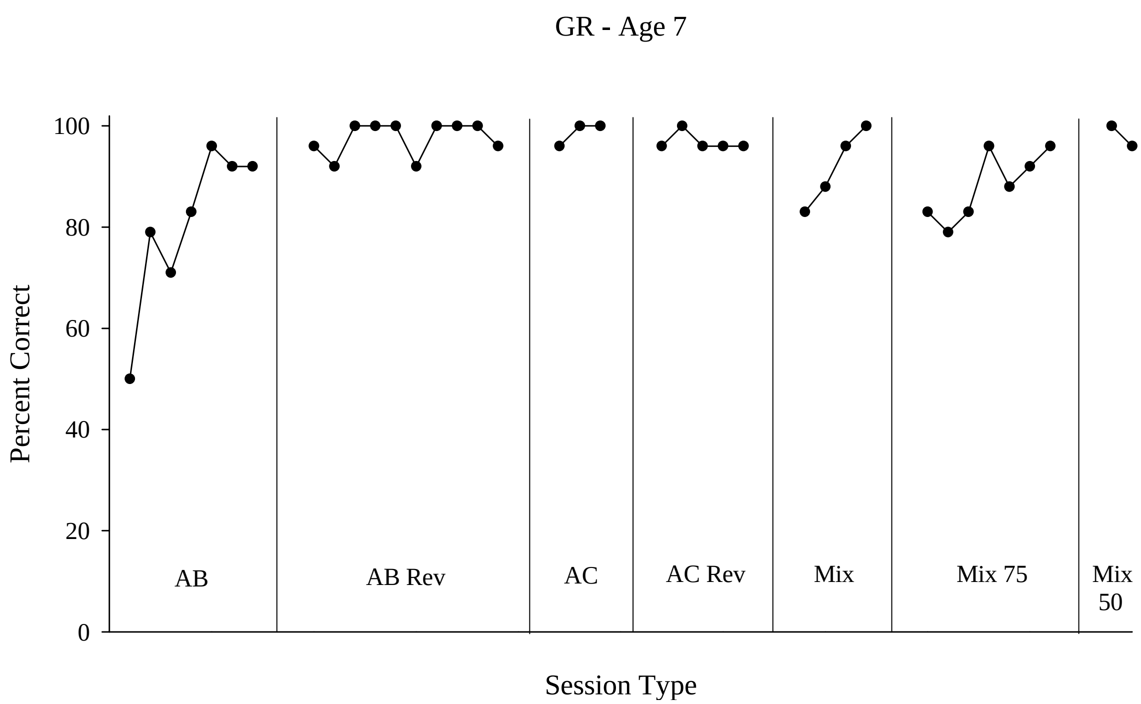
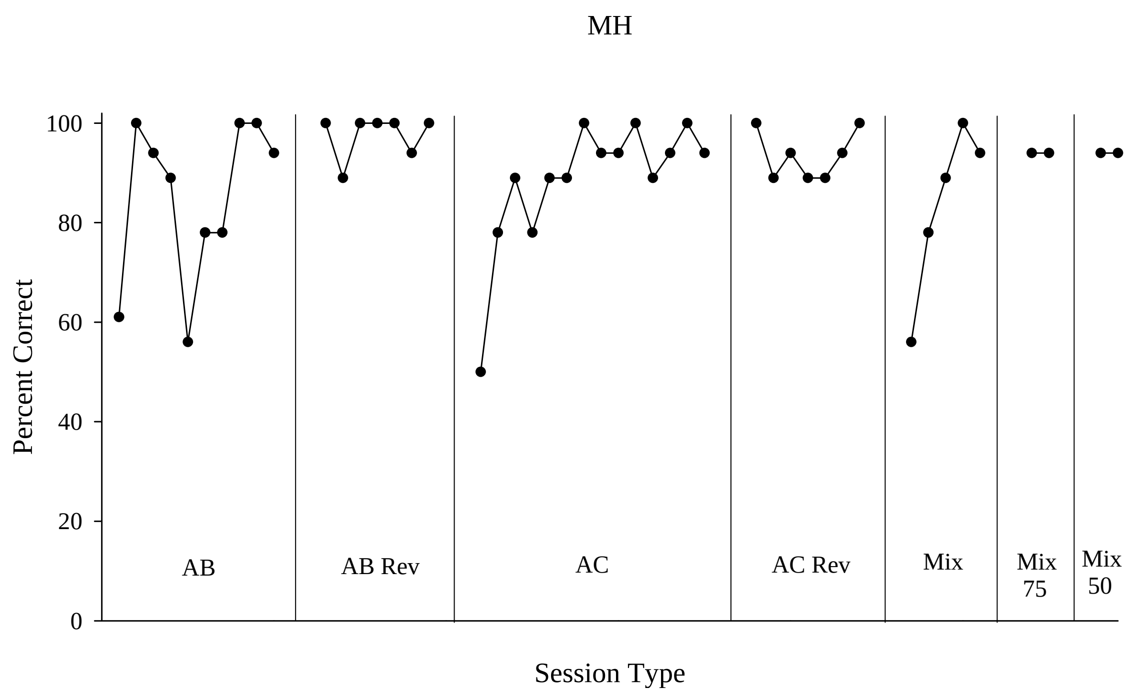


Figure 3. Baseline training for Participant GR during Experiment 1. Double lines indicate that intervening specialized training sessions were conducted.



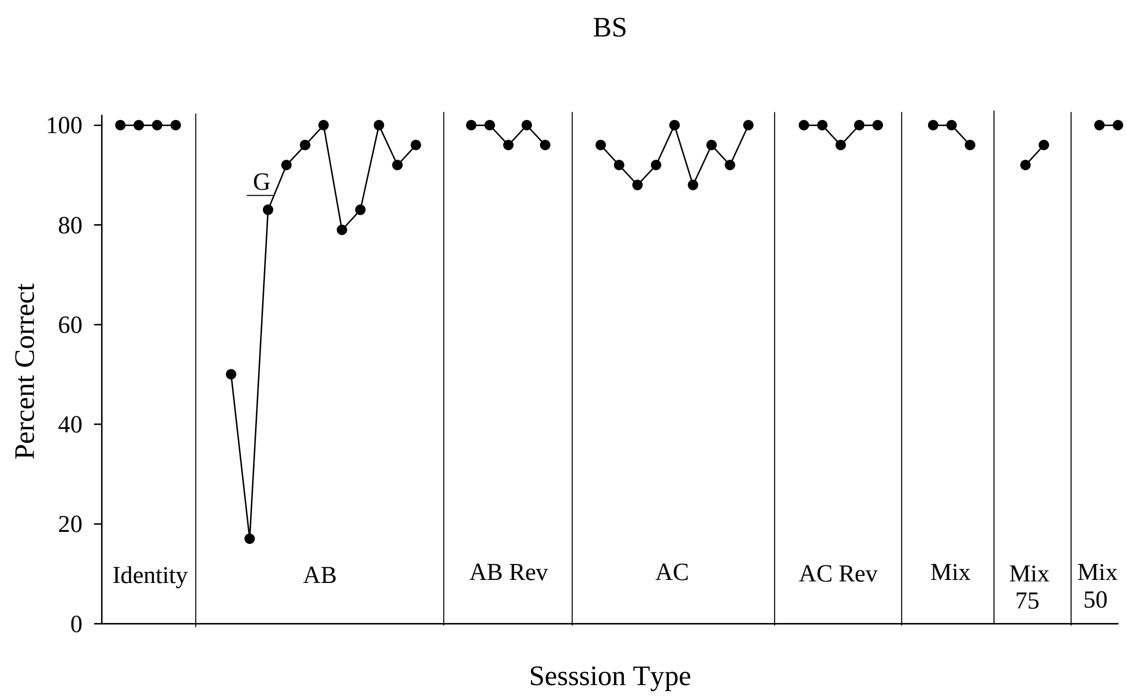


Figure 4. Baseline training for Participants MH and BS during Experiment 1. Data points under the horizontal line labeled G indicate sessions in which the participant received general instructions.

session of mix block training.

Participant DP

Refer to Figure 2. Although the preferred stimulus varied from session to session, during initial training sessions Participant DP showed evidence of a strong stimulus preference. Thus, throughout his fifth session DP was told, "You need to pick different ones." Due to a drastic decline in accuracy, he was next exposed to correction sessions, followed by correction sessions alternating with typical AB sessions, where he quickly met criterion. Participant DP showed some moderate disruption during both AB and AC outcome-reversal training. It is interesting to note that Participant DP commented on the AB outcome reversals immediately, although no disruption occurred until the following session when his score fell to 71%. For example, during the first session of AB outcome-reversal training DP pointed to two of the reinforcers on the tally sheet and asked, "Why did it do that one instead of that one?" The question was not addressed. During the third session of AC outcome reversal training DP's accuracy showed a moderate decline, down to 79%. No further disruption was observed.

Participant GR

Refer to Figure 3. This participant withdrew from the school that served as the testing site and returned approximately 8 months later. Thus, Participant GR completed the experiment twice, once at age 6 with Stimulus Set 1 and again at age 7 with Stimulus Set 3. Both performances will be discussed, as they allow for additional within-subject comparisons. At age 6, GR received a number of specialized training interventions (see Table 7) following the completion of 10 AB sessions with no signs of acquisition. Upon mastering identity sessions, GR again received typical AB training, which he eventually mastered. AB acquisition at age 7 was much quicker and required no specialized training. Although GR (age 6) showed no

Table 7

Sessions Completed in Specialized Training by Participants Who Mastered AB Training

Participant	2 Comparisons	Correction /2 Comparisons	Delayed Cue 5s.	Delayed Cue 10s.	Delayed Cue 15s.	Identity Matching
GR				1/5, 2/6[a]		3/4
ZM	1/39, 8/24[c], 9/5[cd]	2/6	3/2[b]	4/5[b]	5/6[ab]	6/5, 7/5[c]
BS						4

Note. Values to the left of slashes indicate the order in which specialized training sessions were conducted. Values to the right of slashes indicate number of sessions completed. Underlined values indicate specialized-training conditions that were mastered. [a]Training consisted of alternating sessions with and without delayed cue. [b]Training consisted of delayed-cue sessions with two comparisons. [c]Training was conducted with line drawing. [d]Training included general instructions.

disruption during AB outcome-reversal training, some moderate disruption was observed during AC outcome-reversal training. However, additional data collected from Participant GR at age 7 did not replicate these findings.

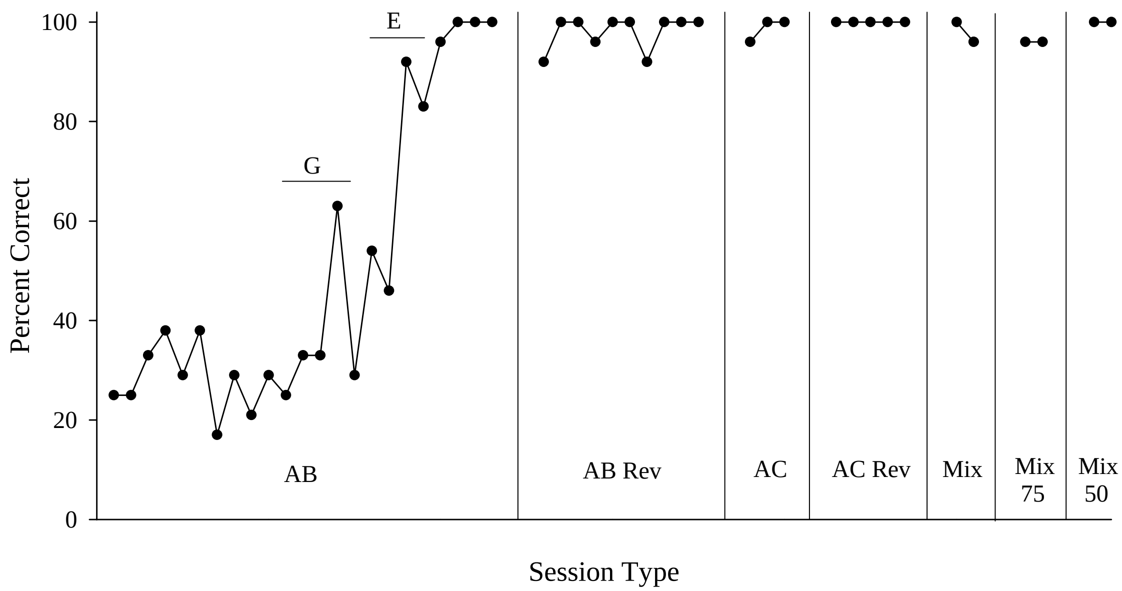
Participants Who Did Not Show Disruption

Data for Participants MH, LR, GM, TK, BS, and ZM are presented in Figures 4-6. Participant MH (see Figure 4) mastered AB training rapidly (within ten sessions). Due to experimenter error MH received additional test sessions beyond mastery criterion during both AB outcome-reversal training and AC training. Participants LR, GM, and TK (see Figures 5-6) received general instructions, explicit instructions, or a combination of both prior to mastering AB training. Although Participant BS received training with Stimulus Sets 1 and 2 prior to mastering AB training with Stimulus Set 3, only data collected during training with Stimulus Set 3 (which began with identity matching) are presented (see Figure 4). As shown in Figure 4, in addition to identity-matching training, BS received general instructions prior to mastering AB training. Participant ZM received a number of specialized training interventions prior to mastering AB training. Figure 6 shows AB training sessions completed prior to receiving specialized training, interventions immediately preceding mastery of AB training, as well as all remaining experimental phases completed by Participant ZM. Table 7 shows additional specialized training and/or verbal instructions completed by ZM. As shown in Figures 4-6, Participants MH, LR, GM, TK, ZM, and BS showed no signs of disruption during either AB or AC outcome-reversal training.

Discussion

The increased rate of acquisition of discriminations with class-specific reinforcement is a robust finding in the animal literature (for a review see Goeters, Susan, Blakely, & Elbert, 1992)

LR



GM

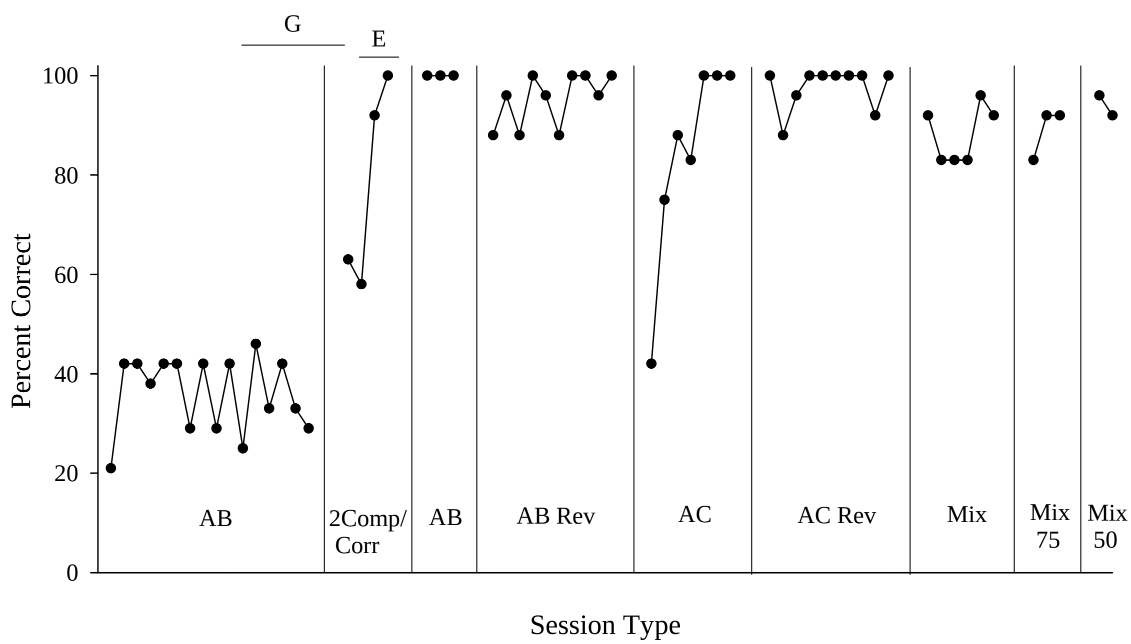


Figure 5. Baseline training for Participants LR and GM during Experiment 1. Data points under horizontal lines labeled G indicate sessions in which the participant received general instructions. Data points under horizontal lines labeled E indicate sessions in which the participant received explicit instructions.

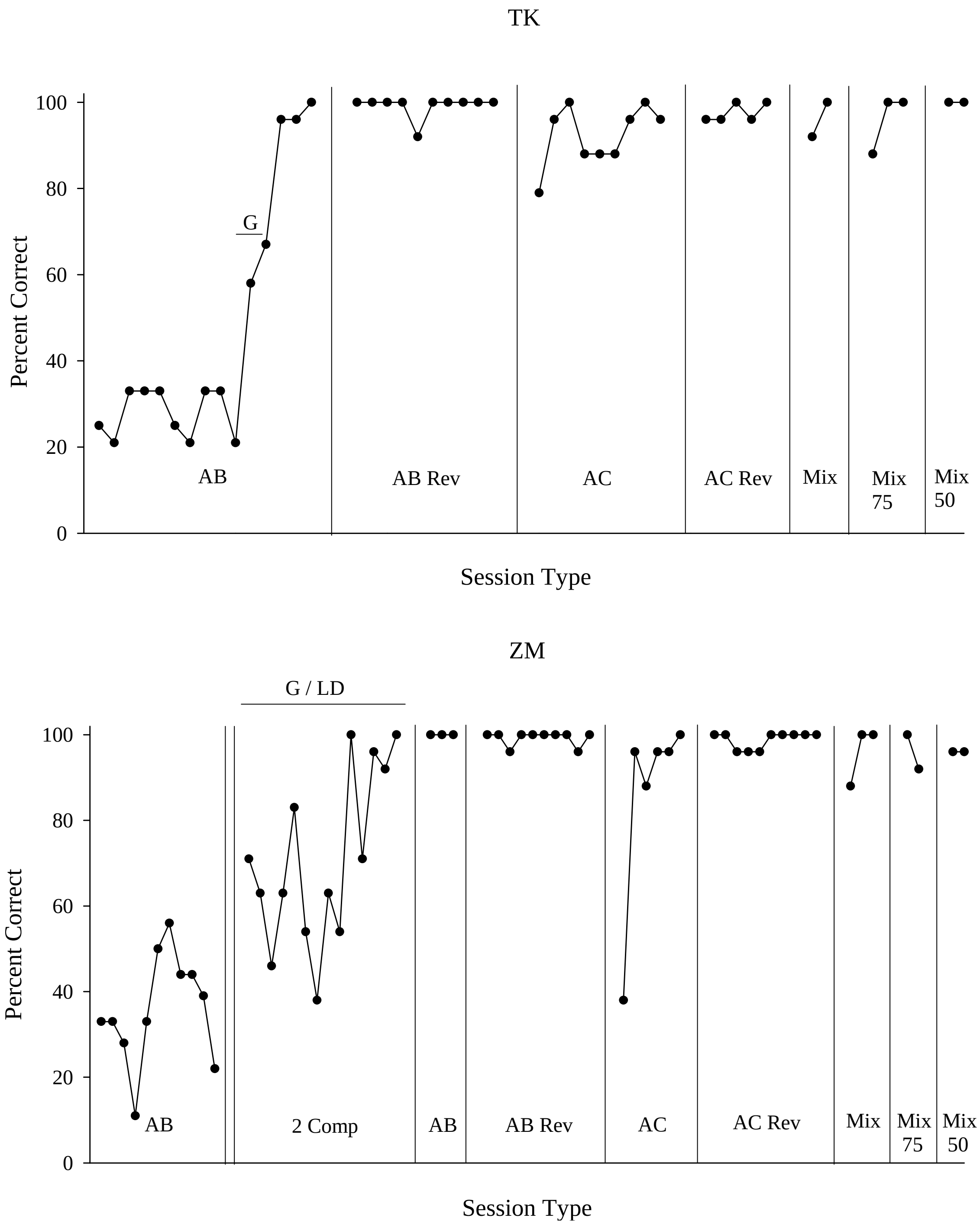


Figure 6. Baseline training for Participants TK and ZM during Experiment 1. Data points under horizontal lines labeled G indicate sessions in which the participant received general instructions. Data points under the horizontal line labeled LD indicate sessions in which the participant received symbolic line drawing. Double lines indicate that intervening specialized training sessions were conducted.

and the effect is evident in at least some studies conducted with humans (e.g., Litt & Shreibman, 1981). The results of Experiment 1, however, were not consistent with these findings. With the exception of one child (MH), none of the participants mastered the initial conditional-discrimination task with class-specific reinforcement alone. In fact, for most of the participants (ST, LR, ZM, TK, BS, and GM) either general or explicit instructions immediately preceded mastery of the AB conditional discrimination. Further, the majority of participants who did not master the AB conditional discrimination despite specialized training, never received verbal instructions and the few who did receive verbal instructions showed signs of acquisition prior to leaving the study. These results are consistent with the findings of Pilgrim, Jackson, and Galizio (2000) who used differential reinforcement to train children aged 3 to 6 years to perform conditional discriminations. Although they did not implement class-specific reinforcement, as with the present study, their participants acquired the conditional discriminations only after receiving verbal interventions (i.e., explicit instructions or naming). Such findings suggest that many of the difficulties in acquiring arbitrary conditional discriminations by young children in the laboratory setting may be due to the absence of instructions or verbal guidance, which typically accompany natural learning situations for children. Thus, it might be that class-specific contingencies in conjunction with instructions are necessary to observe increased rates of conditional discrimination learning in young children. In fact, the training procedures used by Maki, Pauline, Overmier, and Bruce (1995) did combine class-specific reinforcement with verbal instructions, and results showed enhanced conditional-discrimination peformances of children aged 4 years 6 months to 5 years 5 months when compared to control groups trained with random reinforcement and verbal instructions. What remains to be determined is why for some young children, such as MH in the present study, conditional-discrimination peformances are acquired rapidly and without additional training. After all, nonhumans frequently acquire discrimination performances in the absence of lengthy specialized training interventions (e.g., Carlson & Wielkiewicz, 1976; Peterson & Trapold, 1980, 1982)

Of particular interest to the experimenters was the effect of outcome reversals on the conditional-discrimination peformances of humans. Unlike the data reported from outcome-reversal studies conducted with pigeons (e.g., Honig et al., 1984), for most subjects, accuracy on the arbitrary tasks did not decline when the training contingencies were shifted from the original-outcomes procedure to the outcome-reversal procedure. Of the participants (ST, DP, GR) who did show a decline in accuracy following outcome-reversals, Participant ST demonstrated the greatest degree of disruption (i.e., during AB outcome-reversal training). This was not replicated however, during AC outcome-reversal training. If the change in training contingencies was in fact responsible for ST's decline in accuracy during AB outcome-reversal tests, the fact that ST did not show a decline in accuracy during AC outcome-reversal tests is of particular concern. One possibility is that during AC outcome-reversal training, ST learned that a change in the reinforcement contingencies does not affect sample-comparison matching, and that this generalized to AC outcome-reversal training.

Although it was not immediate, Participants DP and GR (age 6) showed some moderate disruption during at least one outcome-reversal training phase. When considering such a transient phenomenon, one must consider the possibility that some uncontrolled variable (e.g., fatigue) was in fact responsible for the decline in accuracy. For example, motivation appeared to be an issue for Participant DP, as his performance showed some bounce throughout the duration of the Experiment. For Participant GR, who did not show a decline in accuracy following outcome-reversals during a replication of Experiment 1, the third variable possibility also seems particularly feasible. Further, it is not clear why a disruption would occur following AC outcome reversals but not AB outcome reversals, as was the case for GR the first time he participated in Experiment 1.

What remains to be determined, however, are the sources for the differences in the outcome-reversal performances of pigeons and humans. Different findings across species in similar experiments are not uncommon, and many have speculated as to the basis for these differences. For example, Buskist, Morgan, and Barry (1983) have suggested that methodological and interspecies behavioral differences may contribute to the discrepancies in experimental results between humans and animals. While the present study was conducted with conditioned reinforcers, the pigeon studies (Honig et al., 1984; Peterson & Trapold, 1980, 1982; Peterson et al., 1978) were conducted with at least one (food vs. tone), if not two primary reinforcers (food vs. water). Further, while the pigeons where food deprived, subjects in the present study were not, potentially impacting the significance of the reinforcers.

It is also possible that species-specific behavior differences can account for the discrepancies in findings in pigeons and humans. Dube, Rocco, and McIlvane (1989) suggested that pigeons and humans might perform match-to-sample tasks in a qualitatively different way. They point to evidence of generalized identity matching in humans as evidence for this. Although humans frequently exhibit generalized identity matching, pigeons do not, even with similar experimental procedures (e.g., Cumming & Berryman, 1961). Thus, it may be that different stimulus control topographies (SCTs) are a significant contributor to the differences observed in pigeon and human experiments (McIlvane & Dube, 2003).

On a broader note, as is always the case when considering the discrepancies between animal and human experimental findings, the possibility remains that the complex history of the human subject, which is inundated with elaborate repertoires and exceedingly complex verbal processes, is the source of the discrepancies between the pigeon and human studies. For example, humans have a long history of receiving a variety of reinforcers (primary and conditioned) for emitting a multitude of behaviors (especially during tact training), which may make them less sensitive to the specificity of reinforcers. Although this is not the case for the animal subject, the complex history of the human subject is often viewed as taking precedence over experimental procedures (e.g., Baron, Perone, & Galizio, 1991).   Finally, it is also possible that extra-experimental factors such as uncontrolled experiences between experimental sessions, which are not as problematic in animal studies, may have contributed to the different findings in the pigeon and animal studies.

CHAPTER 4. EXPERIMENT 2

Experiment 1 showed that for young children, outcome reversals had few adverse effects on conditional-discrimination peformances. For most of the participants, AB and AC outcome-reversal training was completed without any significant decrease in accuracy. Every participant who completed each phase of Experiment 1 also participated in Experiment 2, which was designed to investigate whether training with reversed outcomes would effect equivalence-class formation. Thus, children received testing with equivalence probes to evaluate equivalence-class formation, and with reinforcer probes to determine whether the reinforcers had become members of the equivalence classes.

Method

Participants

Eight of the participants (LR, ZM, BS, MH, TK, DP, GM, and GR) who completed all phases of Experiment 1 participated (see Table 2).

Stimuli

Training and testing were conducted using one of three sets of experimental stimuli (see Figure 1). Each participant completed Experiment 2 with the same stimulus set used in Experiment 1 (see Table 1).

Procedure

Equivalence, symmetry, and reflexivity probes were administered to evaluate the formation of stimulus classes A1B1C1, A2B2C2, and A3B3C3. In addition to the traditional probes for class formation, a series of reinforcer probes was administered in order to ascertain whether the reinforcers had become class members. Probe testing was conducted in blocks of five sessions, where one probe block contained the following: one equivalence-probe session, one symmetry-probe session, one reflexivity-probe session, one reinforcer-probe session in which reinforcer stimuli were presented as samples, and one reinforcer-probe session in which reinforcer stimuli were presented as comparisons, in that order. Overall reinforcement density for all probe sessions was set at 50%, and no more than two probe trials ever occurred in succession. Table 8 shows the composition of trial blocks for each probe session. Probe sessions included trials for both AB and AC conditional discriminations interspersed with equivalence, symmetry, reflexivity, or reinforcer probes. Baseline reinforcement reduction was evenly balanced between AB and AC conditional-discrimination trials. Reinforcement (when provided) for either baseline conditional discrimination was consistent with that employed during outcome-reversal training (see Table 4). Following the completion of four probe blocks, response stability was calculated ($X_{1\text{-}2} - X_{3\text{-}4} \leq (.10)\ X_4$). Participants continued with probe testing until performance was stable for each probe type or until they had completed 10 probe blocks, whichever came first. Upon completing probe testing,

participants completed a post-sort task to allow for further evaluation of equivalence-class formation.

Test Sequence

Equivalence Probes

Equivalence-probe sessions consisted of 24 trials. Six of the 24 trials were equivalence-probe trials. The remaining trials were an even mix of both AB and AC conditional-discrimination trials. On equivalence-probe trials, comparison stimuli included C1, C2, and C3 when the sample was B1, B2, or B3, and B1, B2, and B3 when the sample was C1, C2, or C3 (see Table 8).

Table 8

Session Composition for Probe Testing

Probe type	Trial type	No. probe trials per session	No. baseline trials per session	
			Reinforced	Unreinforced
REFLEXIVITY	A1: A1, A2, A3	9	18	9
	A2: A2, A3, A1			
	A3: A3, A1, A2			
	B1: B1, B2, B3			
	B2: B2, B3, B1			
	B3: B3, B1, B2			
	C1: C1, C2, C3			
	C2: C2, C3, C1			
	C3: C3, C1, C2			
SYMMETRY	B1: A1, A2, A3	6	12	6
	B2: A2, A3, A1			
	B3: A3, A1, A2			
	C1: A1, A2, A3			
	C2: A2, A3, A1			
	C3: A3, A1, A2			
EQUIVALENCE	B1: C1, C2, C3	6	12	6
	B2: C2, C3, C1			
	B3: C3, C1, C2			

Table 8 cont.

Probe type	Trial type	No. probe trials per session	No. baseline trials per session: Reinforced	No. baseline trials per session: Unreinforced
EQUIVALENCE	C1: B1, B2, B3	6	12	6
	C2: B2, B3, B1			
	C3: B3, B1, B2			
REINFORCER	R1: A1, A2, A3	9	18	9
	R2: A2, A3, A1			
	R3: A3, A1, A2			
	R1: B1, B2, B3			
	R2: B2, B3, B1			
	R3: B3, B1, B2			
	R1: C1, C2, C3			
	R2: C2, C3, C1			
	R3: C3, C1, C2			
	A1: R1, R2, R3			
	A2: R2, R3, R1			
	A3: R3, R1, R2			
	B1: R1, R2, R3			
	B2: R2, R3, R1			
	B3: R3, R1, R2			

Table 8 cont.

Probe type	Trial type	No. probe trials per session	No. baseline trials per session: Reinforced	Unreinforced
REINFORCER	C1: R1, R2, R3	9	18	9
	C2: R2, R3, R1			
	C3: R3, R1, R2			

Note. Probe trial types are listed with the sample stimulus first, followed by the three comparison stimuli. Class consistent comparisons are those immediately following the sample.

Symmetry Probes

Symmetry-probe sessions consisted of 24 trials. Six of the 24 trials were symmetry-probe trials. The remaining trials were an even mix of both AB and AC conditional-discrimination trials. On symmetry-probe trials in which B1, B2, or B3 was presented as the sample stimulus, comparison stimuli included A1, A2, and A3. On symmetry-probe trials in which C1, C2, or C3 was presented as the sample stimulus, comparison stimuli again included A1, A2, and A3 (see Table 8).

Reflexivity Probes

Reflexivity-probe sessions consisted of 36 trials. Nine of the 36 trials were reflexivity-probe trials. The remaining trials were an even mix of both AB and AC conditional-discrimination trials. On reflexivity-probe trials in which A1, A2, or A3 was presented as the sample stimulus, comparison stimuli included A1, A2, and A3. On reflexivity-probe trials in which B1, B2, or B3 was presented as the sample stimulus, comparison stimuli included B1, B2, and B3. During reflexivity-probe trials in which C1, C2, or C3 was presented as the sample stimulus, comparison stimuli included C1, C2, and C3 (see Table 8).

Reinforcer Probes

Reinforcer-probe sessions consisted of 36 trials. Nine of the 36 trials were reinforcer-probe trials. The remaining trials were an even mix of both AB and AC conditional-discrimination trials. Sessions included one of two types of reinforcer-probe trials. On reinforcer-probe trials in which R1, R2, or R3 was presented as the sample stimulus, comparison stimuli included A1, A2, and A3; B1, B2, and B3; or C1, C2, and C3. On reinforcer-probe trials in which A, B, and C stimuli were presented as samples,comparison stimuli included R1, R2, and R3 (see Table 8).

Post-Sort Task

Participants were presented with 12 index cards, each with a picture (one on each card) of a relevant experimental (i.e., A1, B1, C1, A2, B2, C2, A3, B3, and C3) or consequential stimulus (i.e., R1, R2, and R3). The experimenter then provided the participant with the following instructions: "Put these however you think they should go." If the child responded by making more than three piles, the experimenter would then say, "Now, I would like you to put them into three piles - however you think they should go." Following each sort, the experimenter pointed to each pile of cards and asked, "Why do these go together?" All responses were recorded and no feedback was provided for the duration of post-sort tasks.

Results

Equivalence-Probe Performances

Results were mixed with respect to the impact of outcome-reversals on equivalence-class formation. Despite outcome-reversal training, the equivalence performances of half of the participants (LR, ZM, BS, and MH) were relatively strong (see Figures 7-10). For the remaining participants (TK, DP, GM and GR), performance on one or more probe types indicated a lack of equivalence-class formation (see Figures 11-14).

The baseline performances of Participants LR, ZM, BS, and MH remained strong for the duration of equivalence-probe testing, and overall, responses on equivalence probes were highly class consistent. After completing six blocks, the responses of Participant LR (see Figure 7) on equivalence, symmetry, and reflexivity probes were both stable and highly class consistent. Following the completion of five blocks, the responses of Participant ZM (see Figure 8) were also stable and highly class consistent. However, he completed three additional blocks to allow for further evaluation of his reinforcer-probe performances (reinforcer-probe performances will

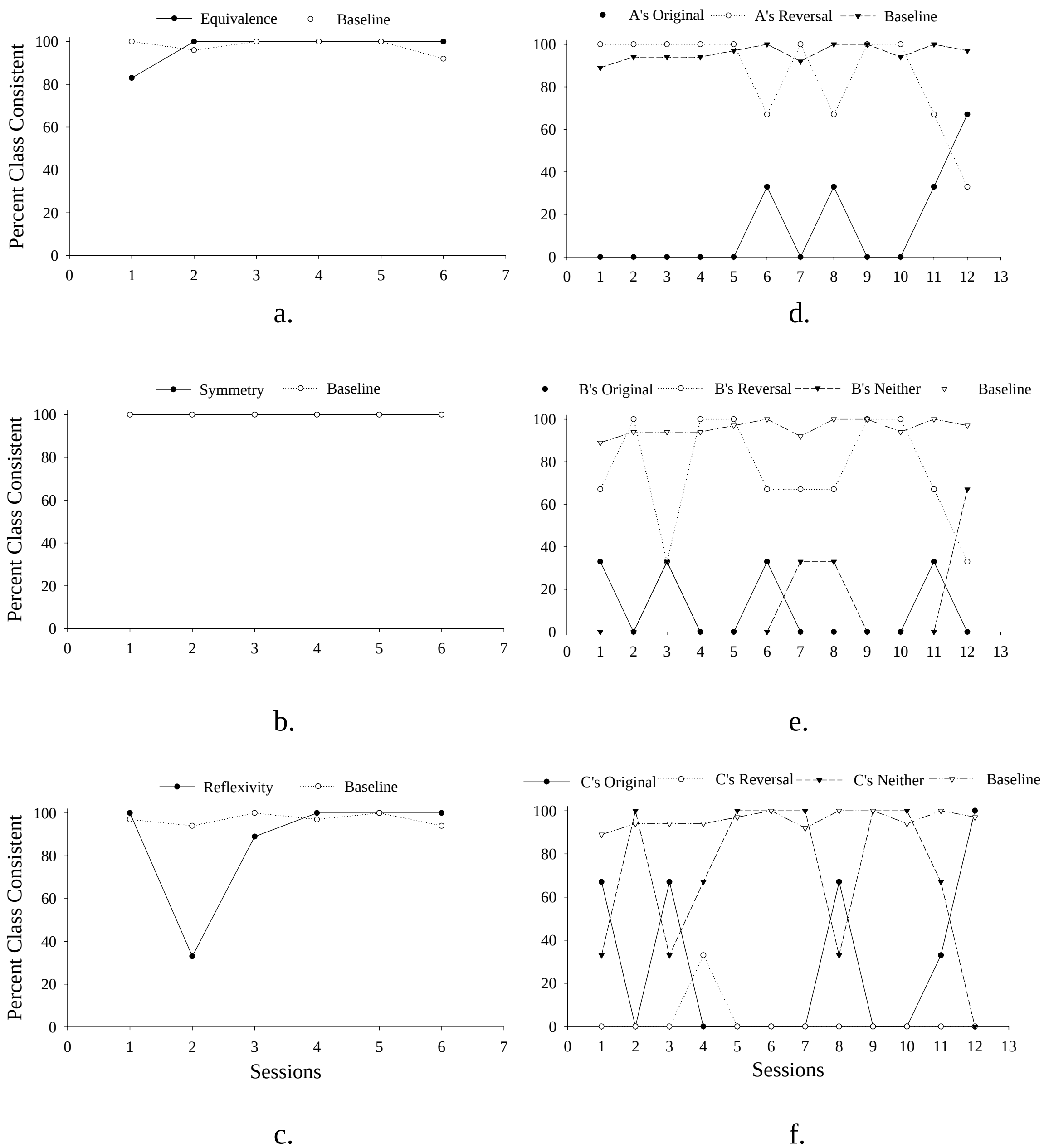


Figure 7. a., b., c.) Equivalence-probe performances for Participant LR during Experiment 2.

d., e., f.) A, B, and C reinforcer-probe performances for Participant LR during Experiment 2. Legend labels indicate performances consistent with the training contingencies of the original, outcome reversal, or neither of the training phases. Consequential stimuli served as comparisons during odd-number sessions and as samples during even-number sessions.

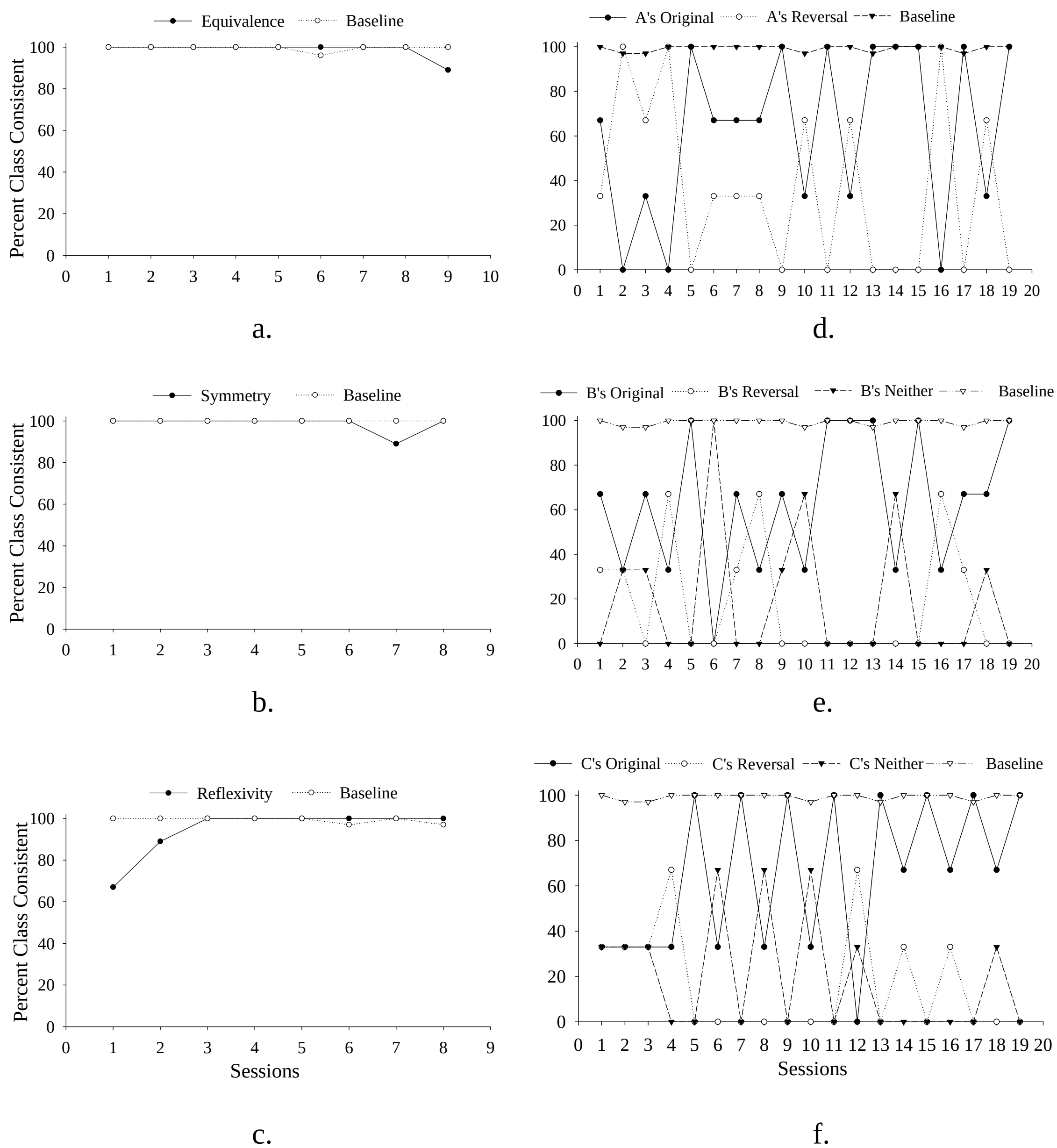


Figure 8. a., b., c.) Equivalence-probe performances for Participant ZM during Experiment 2.

d., e., f.) A, B, and C reinforcer-probe performances for Participant ZM during Experiment 2. Legend labels indicate performances consistent with the training contingencies of the original, outcome reversal, or neither of the training phases. Consequential stimuli served as comparisons during odd-number sessions and as samples during even-number sessions.

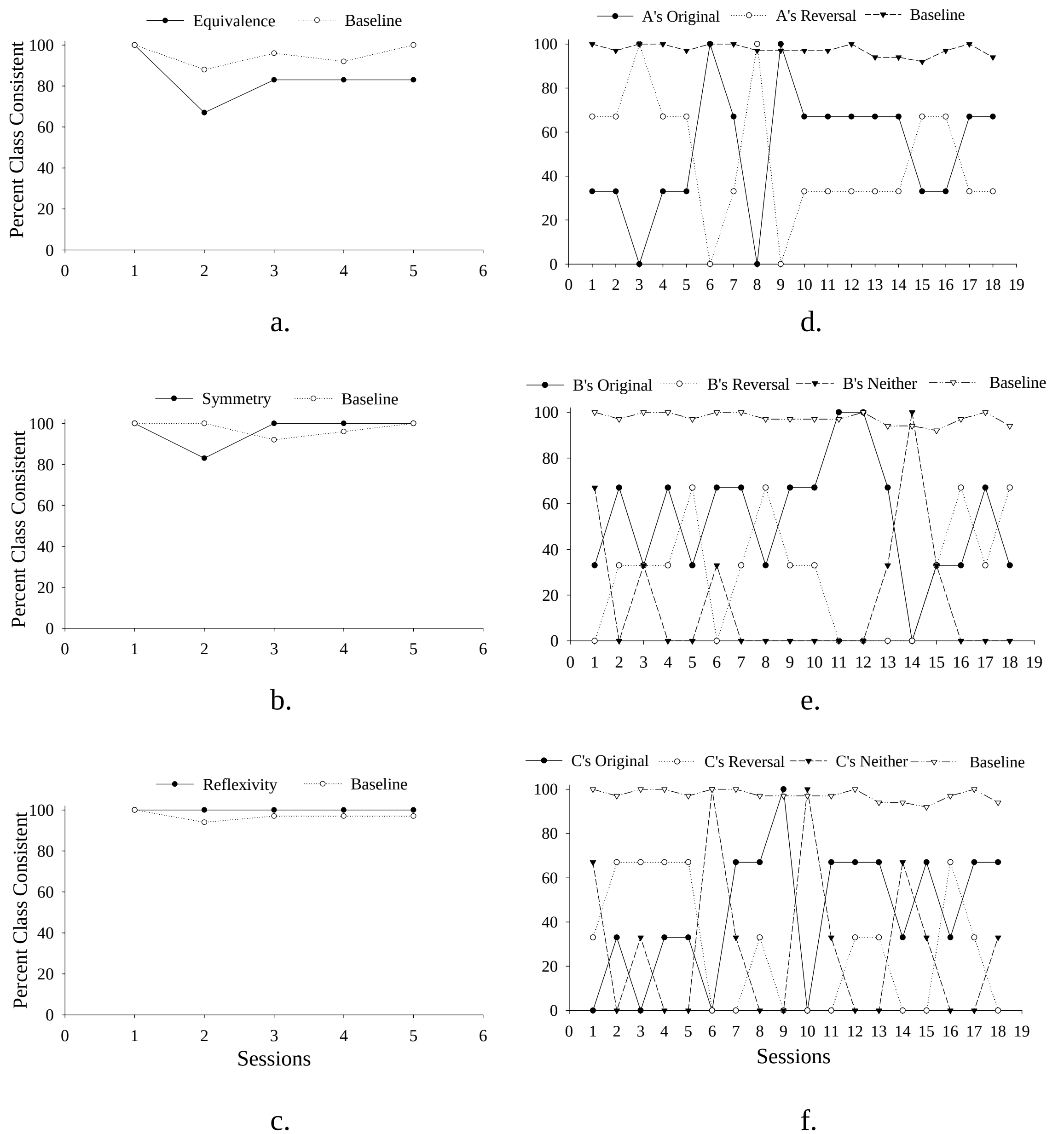


Figure 9. a., b., c.) Equivalence-probe performances for Participant BS during Experiment 2.

d., e., f.) A, B, and C reinforcer-probe performances for Participant BS during Experiment 2. Legend labels indicate performances consistent with the training contingencies of the original, outcome reversal, or neither of the training phases. Consequential stimuli served as comparisons during odd-number sessions and as samples during even-number sessions.

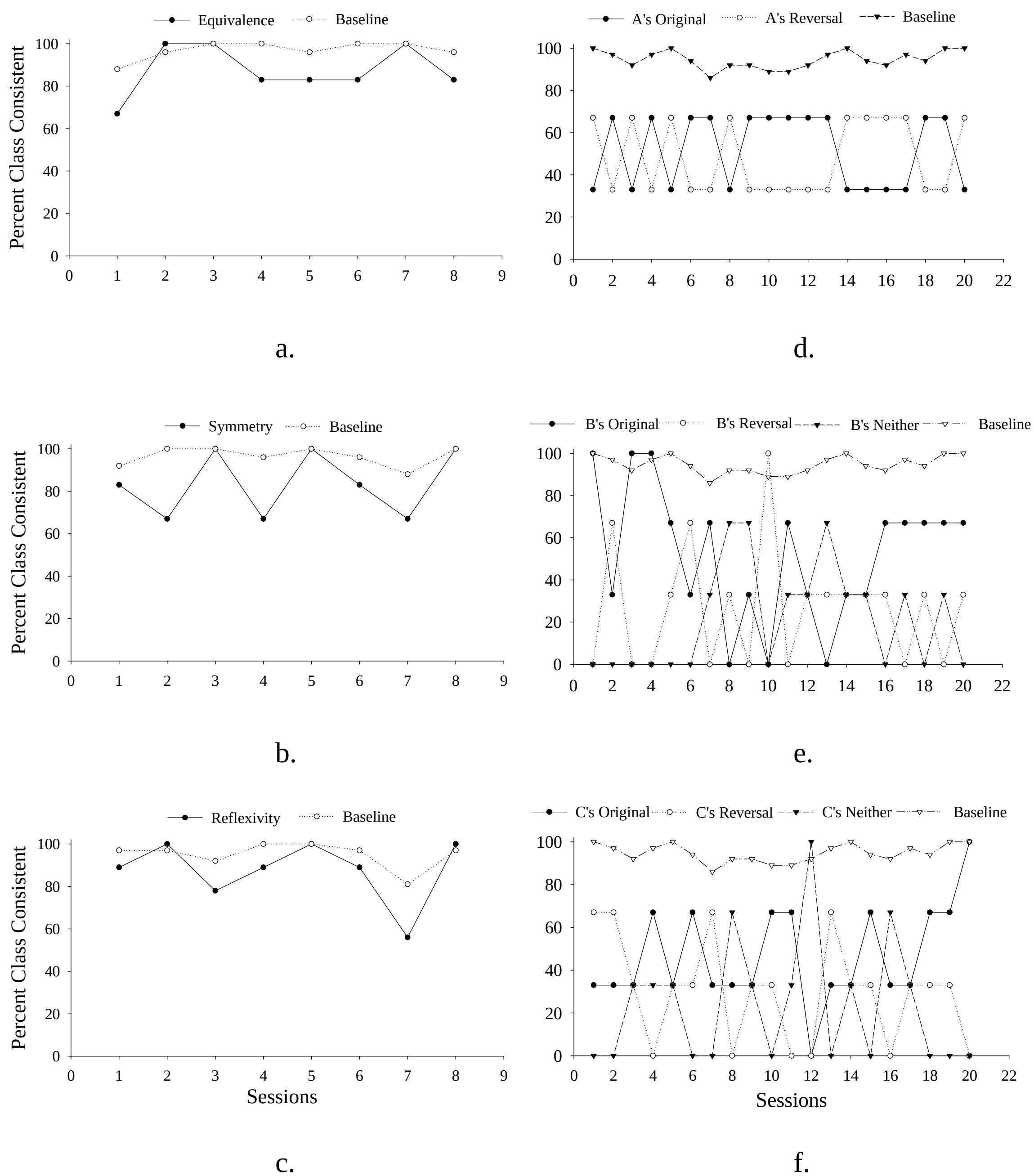


Figure 10. a., b., c.) Equivalence-probe performances for Participant MH during Experiment 2.
d., e., f.) A, B, and C reinforcer-probe performances for Participant MH during Experiment 2. Legend labels indicate performances consistent with the training contingencies of the original, outcome reversal, or neither of the training phases. Consequential stimuli served as comparisons during odd-number sessions and as samples during even-number sessions.

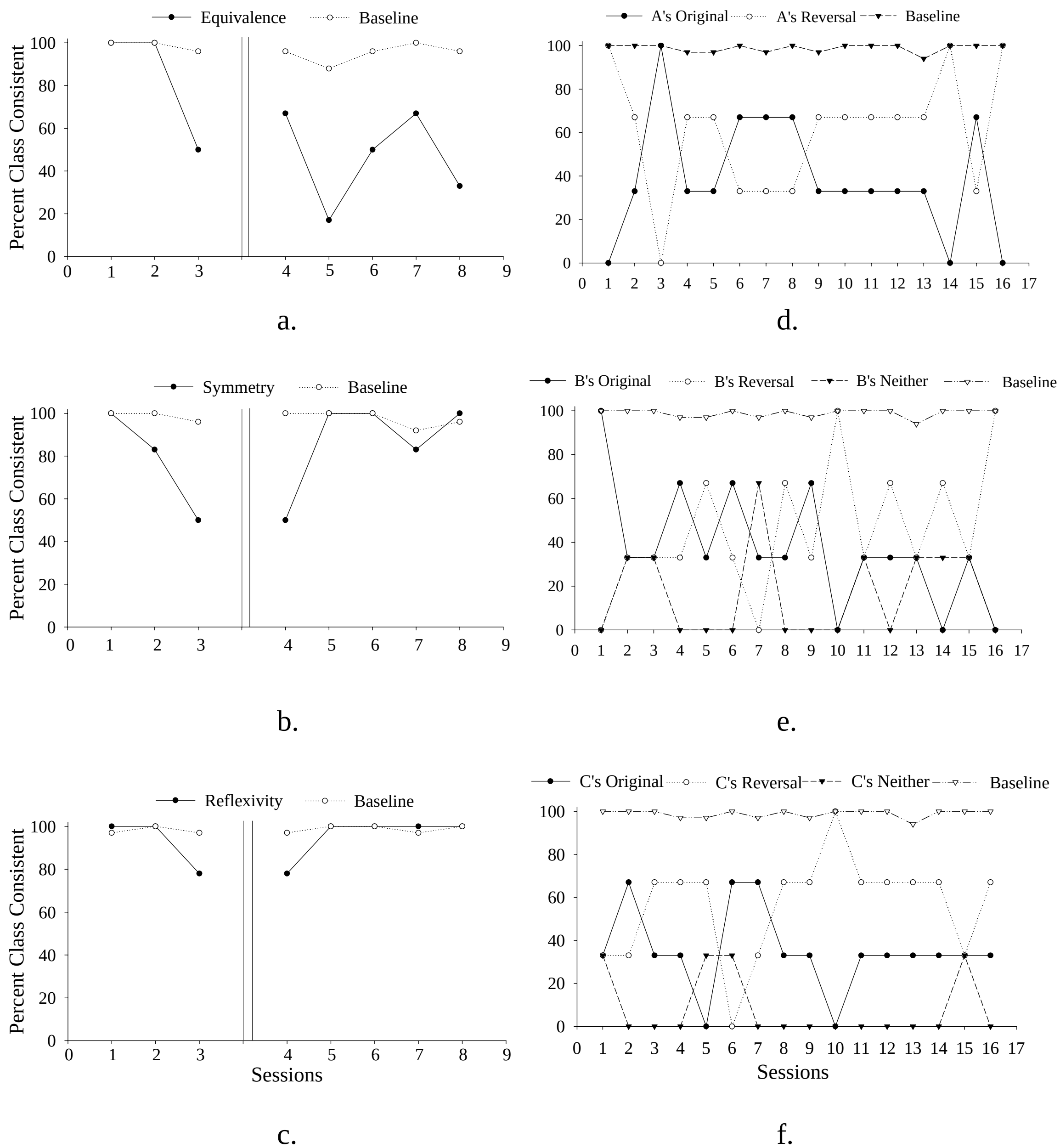


Figure 11. a., b., c.) Equivalence-probe performances for Participant TK during Experiment 2. Double lines indicate that intervening baseline-training sessions were conducted.
d., e., f.) A, B, and C reinforcer-probe performances for Participant TK during Experiment 2. Legend labels indicate performances consistent with the training contingencies of the original, outcome reversal, or neither of the training phases. Consequential stimuli served as comparisons during odd-number sessions and as samples during even-number sessions.

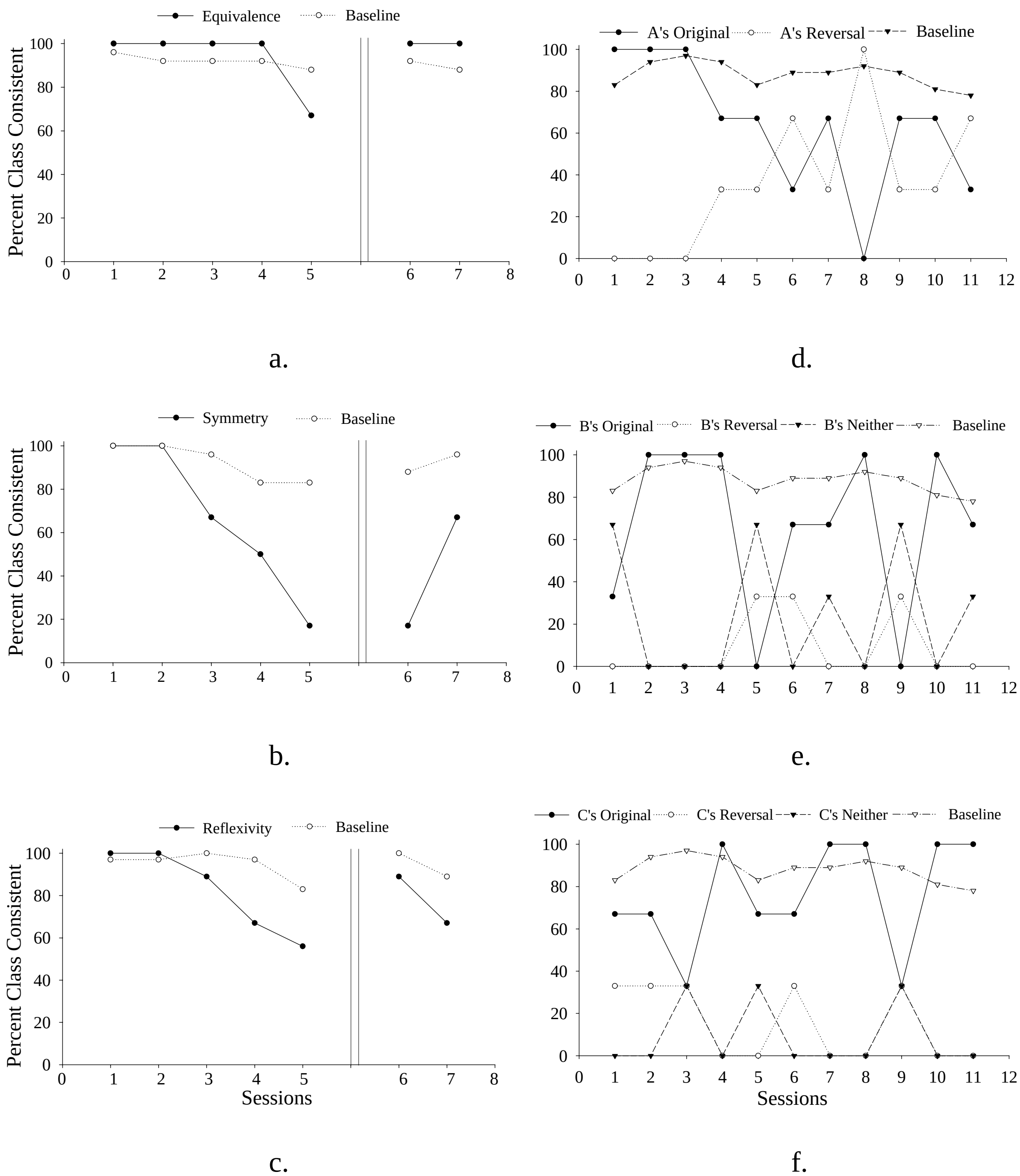


Figure 12. a., b., c.) Equivalence-probe performances for Participant DP during Experiment 2. Double lines indicate that intervening baseline-training sessions were conducted.
d., e., f.) A, B, and C reinforcer-probe performances for Participant DP during Experiment 2. Legend labels indicate performances consistent with the training contingencies of the original, outcome reversal, or neither of the training phases. Consequential stimuli served as comparisons during odd-number sessions and as samples during even-number sessions.

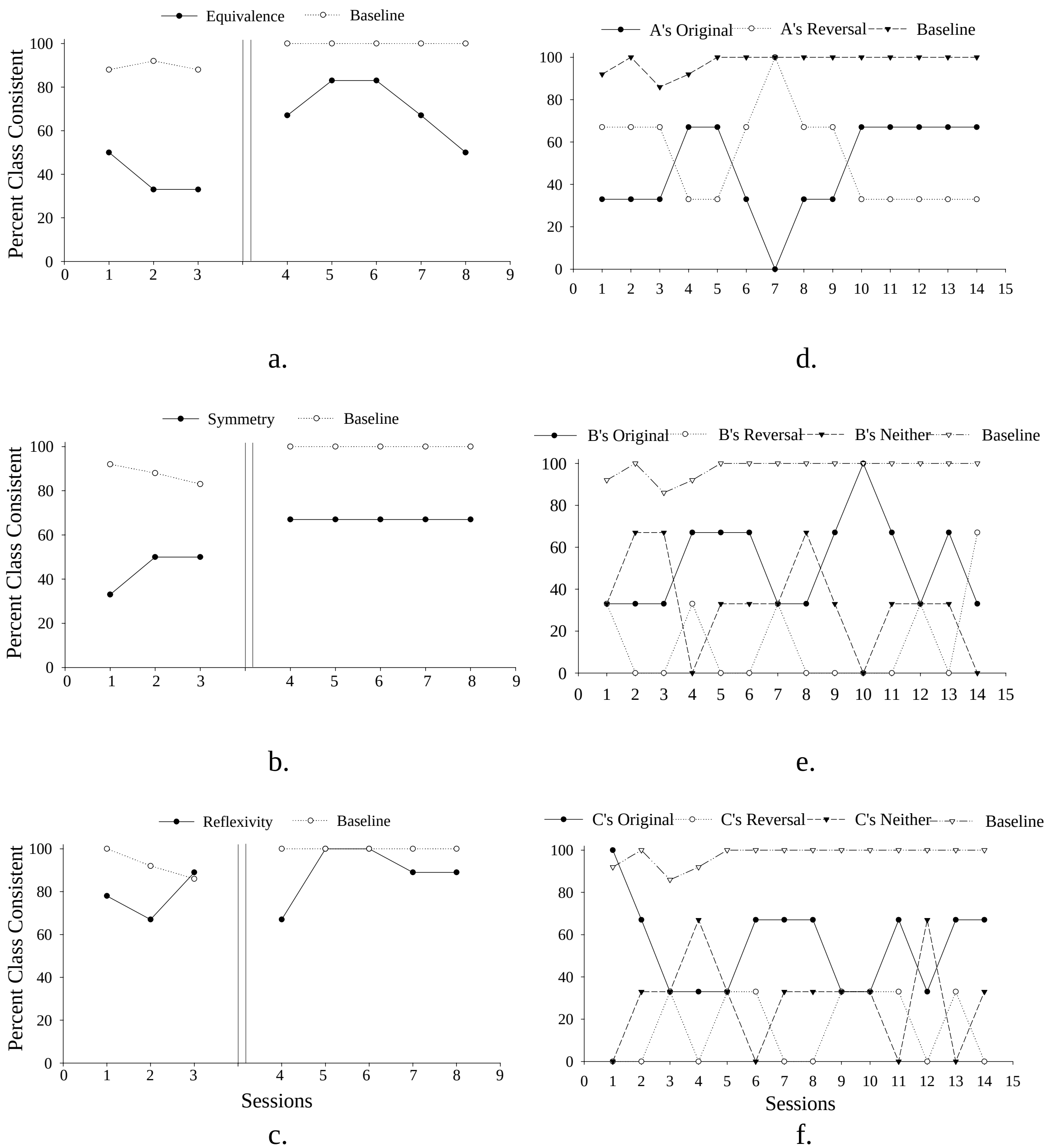


Figure 13. a., b., c.) Equivalence-probe performances for Participant GM during Experiment 2. Double lines indicate that intervening baseline-training sessions were conducted.

d., e., f.) A, B, and C reinforcer-probe performances for Participant GM during Experiment 2. Legend labels indicate performances consistent with the training contingencies of the original, outcome reversal, or neither of the training phases. Consequential stimuli served as comparisons during odd-number sessions and as samples during even-number sessions.

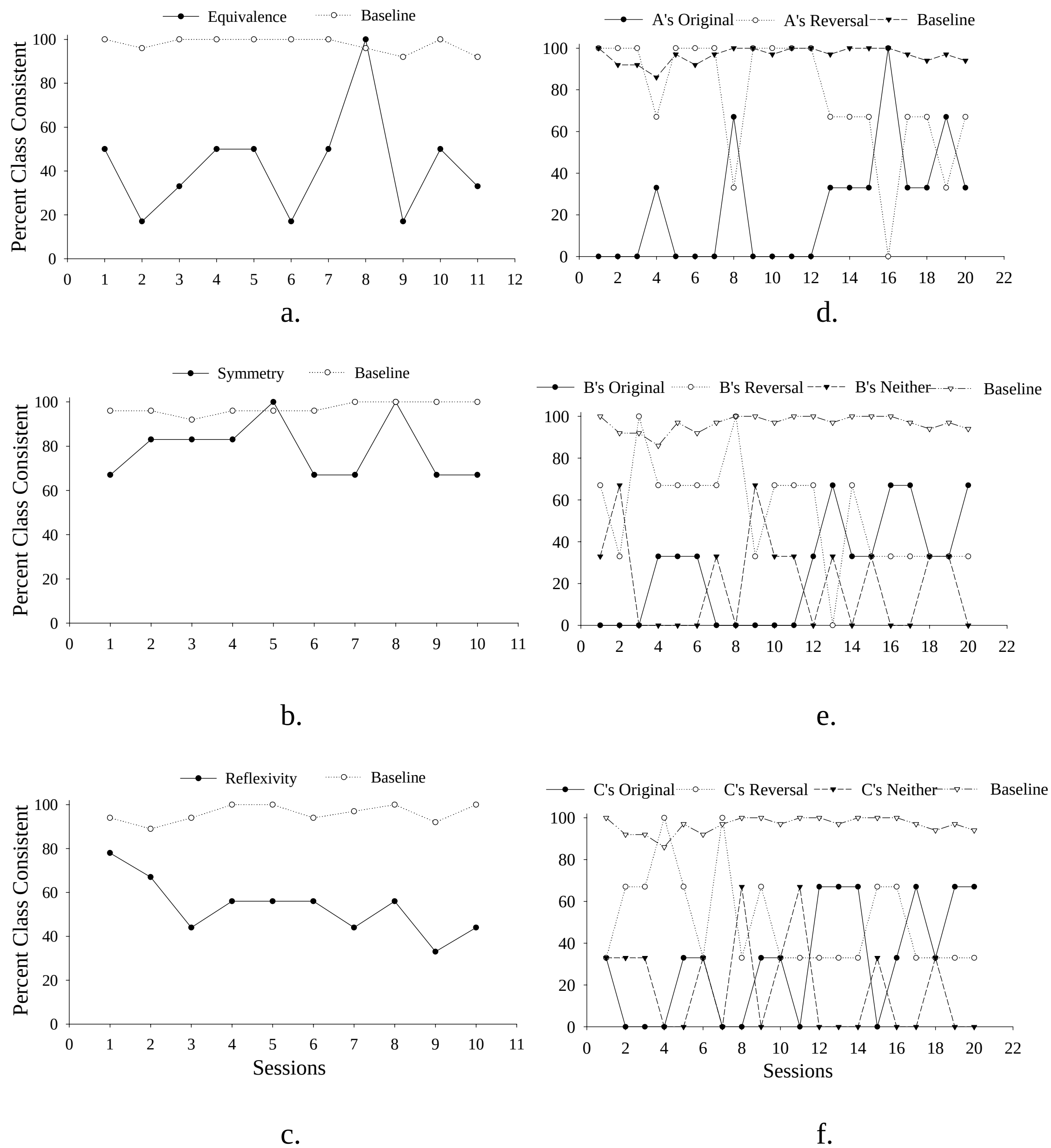


Figure 14. a., b., c.) Equivalence-probe performances for Participant GR during Experiment 2.
d., e., f.) A, B, and C reinforcer-probe performances for Participant GR during Experiment 2. Legend labels indicate performances consistent with the training contingencies of the original, outcome reversal, or neither of the training phases. Consequential stimuli served as comparisons during odd-number sessions and as samples during even-number sessions.

be discussed in detail below). Participant BS (see Figure 9) responded class-consistently on both symmetry and reflexivity probes, and although her equivalence-probe performances were not perfect, they were relatively strong. By the fifth block her responses were stable and class consistent. For Participant MH (see Figure 10), performance was less stable across all probe types. Even so, her responses on several equivalence, symmetry, and reflexivity-probe sessions were perfectly class consistent. After completing eight blocks, the responses of Participant MH were both stable and predominantly class consistent.

In contrast to the aforementioned performances, the performance of the remaining participants (TK, DP, GM, and GR) showed a lack of equivalence-class formation. Further, three of the participants received additional baseline training (previously conducted in Experiment 1) following a decline in either baseline or equivalence performance levels.

Although his baseline performances remained strong, by the third block, performance on all three-probe types had declined for Participant TK (see Figure 11). Thus, intervening baseline-training sessions were conducted. After completing three AB/AC-mixed training sessions at 100%, 75%, and 50% reinforcement densities, in that order (accuracy was 100%, 92%, and 63%, respectively), TK completed an additional round of AB/AC-mixed training sessions (two sessions each at 100%, 75%, and 50% reinforcement densities, and in that order) and his performance returned to mastery levels. He then completed five additional probe blocks. While performance on symmetry and reflexivity probes proved to be highly class consistent for TK, his performance on equivalence probes indicated a lack of equivalence-class formation. Even after completing eight blocks, stability on all three probes types concurrently was never achieved for

Participant TK. At this point, training for TK was discontinued to allow for participation in Experiment 3.

After completing most of five probe blocks (the fifth probe block did not include reinforcer-probe sessions), Participant DP (see Figure 12) began AB/AC-mixed training sessions (three at 50% reinforcement and one at 75% reinforcement) due to a decline in baseline performance. After scoring a 92% on his fourth mixed session, DP completed two additional probe blocks. While his performance on equivalence probes was highly consistent across all probe blocks, his later performance on symmetry and reflexivity-probe sessions suggested a lack of equivalence-class formation. At the completion of seven probe blocks total, DP's responses on all probe types were unstable and his baseline performance again showed a decline in accuracy. He then completed six AB/AC-mixed training sessions at 100% reinforcement density at which time his baseline performance continued to deteriorate (he scored a 67%, 25%, 58%, 33%, 67%, and a 50%, respectively). No further testing was conducted with Participant DP.

Following the completion of most of three probe blocks (the third probe block did not include reinforcer-probe sessions), a moderate decline in the baseline performance of Participant GM was observed. Thus, GM (see Figure 13) began AB/AC-mixed training sessions where he completed two sessions each at 100%, 75%, and 50% reinforcement densities, and in that order (accuracy was 100% on all but the first session). Participant GM then completed an additional five probe blocks and while his performance on all probe types was stable, only responses on reflexivity probes were strongly class consistent. Responses on both equivalence and symmetry-probe sessions by Participant GM call equivalence-class formation into question, although a majority of responses were class consistent.

The baseline performance of Participant GR (see Figure 14) remained strong for the duration of equivalence-probe testing. Although not perfect, GR's responses on symmetry probes were fairly class consistent and stable across the 10 probe blocks completed.   His responses on equivalence and reflexivity probes, however, were not class consistent (with the exception of his equivalence-probe performance on session 9) and showed a greater degree of bounce. After completing 10 probe blocks, the responses of Participant GR on equivalence and reflexivity probes remained class inconsistent and lacked stability.

Reinforcer-Probe Performances

Table 9 presents a summary of the reinforcer-probe performances for each participant. For B and C reinforcer probes, number of responses consistent with the training contingencies of the original, outcome reversal, and neither of the training phases is shown. For A reinforcer probes, number of responses consistent with the training contingencies of the original and outcome-reversal training phases is shown. Because the A stimuli were the nodes for the two interrelated conditional discriminations, they were associated with each of the reinforcers produced by selections of the B and C stimuli throughout both original and outcome-reversal training. Thus, on A reinforcer probes, it was impossible to make a response (i.e., a neither response) that was not consistent with at least one of the training arrangements.

With the exception of DP and GM, the baseline performances of each of the participants remained relatively strong for the duration of reinforcer-probe testing (see Figures 7-14). As mentioned previously, the decline in accuracy in the baseline performances of DP (see Figure 12) and GM (see Figure 13), which was also evident during equivalence-probe testing, necessitated additional baseline training (following Sessions 5 and 11 for DP and following Session 4 for GM). Although GM's baseline performance returned to criterion level, the baseline performance of DP showed some bounce for the remainder of testing.

Table 9

A, B and C Reinforcer-Probe Performances for Each Participant During Experiment 2

	A's		B's			C's		
Participant	Original	Reversal	Original	Reversal	Neither	Original	Reversal	Neither
ZM	36	21	36	10	11	37	9	11
DP	21	12	22	3	8	25	5	3
BS	28	26	29	16	9	24	15	15
MH	31	29	31	16	13	28	18	14
GM	20	22	22	6	14	23	7	12
LR	5	31	4	27	5	10	1	25
TK	19	29	18	22	8	17	27	4
GR	14	46	16	32	12	19	30	11

For five participants (ZM, DP, BS, MH, and GM), a majority of the responses on reinforcer probes were consistent with the original-class outcomes. Only three participants (LR, TK, and GR) responded in a manner mostly consistent with the reversed outcomes.

Participants ZM (see Figure 8) and DP (see Figure 12), showed the reinforcer- probe patterns that were most strongly consistent with the original-class outcomes.

For Participants BS (see Figure 9) and MH (Figure 10), responses on A, B, and C reinforcer probes were slightly more consistent with the original-class outcomes, yet the difference between these responses and those consistent with the outcome reversal or with neither of the training phases was minimal.

Reinforcer-probe responses by Participant GM (see Figure 13) were mixed. Even so, a majority of his responses were consistent with the original-class outcomes. Thus, on A reinforcer probes, GM's responses were slightly more consistent with the reversed outcomes while, on B and C reinforcer probes, his responses were slightly more consistent with the original-class outcomes.

Only the responses of Participants LR (see Figure 7), TK (see Figure 11), and GR (see Figure 14) were mostly consistent with the reversed outcomes. With the exception of his responses on C-reinforcer probes (which were not consistent with either the original or outcome-reversal training contingencies), Participant LR showed the reinforcer-probe pattern that was most strongly consistent with the reversed outcomes. Thus, his responses were largely indicative of the formation of the following classes: A1B1C1R2, A2B2C2R3, and A3B3C3R1. For both Participants TK and GR, responses were minimally consistent with the reversed outcomes. That is, their responses on A, B, and C reinforcer probes were slightly more consistent with the reversed outcomes, yet the difference between these responses and those consistent with the original or with neither of the training phases was minimal.

Post-Sort Task Performances

Participants MH and DP did not complete the post-sort task. Thus, post-sort data are not reported for these subjects. Table 10 shows post-sort data for each of the remaining participants.

In accord with their strong equivalence-probe performances, Participants BS, ZM, and LR all sorted the cards into groups perfectly consistent with the experimenter programmed equivalence classes (i.e., A1B1C1, A2B2C2, and A3B3C3). However, with respect to reinforcer stimuli, results were mixed. Participant BS's sorting suggested that the reinforcers had joined the original equivalence classes. That is, when prompted to sort the cards into three piles, BS sorted the cards in the following manner: A1B1C1R1, A2B2C2R2, and A3B3C3R3. No response was offered for why she sorted them in the manner chosen. She initially sorted them into four piles (i.e., A1B1C1, A2B2C2, A3B3C3, and R1R2R3) at which time she pointed to the pile of consequential stimuli and responded, "I don't like these because I don't know which ones (i.e., experimental stimuli) they go with."

For Participant ZM, on the other hand, responses on the post-sort task were indicative of multiple sources of stimulus control (i.e., control by both the original and the outcome-reversal training contingencies). Participant ZM first sorted the cards into four groups as follows: A1B1C1R2, A2C2R1, A3B3C3R3, and B2. When prompted to sort the cards into three groups, ZM resorted the cards in the following manner: A1B1C1R2, A2B2C2R1, and A3B3C3R3. When prompted to explain his sorts (following each sort), Participant ZM, while pointing to the consequential stimuli in each pile, responded, "Because they (i.e., the experimental stimuli) match with that one (i.e., the consequential stimulus)."

Table 10

Post-Sort Groups as Sorted by Each Participant

Participant	Experiment	Post-sort groups
BS	2	A1B1C1R1, A2B2C2R2, A3B3C3R3
	3	A1B1C1R1, A2B2C2R2, A3B3C3R3
ZM	2	A1B1C1R2, A2B2C2R1, A3B3C3R3
	3	—
	4	A1B1C1R1, A2B2C2R2, A3B3C3R3
LR	2	A1B1C1R2, A2B2C2R3, A3B3C3R1
	3	—
TK	2	A1B1C1B2R3, A2C2R2, A3B3C3R1
	3	—
GM	2	A1R2, R1R3, A2A3B1B2B3C1C2C3
	3	A1C2C3R2, A2R1R3, A3B1B2B3C1
	4	A1A2A3R3, B1B3R1R2, C1C2C3B2
GR	2	A1C1R3, B1C2R1R2, A2A3B2B3C3
	3	—
DP	2	—
MH	2	—
	3	A1B1C1R3, A2B2C2R2, A3B3C3R1
	4	A1B1C1R1, A2B2C2R3, A3B3C3R2

Note. Post-sort data containing more than three groups is not reported. Dashes indicate that post-sort data was not obtained.

Participant LR's responses on the post-sort task were most in line with the reversed outcomes, specifically the AB outcome-reversal training contingencies. Thus, Participant LR sorted as follows: A1B1C1R2, A2B2C2R3, and A3B3C3R1. When prompted to explain his sorts, Participant LR, while pointing to the consequential stimuli in each group, responded, "Because they match (i.e., the experimental stimuli) with that one (i.e., the consequential stimulus)."

As stated previously, the performances of Participants TK, GM, and GR on equivalence probes indicated a lack of equivalence-class formation. Their responses on the post-sort task were consistent with this analysis. That is, none of these participants sorted the cards into groups consistent with the experimenter programmed equivalence classes (i.e., A1B1C1, A2B2C2, and A3B3C3). Participant TK's responses were the most closely in line with the intended equivalence classes, as he sorted the cards into the following three groups: A1B1C1B2R3, A2C2R2, and A3B3C3R1. His sorting of reinforcer stimuli suggests multiple sources of stimulus control (i.e., control by both the original and the outcome-reversal training contingencies). When prompted to explain his sorts, in reference to the A1, B1, C1, B2, and R3 group, TK said, "Because this group is all kind of squiggly." Regarding the group of A2, C2, and R2, TK stated that he had put them together, "Because they all have a circle in them." In reference to the A3, B3, C3, and R1 group, TK responded, "Because they look like science to me."

The responses of Participants GM and GR on the post-sort task, however, bared little to no resemblance to the experimenter programmed equivalence classes (i.e., A1B1C1, A2B2C2, and A3B3C3). Moreover, their sorting of reinforcer stimuli appeared to be mostly random as well. During his post sort, GM initially sorted the cards into two piles, one containing all experimental stimuli and the other containing all consequential stimuli. Following a prompt to sort the cards into three groups, Participant GM sorted as follows: A1R2, R1R3, and A2A3B1B2B3C1C2C3. When prompted to explain his sorts, in reference to the A1 and R2 group, GM said, “They both look like circles.” Regarding the R1 and R3 group, GM stated, “They’re both squares.” In reference to the group containing A2, A3, B1, B2, B3, C1, C2, and C3, GM stated, “These are not shapes.”

During his post-sort task, Participant GR initially sorted the cards into six groups as follows: A1B2, A2R1, A3B3, B1R2, C1R3, and C2C3. When prompted to sort the cards into three groups, GR resorted the cards in the following manner: A1C1R3, A2A3B2B3C3, and B1C2R1R2. Only the A1C1R3 group, which was consistent with the AC outcome-reversal training contingencies, reflected previous training. No response was offered for why the cards were sorted in this manner.

Discussion

The responses of half of the participants (LR, ZM, BS, and MH), on both equivalence probes (equivalence, symmetry, and reflexivity) and the post-sort task, showed clear evidence of the formation of three three-member equivalence classes (i.e., A1B1C1, A2B2C2, and A3B3C3). In contrast, the responses of the remaining participants (GM, GR, TK and DP) on equivalence probes and the post-sort task raise questions about equivalence-class formation.

In regard to reinforcer-probe performances, although none of the participants’ responses were completely consistent with either of the training conditions, the majority of participants (BS, ZM, DP, MH, and GM) showed a pattern of responses that was more consistent with the original-training contingencies than with the outcome-reversal training contingencies. Of these five participants, however, only the responses of BS remained consistent across each of the tasks in the experimental-test sequence. (i.e., equivalence probes, reinforcer probes, and the post-sort task). Thus, her responses demonstrated the formation of the A-B-C classes and provided the strongest evidence for the expansion of those classes to include the reinforcers (i.e., A1B1C1R1, A2B2C2R2, and A3B3C3R3). For the remainder of the participants (LR, TK, and GR), responses were more consistent with the outcome-reversal training arrangement.

There are several possible theoretical positions relevant to the findings of these studies. For example, the pattern of responses on equivalence-probe trials by Participants TK and DP highlights the role of reinforcement in the maintenance of responses. Although, their responses on all equivalence-probe types were initially highly class consistent, there was later a decline in accuracy. Because equivalence-probe trials were conducted in extinction, differential reinforcement was not available as feedback to participants on choice accuracy. Thus, the discriminative responses of TK and DP on probe trials may have undergone extinction. Another possibility is that their responses reflect extinction-induced variations. What remains unclear, however, is why both participants, demonstrated patterns on at least one probe type that remained highly class consistent (i.e., reflexivity probes for TK and equivalence probes for DP with the exception of Session 5).

The decline in accuracy evident in the baseline performances of Participants DP and GM suggests yet another explanation for negative outcomes on tests for equivalence. For the majority of probe testing, DP failed to maintain criterion accuracy levels on his baseline performance. Participant GM also showed a moderate decline in his baseline accuracy. In the absence of firmly established baseline conditional discriminations, questionable equivalence performances should not come as a surprise. In fact, the performances of both DP and GM on equivalence, symmetry, and reflexivity probes did show some improvement following a return to baseline training.

Perhaps the most obvious explanation for the questionable performances of several of the participants on one or more of the experimental tasks (equivalence probes, reinforcer probes, or the post-sort task) is the outcome-reversal training contingencies in place during Phases 2, 4, and 5 of Experiment 1 and throughout probe testing during Experiment 2. Sidman's (2000) theory, which maintains that equivalence is a basic process that occurs as a direct result of reinforcement contingencies, seems to offer one account of why the outcome-reversal training contingencies may have yielded negative or inconsistent findings on experiment tasks for at least some of the participants. It is important to note, however, that since equivalence tests were not conducted following the original-training arrangement, this is purely speculative.

According to Sidman (2000), the reinforcement contingency produces both analytic units and equivalence relations. However, certain training procedures prevent the simultaneous demonstration of both outcomes. For example, training with a common reinforcer initially generates one large equivalence class, thwarting the demonstration of smaller equivalence classes (e.g., A1B1C1, A2B2C2, and A3B3C3), and thus precluding the expansion of those classes to include the reinforcer stimuli (e.g., A1B1C1R1, A2B2C2R2, and A3B3C3R3). The outcome-reversal training arrangement of the present study presents subjects with a similar scenario. For instance, given A1, selections of B1 and C1, respectively, produced R2 and R3, respectively. Thus, both R2 and R3 could potentially join the A1B1C1 equivalence class. Moreover, these same stimuli have also been directly associated with each of the other two equivalence classes (i.e., selections of C3 following A3 produced R2, and selections of B2 following the presentation of A2 produced R3).

When training is conducted with either a common reinforcer, or with overlapping reinforcers (as in the present study), the reinforcers must selectively drop out of the equivalence relation in order for the analytic units to persevere (Sidman, 2000). Moreover, this makes it possible for smaller equivalence classes to form (e.g., A1B1C1, A2B2C2, and A3B3C3).

In keeping with Sidman's (2000) analysis, one must assume that because each of the participants was able to perform the AB and AC conditional discriminations despite training that included overlapping reinforcers, the reinforcers did selectively drop out of the equivalence relation. During the present experiment, it is possible that during baseline training, participants learned that the relations between specific stimuli and the reinforcers were irrelevant (at least on baseline-trial types). Thus, receiving any reinforcer, whether it was R1, R2, or R3, was enough to maintain correct responding (i.e., the reinforcers dropped out of the equivalence relations). By this view, the training that occurred during Experiment 1 with both original and reversed outcomes essentially prevented the reinforcers from becoming class members (i.e., the contingency took precedence). In order to meet baseline mastery criterion, there could be no control by specific stimulus-reinforcer relations on the baseline-trial types. This is not to say, however, that the trained reinforcer relations did not influence responses on other trial types. After all, differential reinforcement was not available on equivalence or reinforcer-probe trials, as they were presented in extinction. Consequently, participants were never "taught" that reinforcer relations were irrelevant in making responses on probe trials. It is possible that the trained reinforcer relations did exert some stimulus control over responses during one or more of the probe-trial types (resulting in class collapse), even if this was not the case during baseline trials. The responses of Participants GM and GR (both of whom failed to demonstrate positive outcomes on tests for equivalence) on the post-sort task make this explanation appear especially feasible.

Participants' patterns of responses on reinforcer-probes lend further support to this supposition. The responses of each of the participants on reinforcer probes were either mostly consistent with the original-class outcomes, or mostly consistent with the reversed outcomes, suggesting that the trained reinforcer relations did in fact exert some control over their responses. It is interesting to note that a majority of the participants' responses were more consistent with the training contingencies of the original rather than the outcome-reversal training arrangement. This is especially noteworthy in light of the fact that participants were so far removed temporally from the original-training contingencies and because the outcome-reversal training contingencies were in place throughout reinforcer-probe testing. Despite important procedural differences, these results bare similarity to the findings of Pilgrim and Galizio (1990; 1995). Following baseline conditional-discrimination training and equivalence testing, one or more baseline conditional discriminations were reversed. For example, although initially selections of C1 were reinforced when A1 was the sample, and C2 when A2 was the sample, during subsequent baseline-reversal training, selections of C2 were reinforced when A1 was the sample, and C1 when A2 was the sample. Results showed that although performances on baseline and symmetry probes conformed to the new contingencies, performances on transitivity/equivalence probes remained consistent with the original equivalence relations. It may be that both transitivity/equivalence and reinforcer-probe performances are considerably less malleable than other equivalence performances (e.g., symmetry and reflexivity). However, because probe testing did not occur prior to the reversal of training contingencies in the present study, a direct comparison is not possible.

In response to reversal findings such as those described above, Dube and McIlvane (1996) have described a mechanism by which multiple sources of stimulus control come to influence responding. Their account, which attributes conflicting SCTs to the lack of consistent control by ongoing training contingencies, is entirely compatible with Sidman's (2000) analysis. Moreover, Dube and McIlvane's (1996) description fits nicelywith our reinforcer-probe data.

For most participants, responses on reinforcer probes indicated multiple sources of stimulus control (i.e., control by both the original and the outcome-reversal training contingencies). A systematic replication of the Pilgrim and Galizio (1990) experiment outlined above, conducted with children aged 5-7 years, yielded similar results (Pilgrim, et al., 1995). Following the baseline reversals, the responses of the majority of participants (across all probe-trial types) were not consistently controlled by the ongoing training contingencies. Similarly, none of our participants' responses on reinforcer-probes were completely consistent with the ongoing training contingencies. In fact, most were to the contrary.

It is worthwhile to note one important difference in the findings of the Pilgirm and Galizio (1995) and the present study. In the Pilgrim and Galizio (1995) study, the experimenters observed that increases in age were correlated with tighter control of equivalence-probe responses by the ongoing baseline relations. No such correlation was evident in the present study.

In sum, the predominant pattern of responses on both reinforcer probes and the post-sort task was one of multiple sources of stimulus control, and reinforcer-probe responses were not always consistent with post-sort responses. Only the responses of Participants BS and LR remained consistent across each of the tasks in the experimental-test sequence. (i.e., equivalence probes, reinforcer probes, and the post-sort task). For Participants ZM and MH, it may be that the reinforcer-probe trials set the occasion for the SCTs established during the original-training arrangement, while the post-sort task set the occasion for the new SCTs established during the outcome-reversal training arrangement. This account, however, does not provide for why the same reinforcer probe may occasion one SCT on one trial and yet a conflicting SCT on another, or for what is responsible for the transition from one SCT to the next. More importantly, it seems that something beyond Dube and McIlvane's (1996) description of conflicting SCTs is needed to account for the principles that determine the different frequencies of SCTs that come to influence the responses of participants with identical training histories. It may be the case that a variety of response patterns are to be expected given the two training procedures. In other words, because both SCTs were equally available to influence responses, response patterns may be seen as likely to vary. Indeed, these findings point to a need for an experimental analysis of variables that might influence such patterns.

CHAPTER 5. EXPERIMENT 3

Experiment 3 was a replication of Experiments 1 and 2 without outcome reversals, and was conducted with the same experimental and consequential stimulus sets used in those studies. Reinforcement throughout baseline training and probe (equivalence and reinforcer) testing was consistent with that of the original training contingencies of Experiment 1. Half of all participants in Experiment 2 showed a lack of equivalence-class formation on one or more probe types. Thus, one purpose of Experiment 3 was to determine if training with consistent class-specific reinforcement (i.e., consistent across the interrelated conditional discriminations) would enhance the equivalence performances of children who did not show evidence of strong equivalence-class formation.

The reinforcer-probe performances of two of the participants (LR and TK) in Experiment 2 were mostly consistent with the reversed outcomes. For these two subjects, an additional goal of Experiment 3 was to determine if the reinforcers would now join the original classes. The reinforcer-probe performances of the remaining six participants in Experiment 2, while mostly consistent with the original class-consistent outcomes, were not perfectly class-consistent. Therefore, for these participants, an additional goal of Experiment 3 was to see if their reinforcer-probe performances would become more class consistent following the reinstatement of the class-consistent reinforcement contingencies.

Method

Participants

Seven of the participants (BS, GM, LR, GR, ZM, TK, and MH) who completed Experiments 1 and 2 participated (see Table 2).

Stimuli

Training and testing were conducted using one of three sets of experimental stimuli (see Figure 1). Each participant completed Experiment 3 with the same stimulus set used in Experiments 1 and 2 (see Table 1).

Procedure

Except where indicated below, the procedure was the same as in Experiments 1 and 2.

Training and Test Sequence

Baseline Training

See Table 3 for the composition of trial blocks for each baseline-training phase. AB and AC conditional-discrimination training was conducted in three phases. The first phase of baseline training included trial blocks with AB conditional-discrimination trials and was identical to Phase 1 of Experiment 1. The second phase of baseline training included trial blocks with AC conditional-discrimination trials and was identical to Phase 3 of Experiment 1. Phase 3 of baseline training included trial blocks composed of both AB and AC conditional-discrimination trials (AB/AC-mixed training) and except for the consistent reinforcement arrangement, was identical to Phase 5 of Experiment 1. The reinforcement procedure during AB/AC-mixed training was consistent with that employed during Phases 1 and 2 of the present experiment and with that employed during the original training phases of Experiment 1 (see Table 11). Additional specialized training was not necessary.

Equivalence and Reinforcer-Probe Testing

See Table 8 for the composition of trial blocks for each probe-test session. Equivalence and reinforcer-probe testing was the same as in Experiment 2. Reinforcement (when provided) for either baseline conditional discrimination was consistent with that employed during the previous

Table 11

Original Training Arrangement

Training phase	Trial type	Reinforcement
AB	A1:B1	R1
	A2:B2	R2
	A3:B3	R3
AC	A1:C1	R1
	A2:C2	R2
	A3:C3	R3

Note. Trial types are listed with the sample stimulus first, followed by its corresponding comparison stimulus.

training phases (see Table 11).

Post-Sort Task

Upon completion of probe testing, participants completed a post-sort task identical to that conducted in Experiment 2.

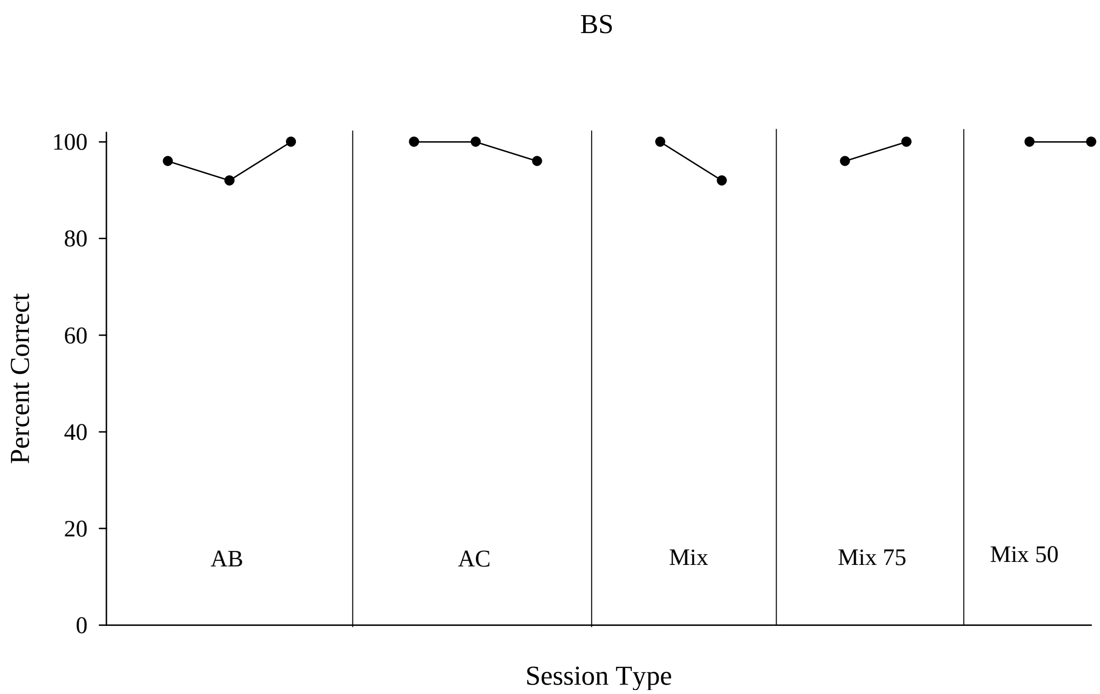
Results

Baseline Performances

Figures 15-18 show the baseline performances of Participants BS, GM, LR, GR, ZM, TK, and MH after the original training contingencies were reinstated. For all participants, AB, AC, and AB/AC mixed conditional discrimination acquisition occurred rapidly and specialized training was not necessary. Participants BS (see Figure 15), GM (see Figure 15), LR (see Figure 16), and GR (see Figure 16) completed all phases of baseline training in the minimum number of sessions required. The remaining participants (ZM, TK, and MH) completed only a few additional sessions (1-3) on one or more of the training phases before meeting mastery criterion (see Figures 17 and 18).

Equivalence-Probe Performances

Figures 19-23 show the children’s equivalence-probe performances. Overall, the performances of Participants ZM, BS, MH and GM, were highly class consistent. Moreover, although Participants LR and TK left the study before completing equivalence-probe testing, their initial equivalence performances were also highly class consistent. In contrast, the initial equivalence performances of Participant GR indicated a lack of equivalence-class formation. Even so, the baseline performances of all participants, including GR, remained above criterion throughout equivalence-probe testing (he too left the study prior to completing equivalence-probe testing).



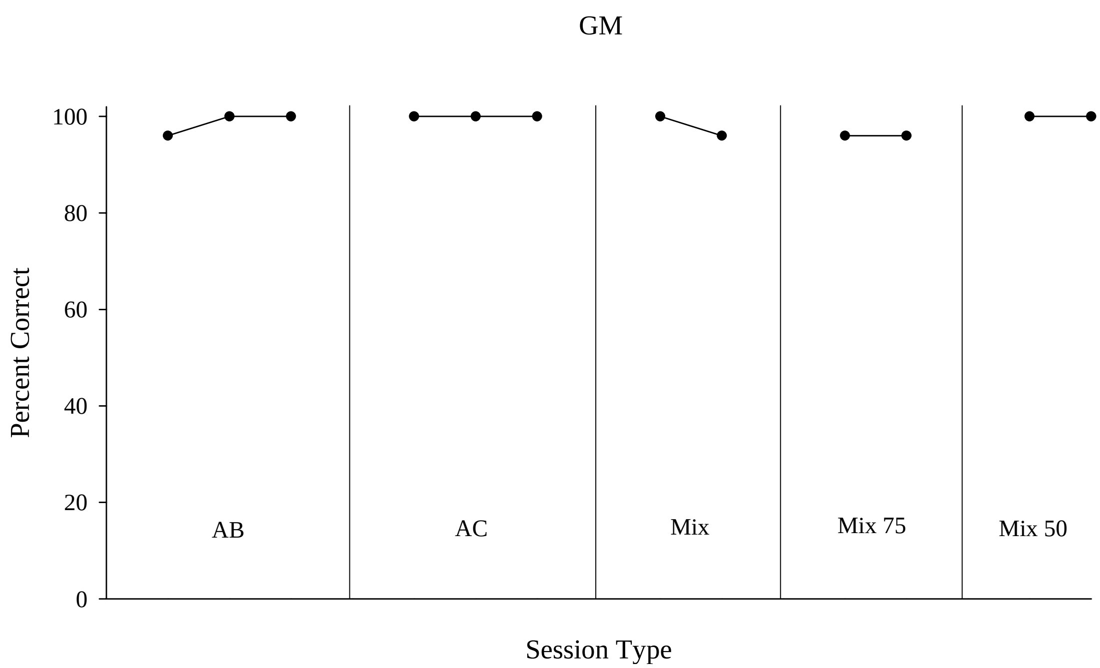
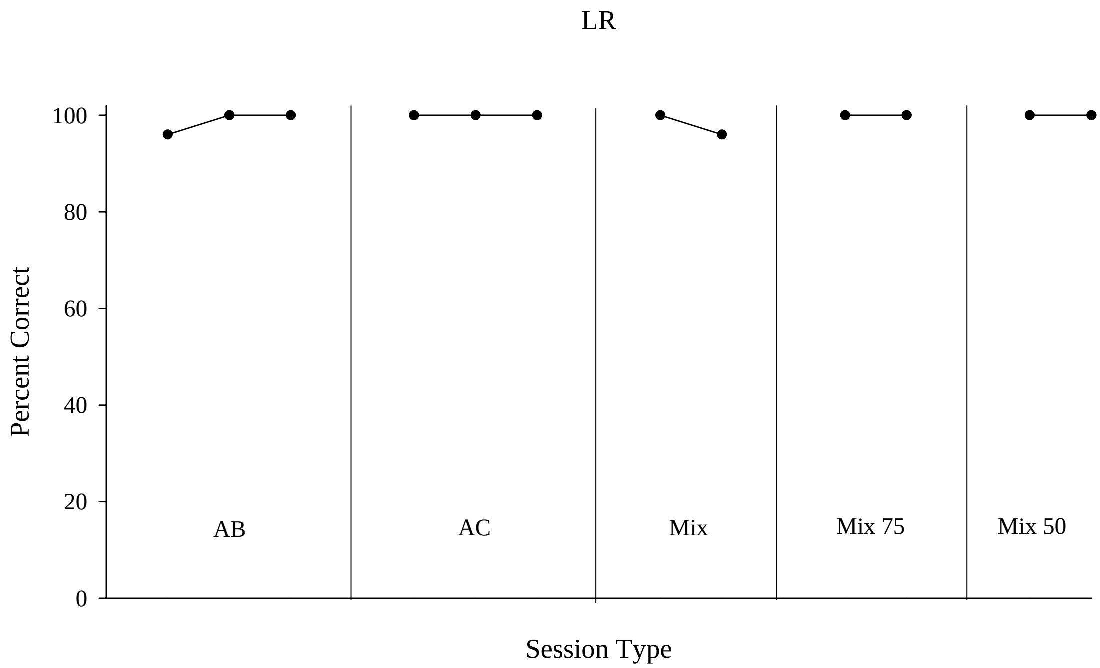


Figure 15. Baseline training for Participants BS and GM during Experiment 3.



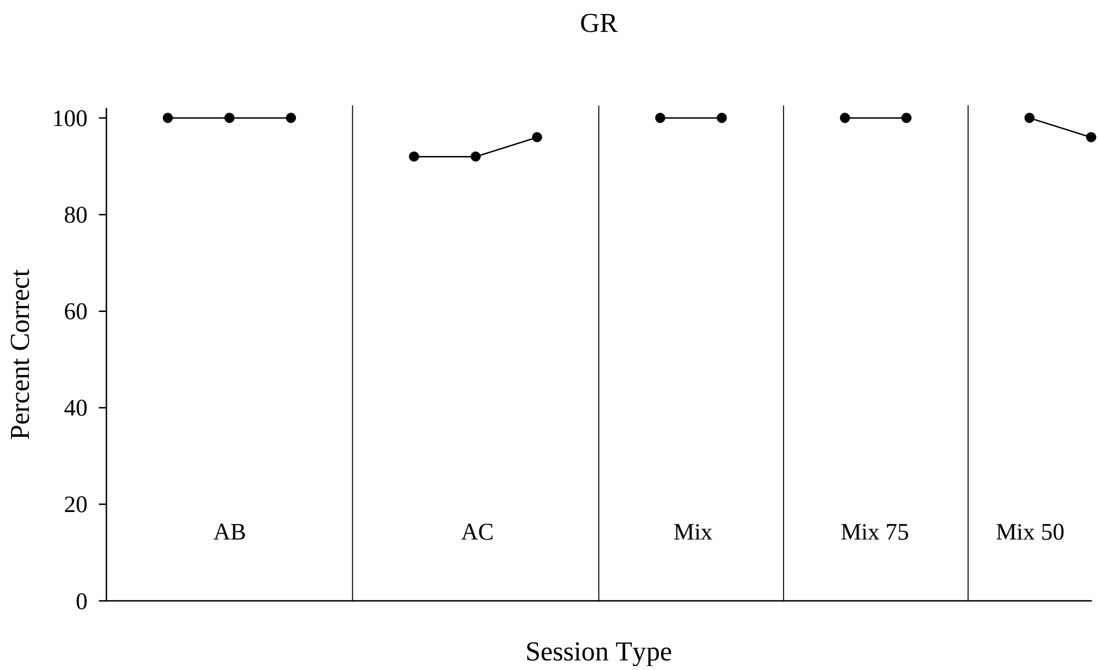


Figure 16. Baseline training for Participants LR and GR during Experiment 3.

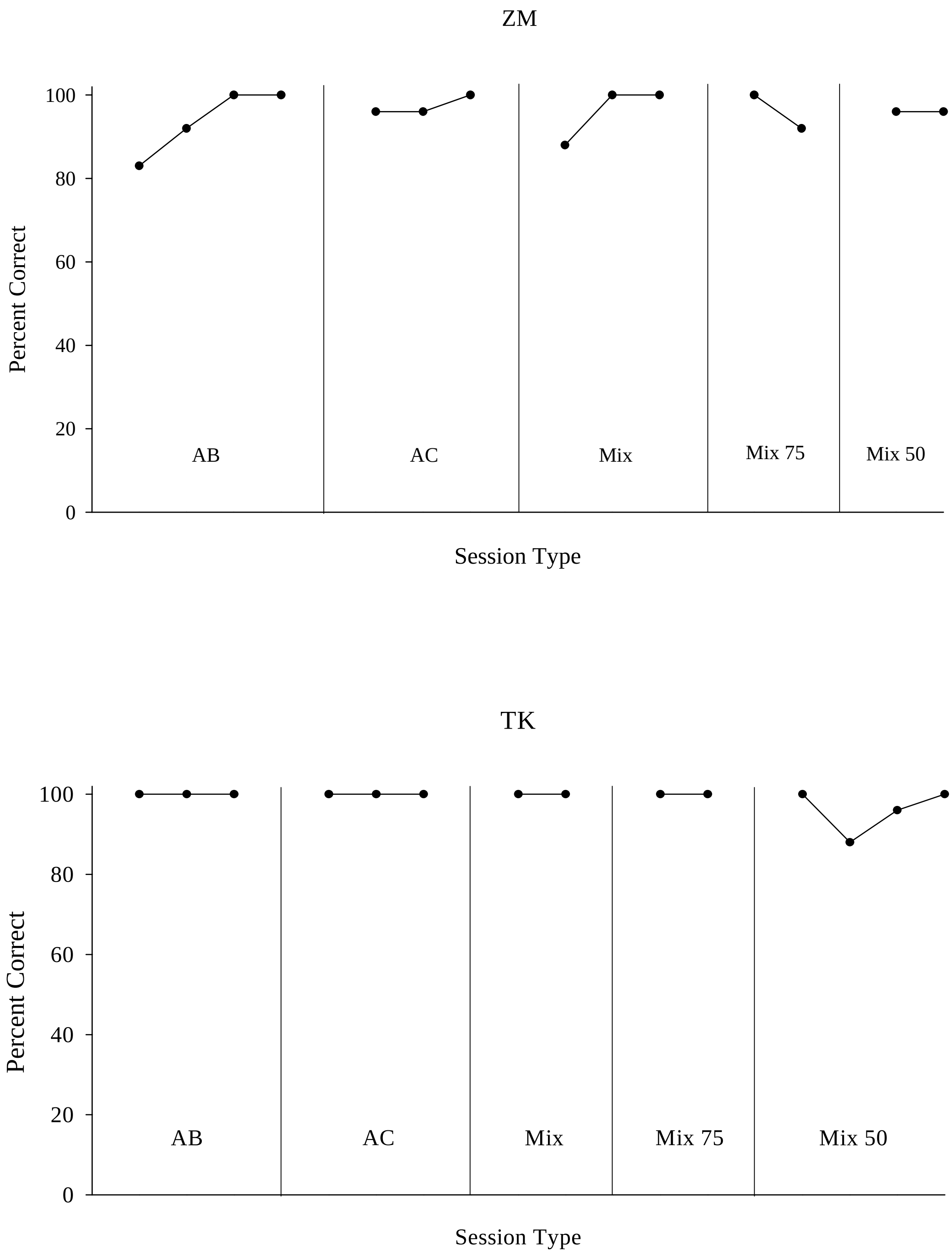


Figure 17. Baseline training for Participants ZM and TK during Experiment 3.

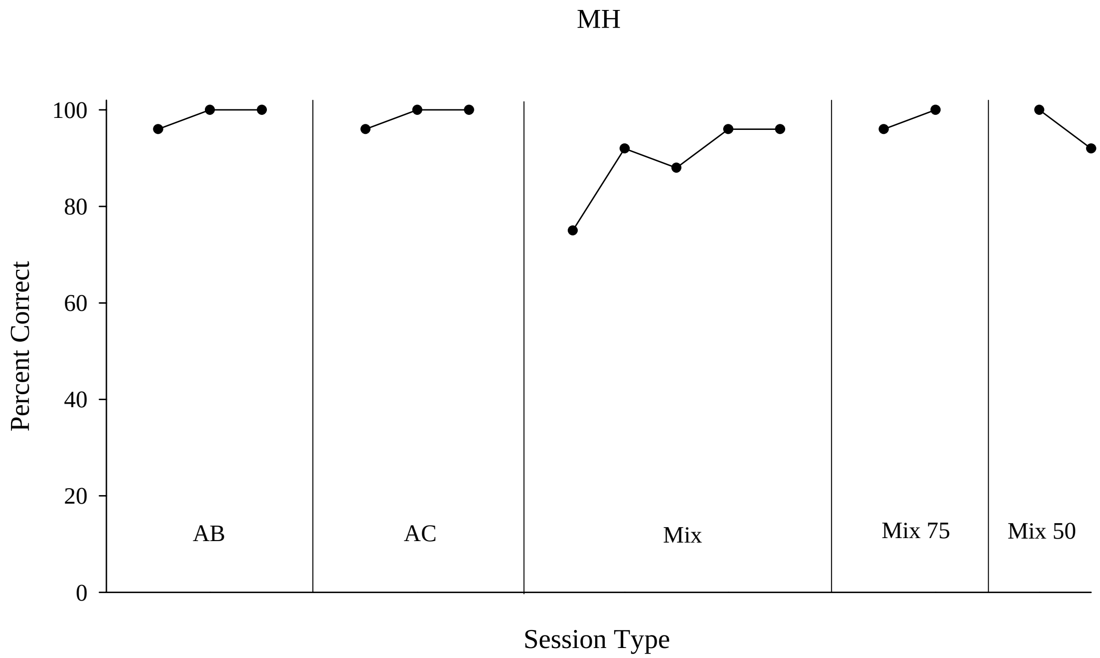


Figure 18. Baseline training for Participant MH during Experiment 3.

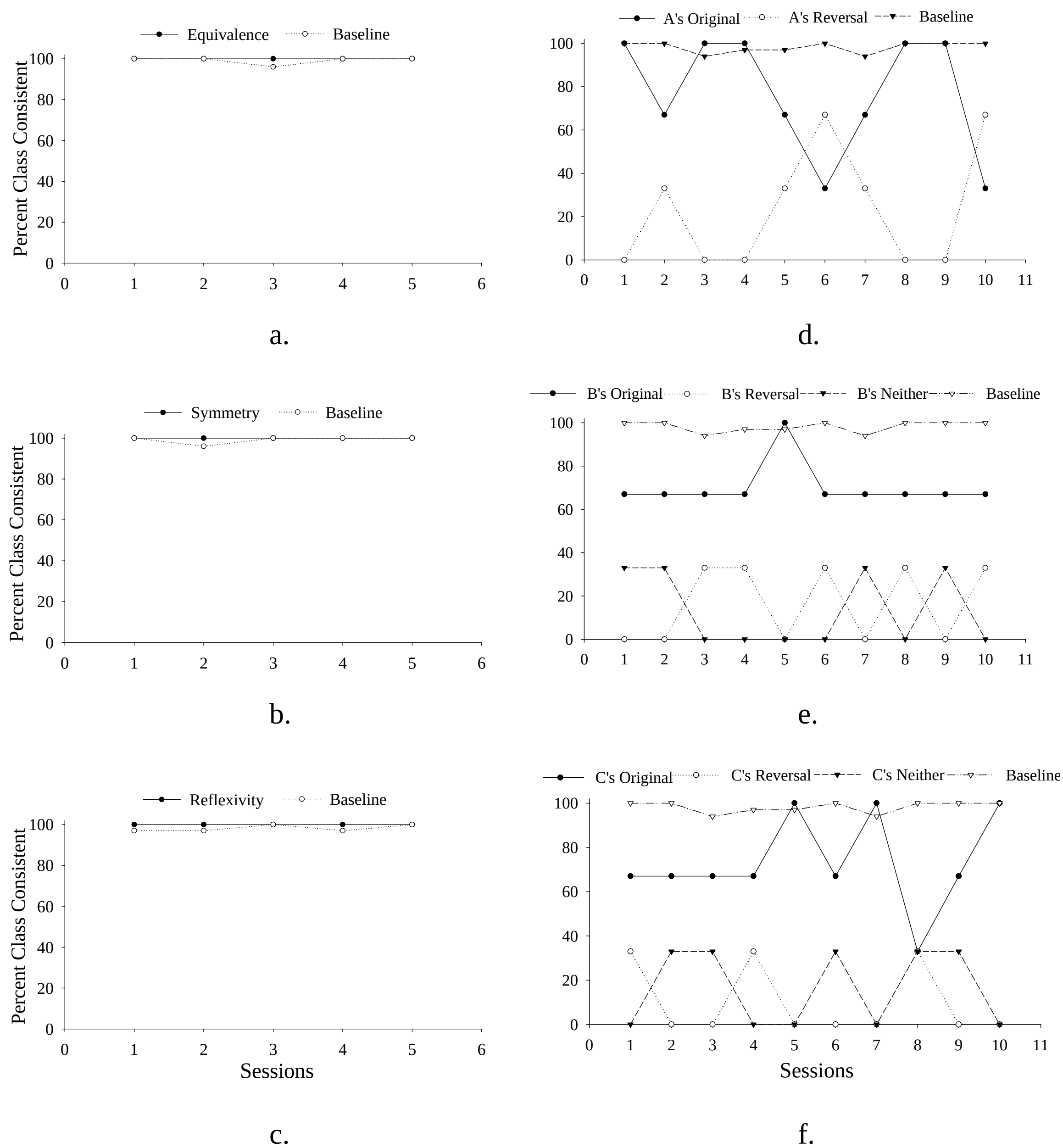


Figure 19. a., b., c.) Equivalence-probe performances for Participant ZM during Experiment 3.
d., e., f.) A, B, and C reinforcer-probe performances for Participant ZM during Experiment 3. Legend labels indicate performances consistent with the training contingencies of the original, outcome reversal, or neither of the training phases. Consequential stimuli served as comparisons during odd-number sessions and as samples during even-number sessions.

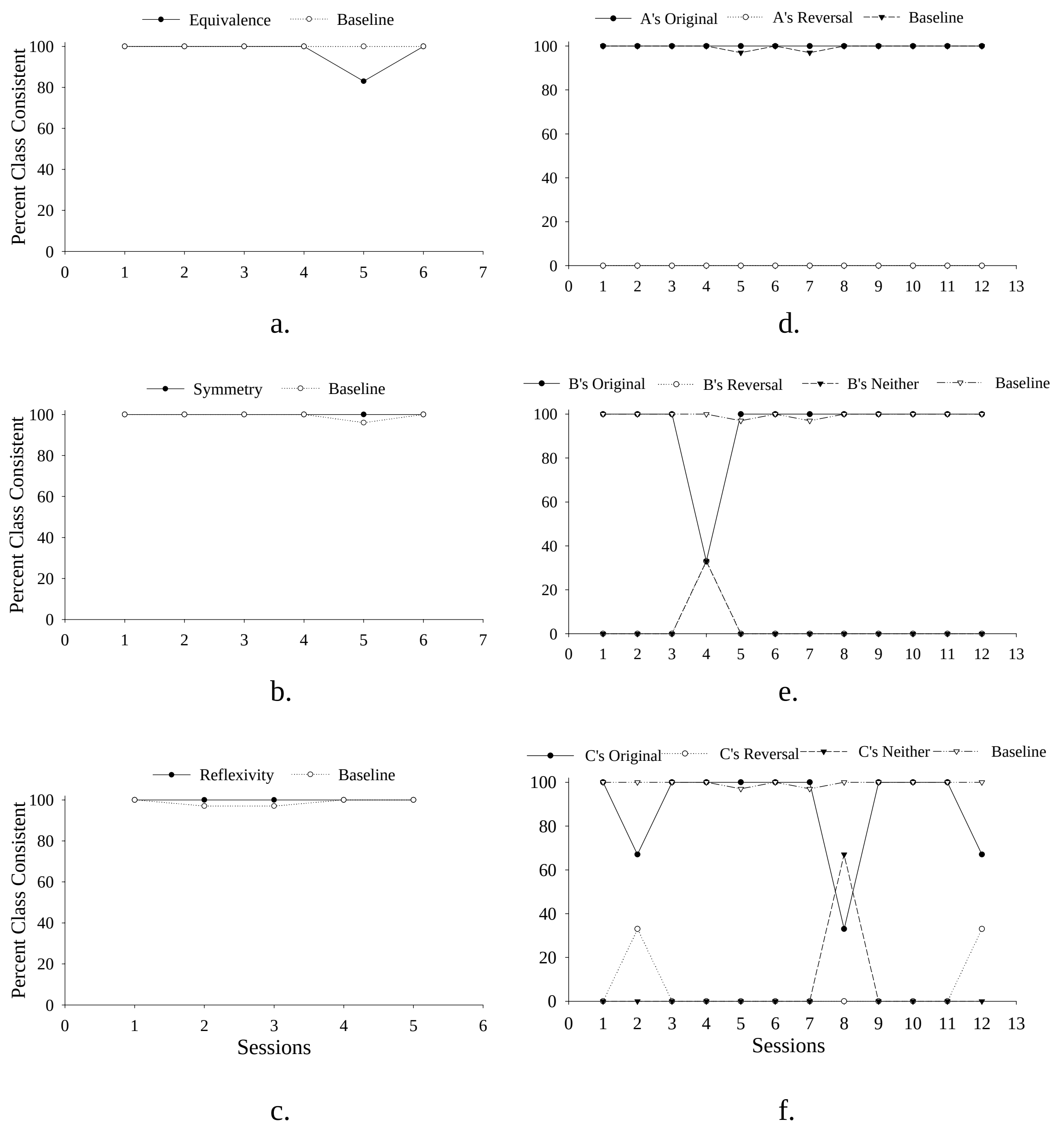


Figure 20. a., b., c.) Equivalence-probe performances for Participant BS during Experiment 3.
d., e., f.) A, B, and C reinforcer-probe performances for Participant BS during Experiment 3. Legend labels indicate performances consistent with the training contingencies of the original, outcome reversal, or neither of the training phases. Consequential stimuli served as comparisons during odd-number sessions and as samples during even-number sessions.

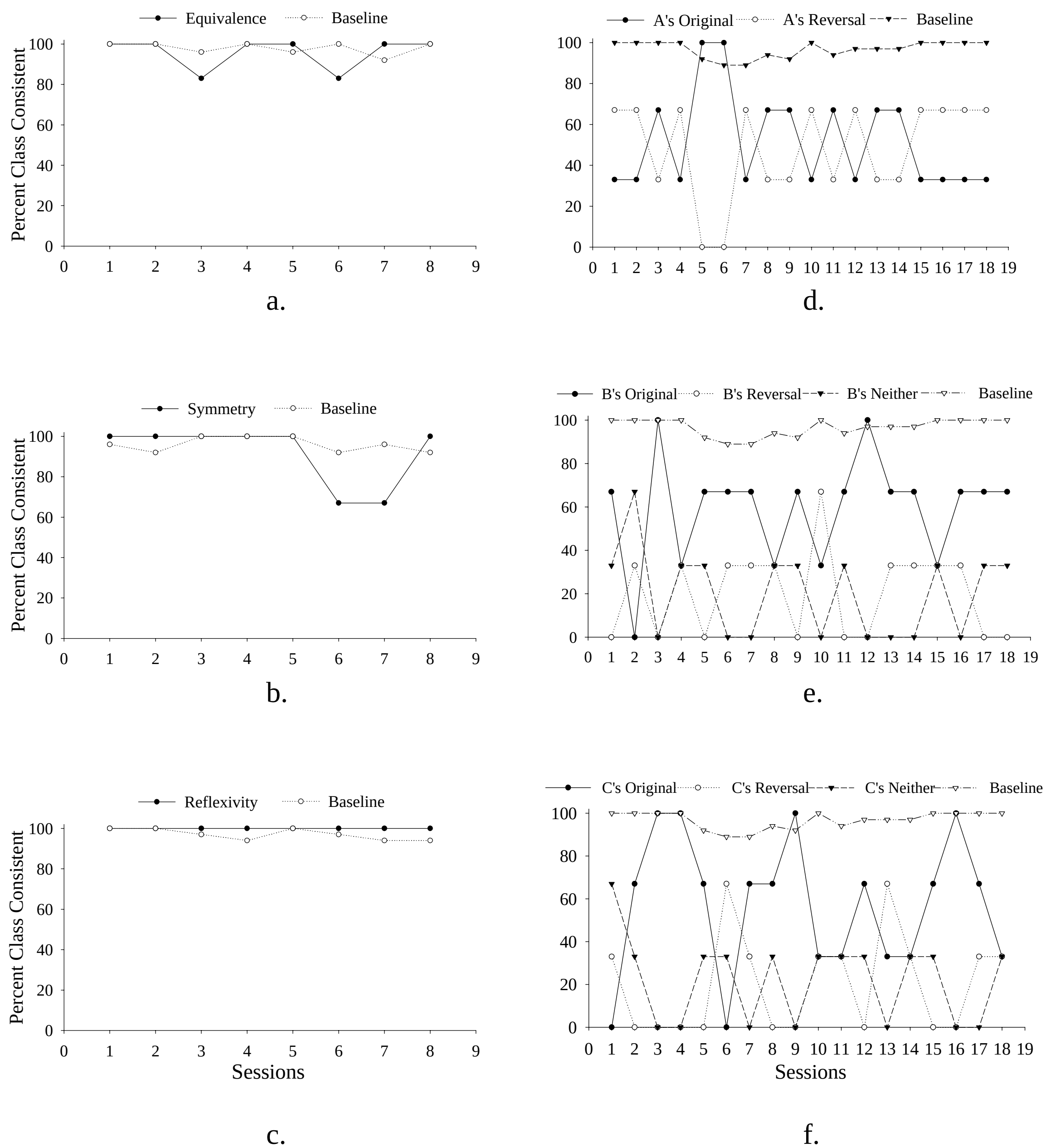


Figure 21. a., b., c.) Equivalence-probe performances for Participant MH during Experiment 3.
d., e., f.) A, B, and C reinforcer-probe performances for Participant MH during Experiment 3. Legend labels indicate performances consistent with the training contingencies of the original, outcome reversal, or neither of the training phases. Consequential stimuli served as comparisons during odd-number sessions and as samples during even-number sessions.

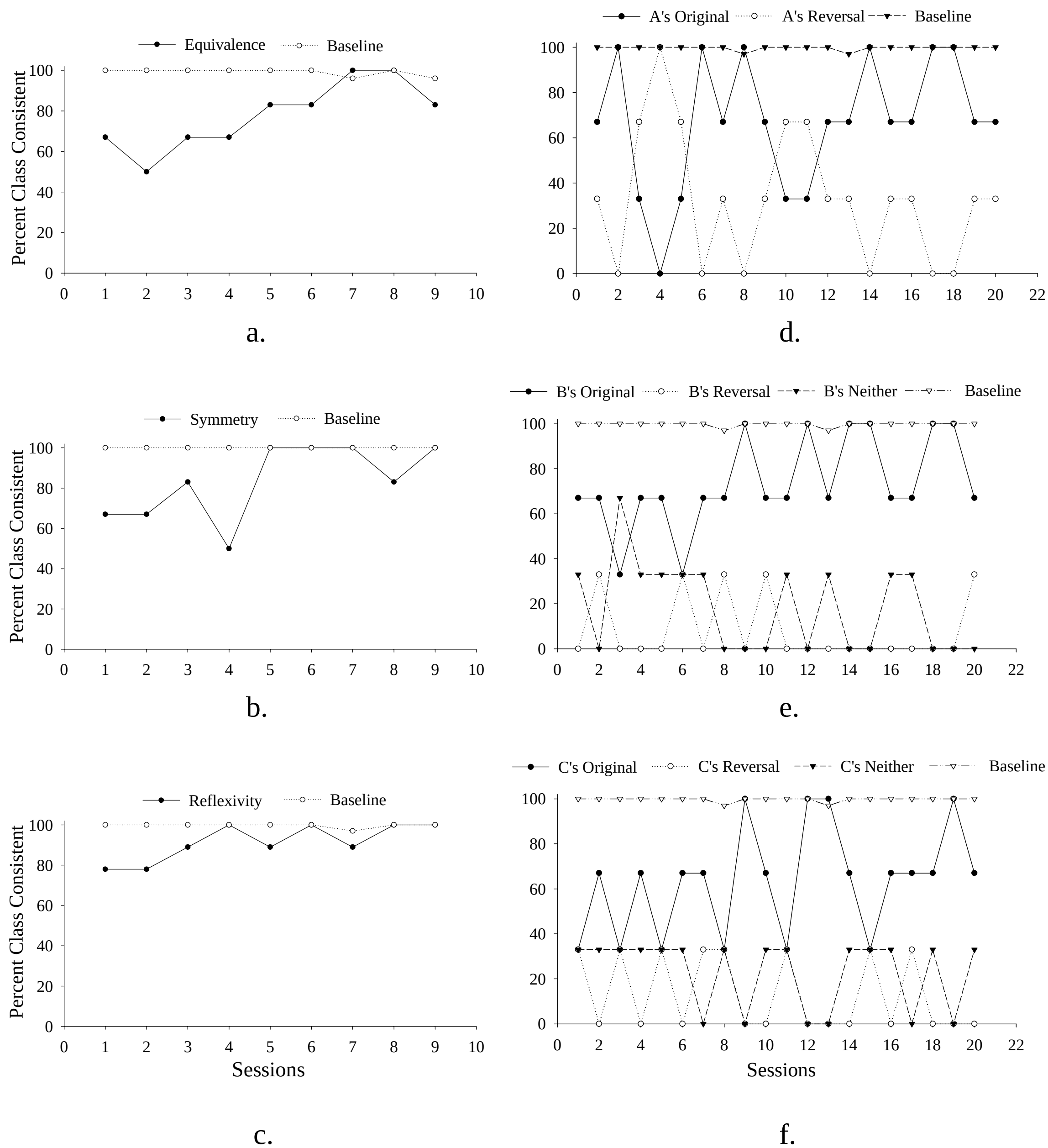


Figure 22. a., b., c.) Equivalence-probe performances for Participant GM during Experiment 3.
d., e., f.) A, B, and C reinforcer-probe performances for Participant GM during Experiment 3. Legend labels indicate performances consistent with the training contingencies of the original, outcome reversal, or neither of the training phases. Consequential stimuli served as comparisons during odd-number sessions and as samples during even-number sessions.

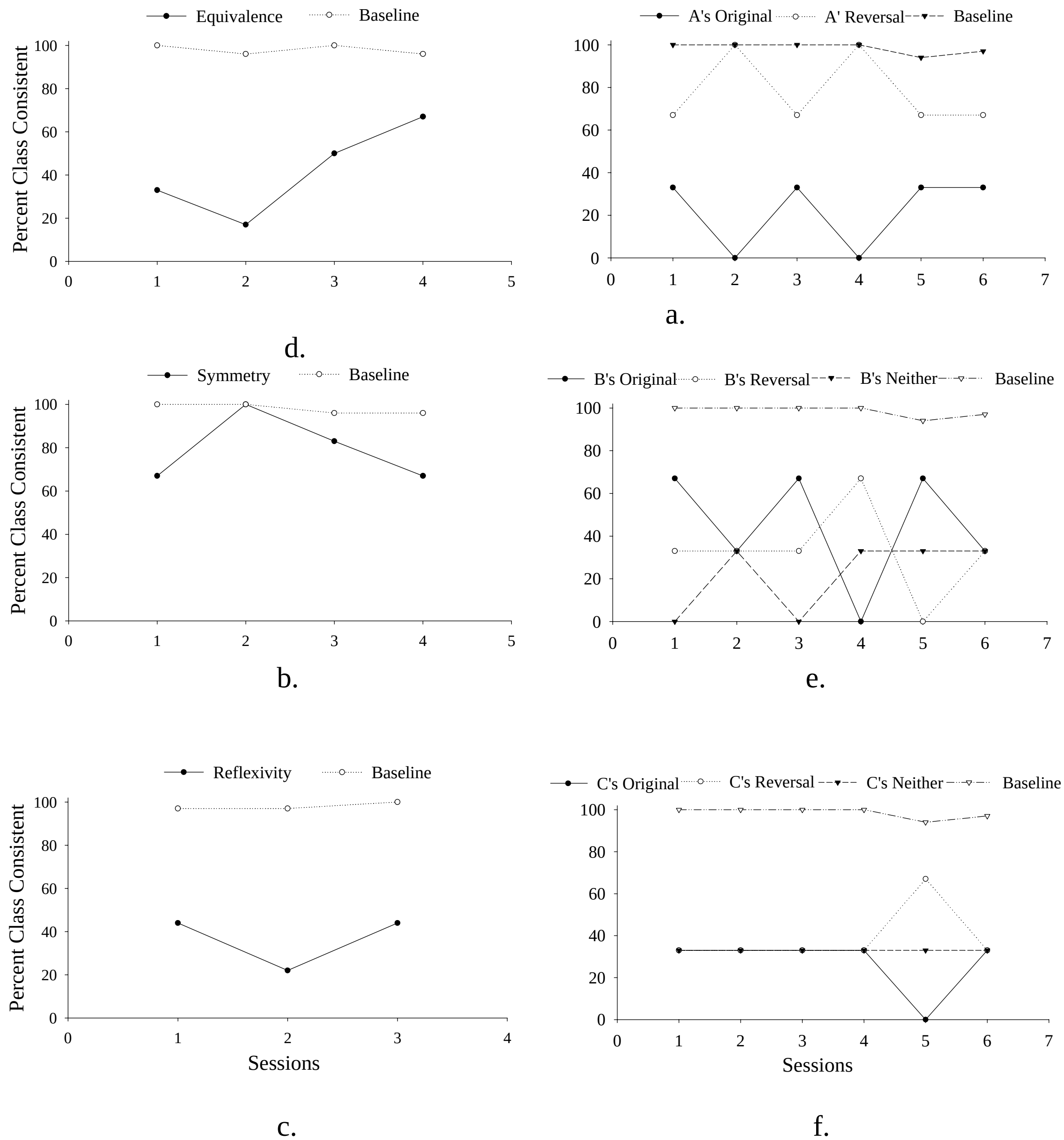


Figure 23. a., b., c.) Equivalence-probe performances for Participant GR during Experiment 3.
d., e., f.) A, B, and C reinforcer-probe performances for Participant GR during Experiment 3. Legend labels indicate performances consistent with the training contingencies of the original, outcome reversal, or neither of the training phases. Consequential stimuli served as comparisons during odd-number sessions and as samples during even-number sessions.

The responses of Participants ZM (see Figure 19) and BS (see Figure 20) on all probe types were highly class consistent. In fact, ZM's responses were perfectly class consistent on every probe session, as was the case for BS on all but one session. After the completion of four probe blocks, the responses of both ZM and BS were stable; however, both completed an additional block to allow for further evaluation of reinforcer-probe data (reinforcer-probe data will be discussed in detail below). Although both participants had shown strong evidence of equivalence formation during Experiment 2 (see Figures 8 and 9), it is interesting to note that BS's responses on one probe type (equivalence) immediately showed improvement following the reinstatement of consistent class-specific reinforcement.

Although the equivalence-probe responses of Participant MH were predominantly class consistent during Experiment 2 (see Figure 10), her responses during the present experiment, which were again class consistent, showed considerably less bounce (see Figure 21). Following the completion of four probe blocks, the responses of MH were both stable and highly class consistent. However, MH then completed several additional equivalence-probe sessions in alternation with reinforcer-probe sessions to allow for further evaluation of her responses on reinforcer-probes. Although MH's responses on symmetry probes showed some variability during her sixth and seventh session, her responses were again perfectly class consistent and stable across all probe types by the eighth session.

The equivalence-probe responses of Participant GM during Experiment 2 (see Figure 13) showed a lack of equivalence-class formation; however, his responses in the present experiment were indicative of the delayed emergence of the equivalence classes (see Figure 22). With the exception of his responses on reflexivity probes, strong evidence of equivalence-class formation was not produced until the fifth test session. Following the completion of nine probe blocks, GM's responses were both stable and highly class consistent.

Participants LR and TK completed a limited number of probe sessions; thus, their data have not been graphed. Nonetheless, their initial equivalence performances were highly class consistent. Participant LR completed two equivalence-probe sessions, two symmetry-probe sessions, and one reflexivity-probe session. With the exception of his responses on the second symmetry-probe session (where 83% of his responses were class consistent), the responses of Participant LR were perfectly class consistent. These results are consistent with LR's equivalence-probe performances during Experiment 2 (see Figure7), which were highly class consistent. Participant TK completed two equivalence-probe sessions, one symmetry-probe session, and two reflexivity-probe sessions. His responses on both the second equivalence-probe session and the first symmetry-probe session were at 83% accuracy. All remaining responses for Participant TK were perfectly class consistent. It is worthwhile to note that after the reinstatement of consistent class-specific reinforcement, TK's responses on one probe type (equivalence) immediately showed improvement.

The responses of Participant GR (see Figure 23) offered the least evidence of equivalence-class formation. Although he too left the study prior to completing equivalence probes, GR's initial responses were very similar to those on equivalence probes during Experiment 2 (see Figure 14). As in Experiment 2, only his responses on symmetry probes showed intermediate accuracy. GR's responses on equivalence and reflexivity probes were indicative of a failure to demonstrate the predicted equivalence classes. It was apparent however, that GR's responses on equivalence-probe types showed a trend towards the emergence of this relation.

Reinforcer Probe and Post-Sort Task Performances

Baseline performances for all participants remained strong for the duration of reinforcer-probe testing (see Figures 19-24). Refer to Table 12 for a summary of the reinforcer-probe performances for each participant during Experiments 2 and 3. For A, B, and C reinforcer probes, number of responses consistent with the training contingencies of the original, outcome reversal, and neither of the training phases is shown for both Experiments 2 and 3. Table 10 shows post-sort data for Participants MH, BS, and ZM. The remaining participants did not complete the post-sort task.

Figures 19-24 show the children's reinforcer-probe performances. In general, for two participants (MH and ZM), responses on reinforcer-probes remained very similar to those following reversed outcomes. In contrast, three participants (BS, TK, and GM) changed their pattern of responding to a manner mostly consistent with the original class-consistent outcomes once the reinforcers were returned to their original pattern. The responses of Participant GR, however, can best be described as random. Participant LR completed only two reinforcer-probe sessions. Thus, his data allow for a very limited interpretation and will not be discussed further.

More specifically, the responses of Participant MH (see Figure 21) were very similar to what they had been during Experiment 2. As in Experiment 2, her responses were only slightly more consistent with the original outcomes than with the remaining two response categories (see Table 12). On the post-sort task, MH's responses were indicative of stimulus control by both the original and the outcome-reversal training contingencies. That is, MH sorted the cards into the following groups: A1B1C1R3, A2B2C2R2, and A3B3C3R1. When prompted to explain her sorts, regarding the A1B1C1R3 group, MH stated, "I always see them do that." In reference to the A2B2C2R2 group, MH said, "I don't know (i.e., why they go together)." In reference to the

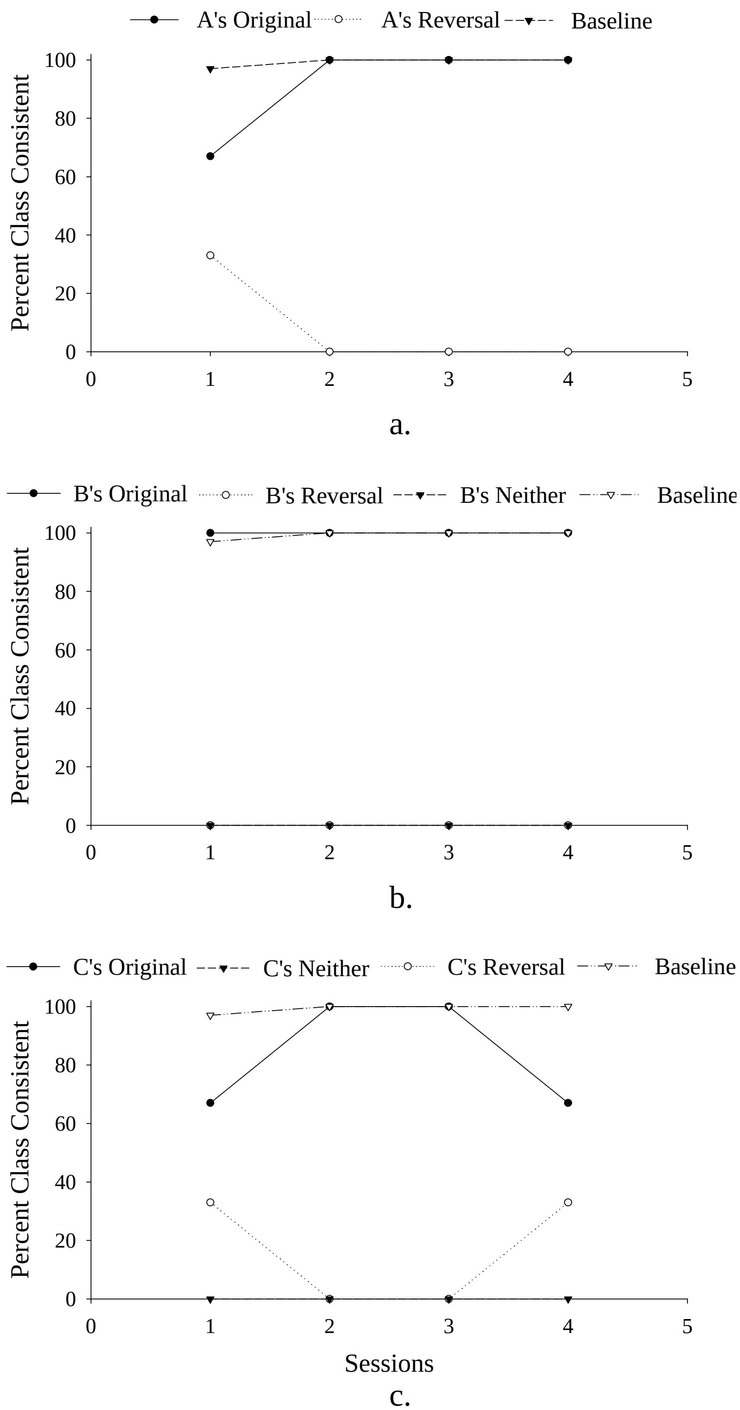


Figure 24. a., b., c.) A, B, and C reinforcer-probe performances for Participant TK during Experiment 3. Legend labels indicate performances consistent with the training contingencies of the original, outcome reversal, or neither of the training phases. Consequential stimuli served as comparisons during odd-number sessions and as samples during even-number sessions.

Table 12

A, B and C Reinforcer-Probe Performances for Each Participant During Experiments 2 and 3

		A's		B's			C's		
Participant	Experiment	Original	Reversal	Original	Reversal	Neither	Original	Reversal	Neither
LR	2	5	31	4	27	5	10	1	25
	3	4	2	4	0	2	2	2	2
MH	2	31	29	31	16	13	28	18	14
	3	28	26	32	11	11	31	11	12
ZM	2	36	21	36	10	11	37	9	11
	3	23	7	21	5	4	22	3	5
BS	2	28	26	29	16	9	24	15	15
	3	36	0	34	1	1	32	2	2
TK	2	19	29	18	22	8	17	27	4
	3	11	1	12	0	0	10	2	0
GM	2	20	22	22	6	14	23	7	12
	3	40	20	44	4	12	38	8	14

Table 12 cont.

		A's		B's			C's		
Participant	Experiment	Original	Reversal	Original	Reversal	Neither	Original	Reversal	Neither
GR	2	14	46	16	32	12	19	30	11
	3	4	14	8	6	4	5	7	6

A3B3C3R1 group, MH stated, “Sometimes I see them do that.”

Over all, the responses of Participant ZM (see Figure 19) remained similar to what they had been during Experiment 2 (see Table 12). That is, while his responses were not always consistent with the expected equivalence classes, he continued to respond in a manner mostly consistent with the original outcomes. A post-sort task was not conducted with ZM.

Participants BS (see Figure 20) and TK (see Figure 24) showed the strongest evidence of the reinforcers becoming members of the expected equivalence classes. Although BS’s responses on reinforcer probes during Experiment 2 were only slightly more consistent with the original-class outcomes, her responses on reinforcer probes during the present experiment were all highly class consistent (see Table 12). Further, BS’s responses on the post-sort task (which were identical to what they had been during Experiment 2) were consistent with these data, as she sorted the cards into the following three groups: A1B1C1R1, A2B2C2R2, and A3B3C3R3. No response was offered as to why she sorted them into the aforementioned groups. Participant TK left the study prior to completing reinforcer-probe testing. Thus, he completed only four reinforcer-probe sessions. In contrast to TK’s responses on reinforcer probes during Experiment 2, which were mostly consistent with the reversed outcomes, responses during the present experiment were highly consistent with the original-class outcomes (see Table 12).
A post-sort task was not conducted with TK.

Although a number of GM’s responses on reinforcer probes during Experiment 2 were consistent with the original-class outcomes, reinstating class-consistent reinforcement contingencies brought his reinforcer-probe performances more closely in line with the original equivalence classes (see Table 12 and Figure 22). As was the case in Experiment 2, during his post-sort task, GM initially sorted the cards in to two groups, one containing experimental stimuli and one containing consequential stimuli. A response was not offered for why he sorted the cards in this manner. Moreover, like in Experiment 2, GM's final sort bared little resemblance to the experimenter programmed equivalence classes (i.e., A1B1C1, A2B2C2, and A3B3C3), as he sorted as follows: A1C2C3R2, A2R1R3, and A3B1B2B3C1. Upon a prompt to explain his sorts, in reference to the A1C2C3R2 group, GM said, "These are all the circle types." Of the A2R1R3 group, GM stated, "These are all the square types." Finally, regarding the A3B1B2B3C1 group, GM said, "These are whatever types." These explanations are remarkably similar to those he provided during Experiment 2.

Participant GR completed only six reinforcer-probe sessions (see Figure 23). In contrast to his reinforcer-probe responses during Experiment 2, which were mostly consistent with the reversed outcomes, responses during the present study appear to be random. Participant GR left the study prior to completing a post-sort task.

Discussion

Each of the seven participants readily mastered the baseline conditional discriminations following the shift in the training contingencies from the outcome-reversal procedure back to the original-outcomes procedure. These results support the findings of Experiment 1, which showed that for most participants, a change in training contingencies involving the specific reinforcer stimuli had few, if any, adverse effects on children's conditional-discrimination peformances. Again, these data support the notion that for these children, the specific stimulus-reinforcer relations were not critical to the maintenance of sample-comparison relations.

One reason for conducting the present study was to determine if training with consistent class-specific reinforcement would enhance the equivalence performances (equivalence, symmetry, and reflexivity) of participants from Experiment 2. Training with class-specific reinforcement has been shown to increase the rate of acquisition of conditional-discrimination peformances in children (e.g., Litt & Shreibman, 1981; Schomer, 2001). In light of these findings, it may follow that class-specific reinforcement procedures also enhance the formation of equivalence classes. In fact, contrary to the results of Experiment 2, which reported strong equivalence performances for only four of eight children, in Experiment 3, six of the seven children demonstrated strong evidence of equivalence-class formation. These results are consistent with the findings of similar studies (e.g., Ashford, 2003; Schomer 2001) that have reported stable equivalence-probe performances for participants who have received training with two interrelated arbitrary conditional discriminations and class-specific reinforcement. Nevertheless, although Participants BS, MH, TK, and GM all showed improvement on one or more probe types following the implementation of consistent class-specific reinforcement, the possibility remains that the additional baseline training and equivalence-probe testing was actually responsible for the enhancement of equivalence-probe performances in these participants.

For Participants BS and MH, responses on both equivalence probes and the post-sort task gave every indication of the formation of three three-member equivalence classes. Interestingly, GM was the only participant to respond class consistently on equivalence probes (i.e., equivalence, symmetry, and reflexivity) but not on the post-sort task. For this participant, it is possible that the post-sort task was different enough from the computer-based testing procedure (used throughout the remainder of the experiment) that it did not occasion the same SCTs. That is, the post-sort task could have set the occasion for different SCTs (e.g., matching based on the absolute properties of the stimuli). GM’s explanations for the way in which he grouped the cards lend further support to this possibility.

Only the responses of Participant GR suggested a lack of equivalence-class formation. However, because he withdrew from the study prematurely, his data permit limited analysis. From the data available, it is apparent that GR’s responses on equivalence probes during the present experiment were very similar to those on equivalence probes during Experiment 2. Nonetheless, subsequent testing may have yielded the gradual emergence of equivalence classes. Indeed, prior to leaving the study, GR’s responses on at least one probe type (equivalence) showed a trend towards emergence.

There remains the primary reason for conducting the present experiment, which was to see if the reinforcers would join the original classes. Interestingly, the shift in training contingencies had an immediate impact on the reinforcer-probe performances of the two oldest participants (BS and TK). Their responses on reinforcer probes quickly conformed to the new contingencies. Moreover, the responses of Participant BS on the post-sort task gave every indication of the formation of the A-B-C classes and the expansion of those classes to include consequential stimuli (i.e., A1B1C1R1, A2B2C2R2, and A3B3C3R3). These results support the findings of numerous studies that have shown that class-specific reinforcers can become class members (e.g., Dube & McIlvane, 1995; Dube et al., 1989; Dube et al., 1987). Furthermore, these findings are consistent with Sidman’s (2000) theory, which maintains that as long as the contingencies and the equivalence relations do not come into conflict, equivalence classes may come to include all elements of the analytic unit, including the reinforcer.

It is not uncommon for participants trained with class-specific reinforcement to demonstrate equivalence classes that include reinforcer stimuli (e.g., Dube & McIlvane, 1995; Dube et al., 1987). Yet, similar training in the present study did not yield highly class consistent reinforcer-probe performances for all of the participants. One obvious difference between the participants in the present study versus those in similar studies is their experimental training history. That is, prior to participating in the present study, each of the participants had completed both original and outcome-reversal training with identical experimental and consequential stimuli. One possibility is that the multiple shifts in training contingencies (from original to outcome reversal and back to original) encouraged similar shifts in responding for at least some of the participants. In fact, this account is consistent with the repeated shifts in response patterns (i.e., from those consistent with original-training contingencies to those consistent with outcome-reversal training contingencies and vice versa) evident in the reinforcer-probe performances of Participants MH, ZM, GM, and GR. However, this explanation does not provide for why these participants would make responses that were inconsistent with both of the training arrangements (i.e., the neither responses).

Conversely, at least some neither responses would be expected if 1) the reinforcers had in fact dropped out of the classes, and this effect was not temporary, following outcome-reversal training; or if 2) the use of the same reinforcer stimuli during Experiment 3, contributed to an insensitivity to the new reinforcer arrangement. Unlike the pattern of responses seen in Participants MH, ZM, and GM, however, these explanations would predict similar distributions of responses across the three response categories (i.e., original, outcome reversal, or neither training arrangement).

From the present study, it is clear that contingency manipulations involving class-specific reinforcers can affect participants in very different ways, particularly with respect to reinforcer-probe performances. Given the multiple training arrangements present in the experimental history of these children, Dube and McIlvane’s (1996) account of conflicting SCTs seems a plausible description of the variable reinforcer-probe responses of some of the participants. However, based on these findings, it may also be necessary to consider variables outside of the experimental training contingencies if one is to identify all of the relevant SCTs (e.g., previous reinforcement history).

CHAPTER 6. EXPERIMENT 4

During Experiment 3, the reinforcer-probe responses of Participants MH, GM and ZM were mostly consistent with the original outcomes. Even so, their responses were not always consistent with the expected equivalence classes (i.e., A1B1C1R1, A2B2C2R2, A3B3C3R3). Moreover, the responses of Participants MH and GM on the post-sort task did not indicate that the reinforcers had joined the original classes.

One possible explanation for these findings pertains to the complex training history (which included training with reversed outcomes) that occurred throughout Experiments 1-3. Participants completed each these experiments with the same set of experimental and consequential stimuli. If the outcome-reversal training was in fact responsible for the lack of perfectly class-consistent responses on reinforcer probes, then training with novel stimuli might yield reinforcer-probe performances more closely in line with the expected equivalence classes. Thus, the purpose of Experiment 4 was to see if training with new sets of experimental and consequential stimuli (that did not have a history with outcome reversals) would result in strong reinforcer-probe performances for Participants MH, GM, and ZM. Therefore, Experiment 4 was a replication of Experiment 3 using new sets of experimental and consequential stimuli.

Method

Participants

Three of the participants (MH, GM, and ZM) who completed Experiments 1, 2, and 3 participated (see Table 2).

Stimuli

Training and testing were conducted using Experimental Stimulus Set 3 and Consequential Stimulus Set 2 (see Table 1 and Figure 1).

Procedure

The training and test sequence was identical to that of subjects' original training.

Results

Baseline Performances

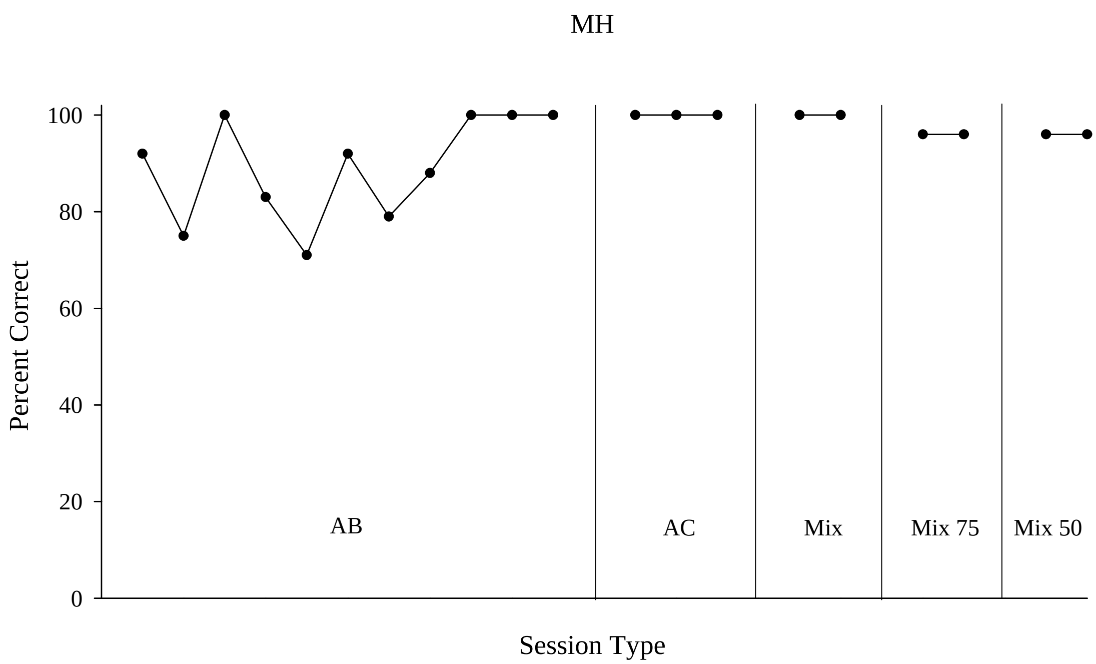
Figures 25 and 26 show the children's baseline performances. For Participants MH and GM (see Figure 25), AB, AC, and AB/AC mixed conditional discrimination acquisition occurred rapidly and without specialized training. Participant ZM (see Figure 26), however, received general instructions before mastering AB training. Additional baseline acquisition for ZM occurred quickly and with no specialized training.

Equivalence-Probe Performances

Figures 27-29 show the children's equivalence-probe performances. The baseline performances of all participants remained strong for the duration of equivalence-probe testing and for the most part, responses on equivalence probes were class consistent.

As in the previous two experiments (see Figures 8 and 19), Participant ZM demonstrated strong evidence of equivalence-class formation (see Figure 27). Following the completion of four blocks his responses on all probe types were both stable and highly class-consistent. However, in order to allow for additional evaluation of his responses on reinforcer-probes (reinforcer-probe performances will be discussed in detail below), ZM completed two additional probe blocks and several additional equivalence-probe sessions conducted in alternation with reinforcer-probe sessions beyond that.

As was the case during Experiment 3 (see Figure 22), the responses of Participant GM (see Figure 28) on equivalence probes were indicative of the delayed emergence of equivalence relations. Following the completion of nine probe blocks, his responses on all probe types were



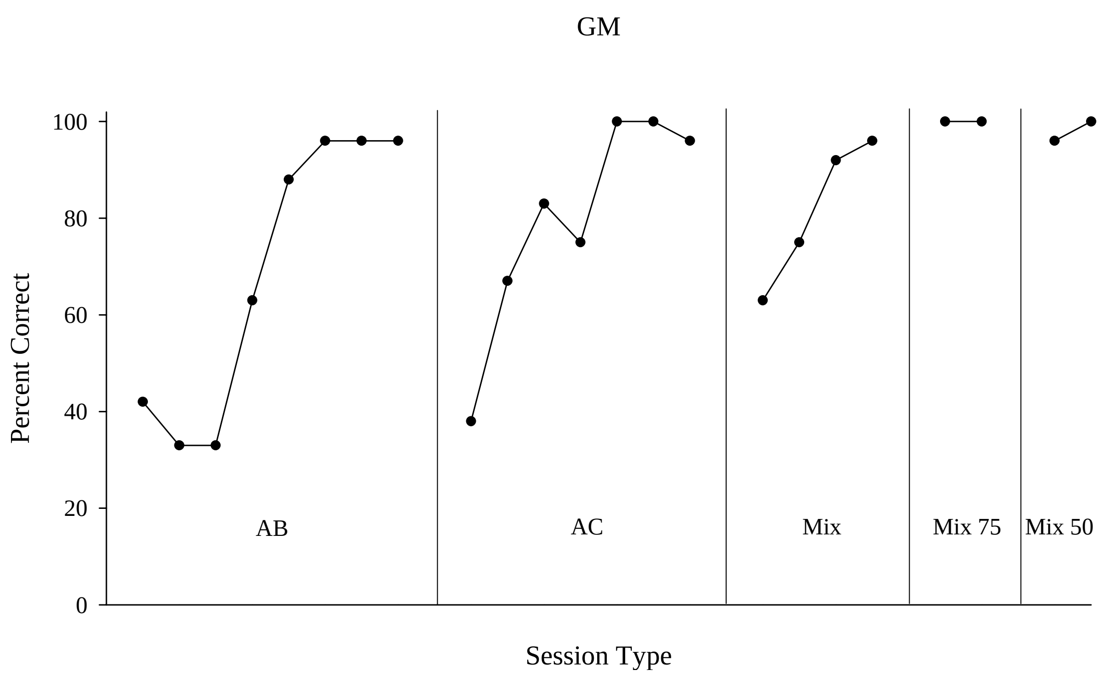


Figure 25. Baseline training for Participants MH and GM during Experiment 4.

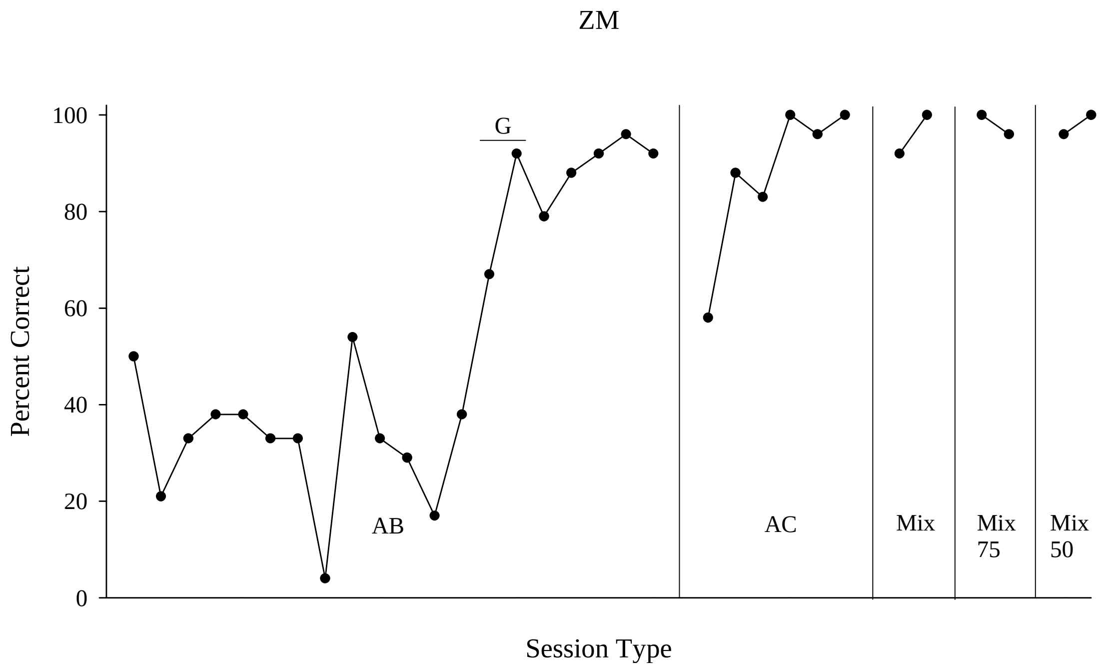
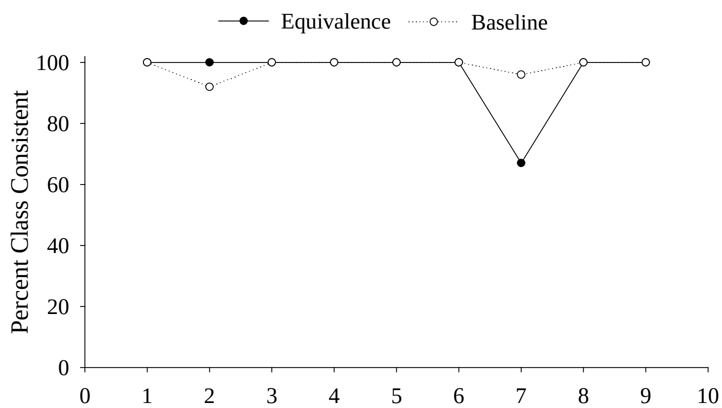
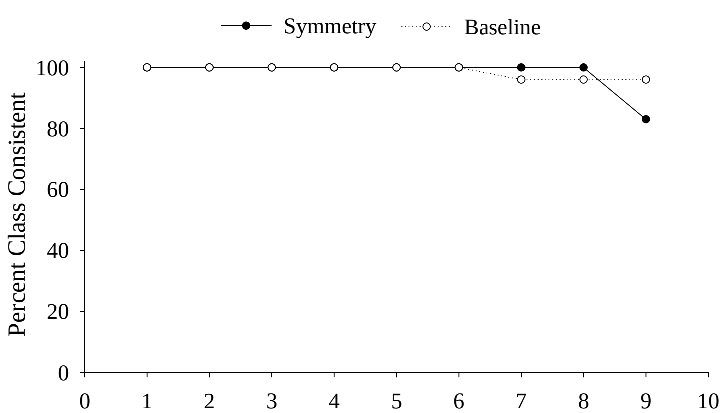


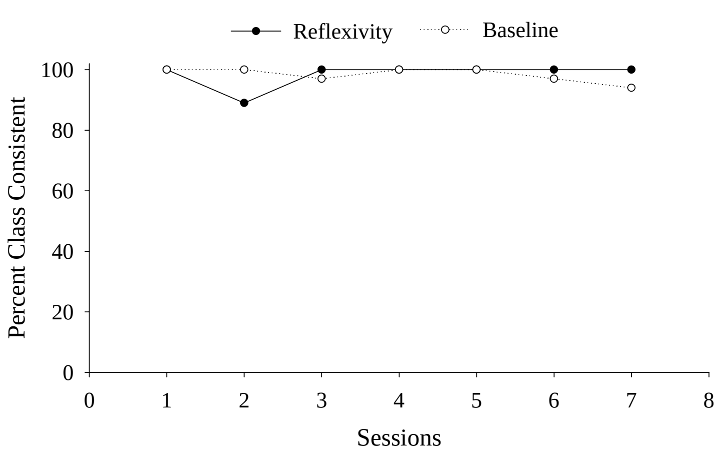
Figure 26. Baseline training for Participant ZM during Experiment 4. Data points under the horizontal line labeled G indicate sessions in which the participant received general instructions.



a.

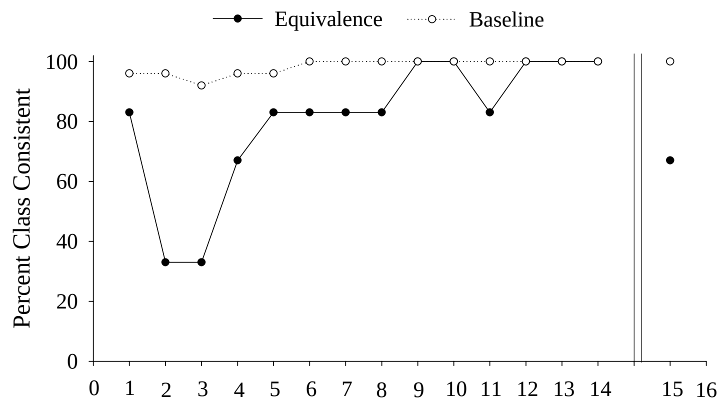


b.

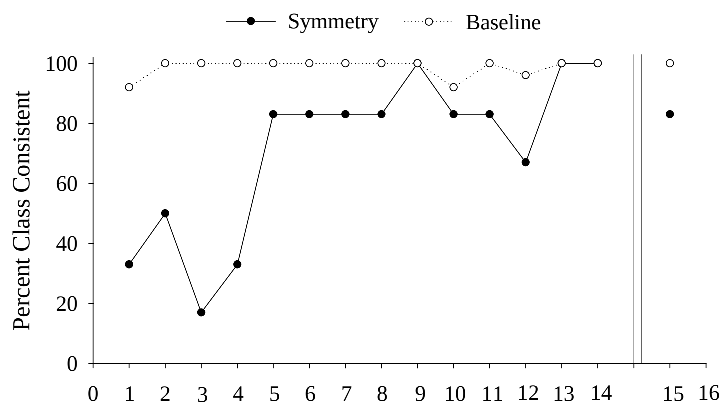


c.

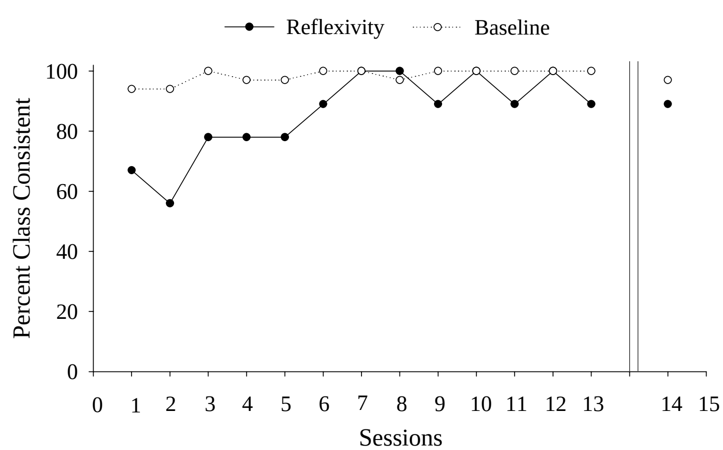
Figure 27. a., b., c.) Equivalence-probe performances for Participant ZM during Experiment 4.



a.



b.



c.

Figure 28. a., b., c.) Equivalence-probe performances for Participant GM during Experiment 4. Double lines indicate a two-month lapse in experimental testing.

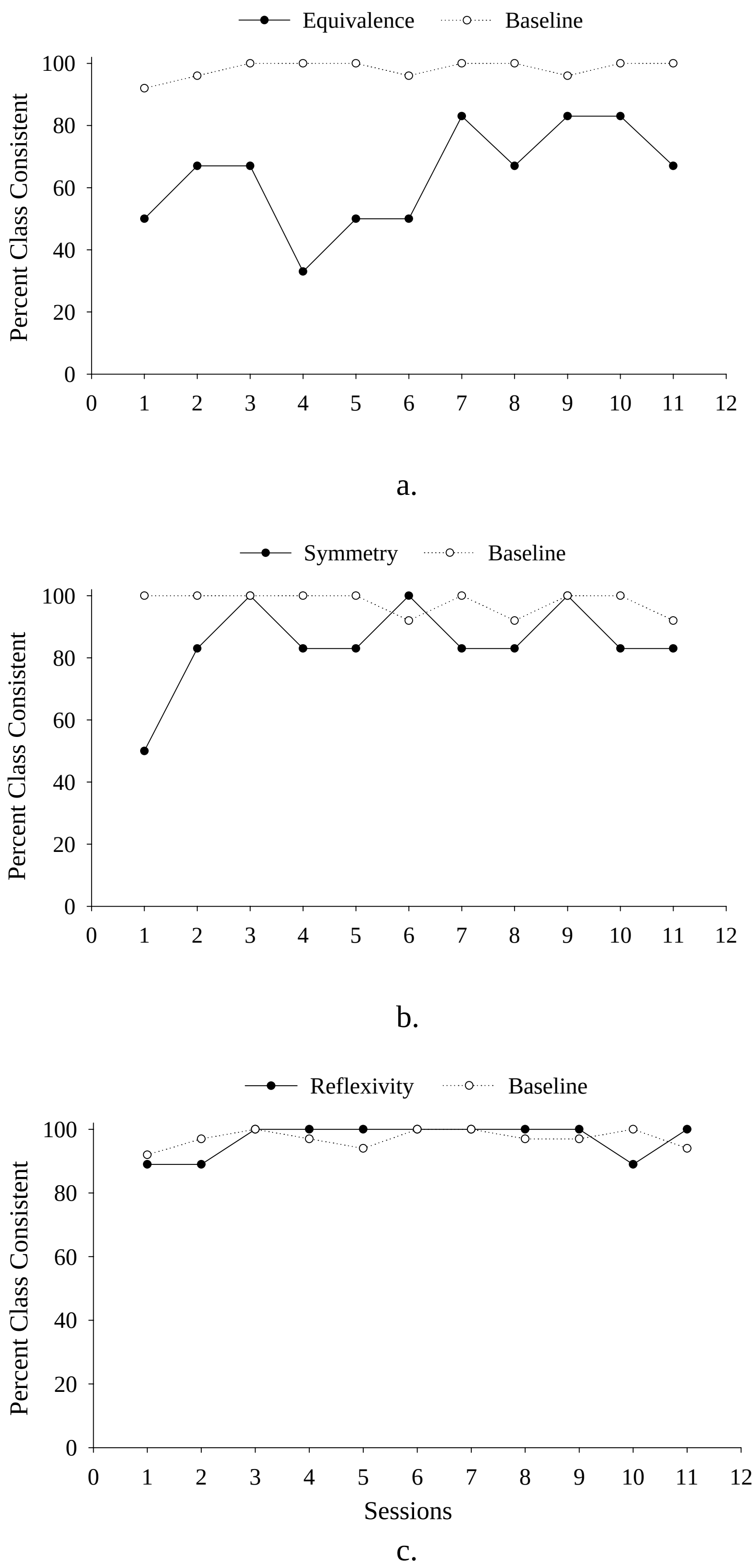


Figure 29. a., b., c.) Equivalence-probe performances for Participant MH during Experiment 4.

both stable and relatively class consistent. GM then completed several additional equivalence-probe sessions in alternation with reinforcer-probe sessions to allow for further evaluation of his responses on reinforcer-probes. Finally, approximately two months after his last test date (due to experimenter error, the post-sort task was not conducted immediately following the completion of probe testing), GM completed one final probe block prior to completing the post-sort task

For Participant MH (see Figure 29), although responses on symmetry and reflexivity probes provided strong evidence for the emergence of these relations, her responses on equivalence probes showed only intermediate accuracy. Interestingly, during both of the two previous experiments, her responses on equivalence-probe types (as well as on symmetry and reflexivity-probe types) were in fact highly class consistent (see Figures 10 and 21). Nevertheless, during the present experiment, MH's responses on the last five equivalence-probe sessions were relatively class consistent. After completing 11 probe blocks however, stability on all three-probe types concurrently was not obtained. No further testing was conducted.

Reinforcer-Probe Performances

Refer to Table 13 for a summary of the reinforcer-probe performances for each participant. For A, B, and C reinforcer probes, number of responses consistent with the training contingencies of the original, outcome reversal, and neither of the training phases is shown for Experiments 2 and 3. For A, B, and C reinforcer responses during Experiment 4, which was conducted with stimuli that had no history with outcome reversals, number of responses consistent with the current training contingencies (original responses) as well as all remaining responses (neither responses) are provided.

Baseline performances for all participants remained relatively strong for the duration of reinforcer-probe testing (see Figures 30-32). For two of the participants (ZM and GM),

Table 13

A, B and C Reinforcer-Probe Performances for Each Participant During Experiments 2, 3, and 4

		A's			B's			C's		
Participant	Experiment	Original	Reversal	Neither	Original	Reversal	Neither	Original	Reversal	Neither
ZM	2	36	21	—	36	10	11	37	9	11
	3	23	7	—	21	5	4	22	3	5
	4	45	—	18	52	—	11	44	—	19
GM	2	20	22	—	22	6	14	23	7	12
	3	40	20	—	44	4	12	38	8	14
	4	68	—	28	71	—	25	64	—	32
MH	2	31	29	—	31	16	13	28	18	14
	3	28	26	—	32	11	11	31	11	12
	4	49	—	35	49	—	35	50	—	34

Note. Dashes indicate conditions that were not applicable to the experiment.

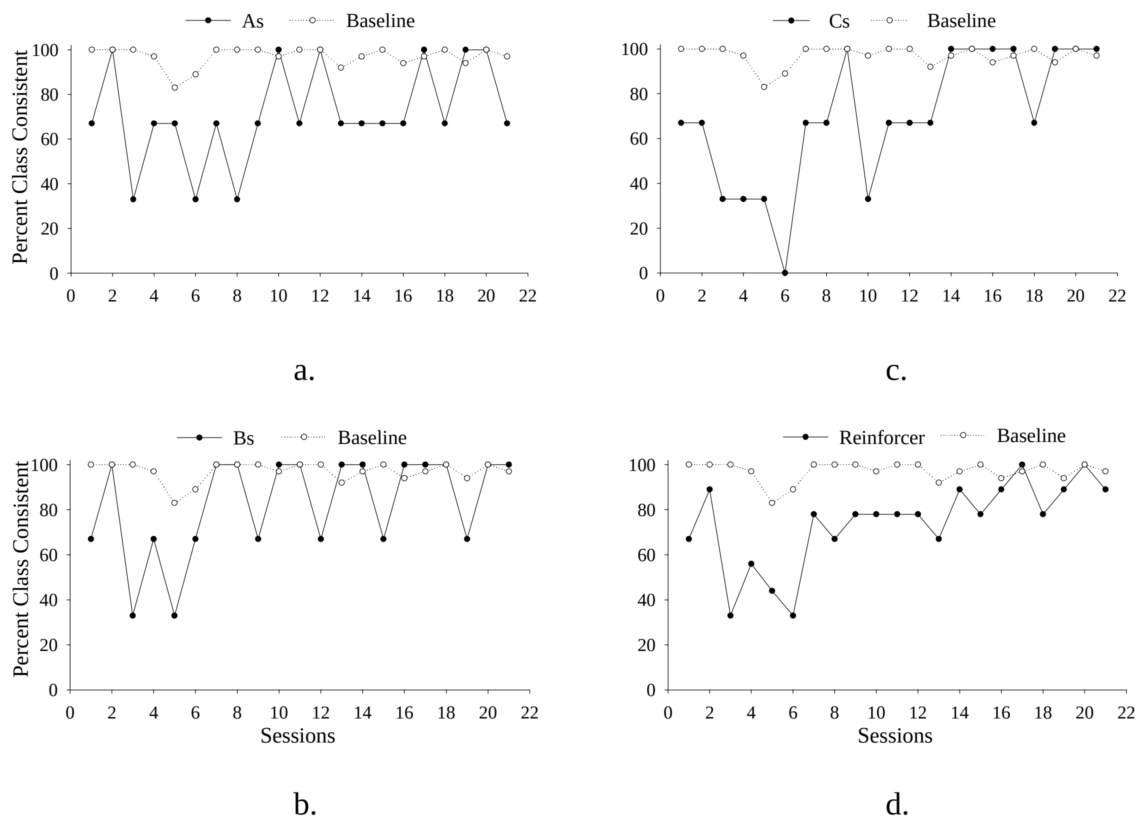
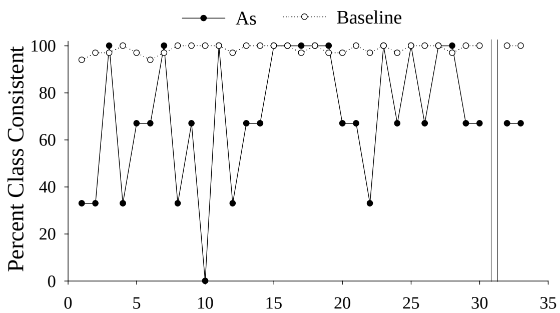
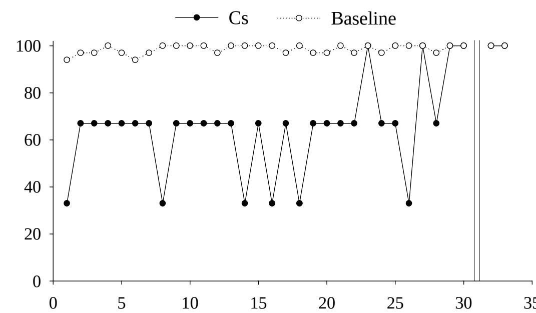


Figure 30. a., b., c.) A, B, and C reinforcer-probe performances for Participant ZM during Experiment 4. Consequential stimuli served as comparisons during odd-number sessions and as samples during even-number sessions.

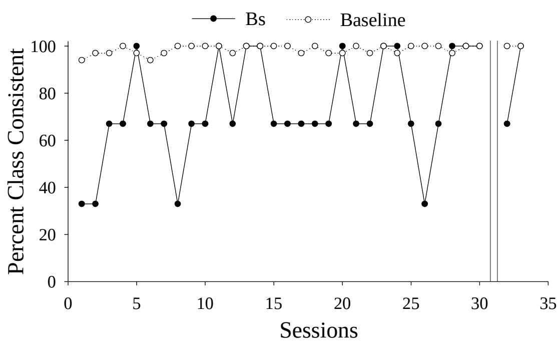
d.) Combined A, B, and C reinforcer-probe performances for Participant ZM during Experiment 4. Consequential stimuli served as comparisons during odd-number sessions and as samples during even-number sessions.



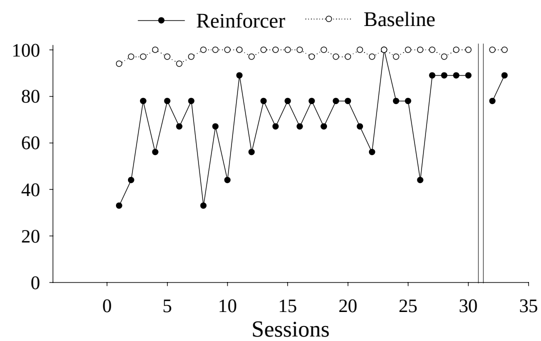
a.



c.



b.



d.

Figure 31. a., b., c.) A, B, and C reinforcer-probe performances for Participant GM during Experiment 4. Consequential stimuli served as comparisons during odd-number sessions and as samples during even-number sessions. Double lines indicate a two-month lapse in experimental testing.

d.) Combined A, B, and C reinforcer-probe performances for Participant GM during Experiment 4. Consequential stimuli served as comparisons during odd-number sessions and as samples during even-number sessions. Double lines indicate a two-month lapse in experimental testing.

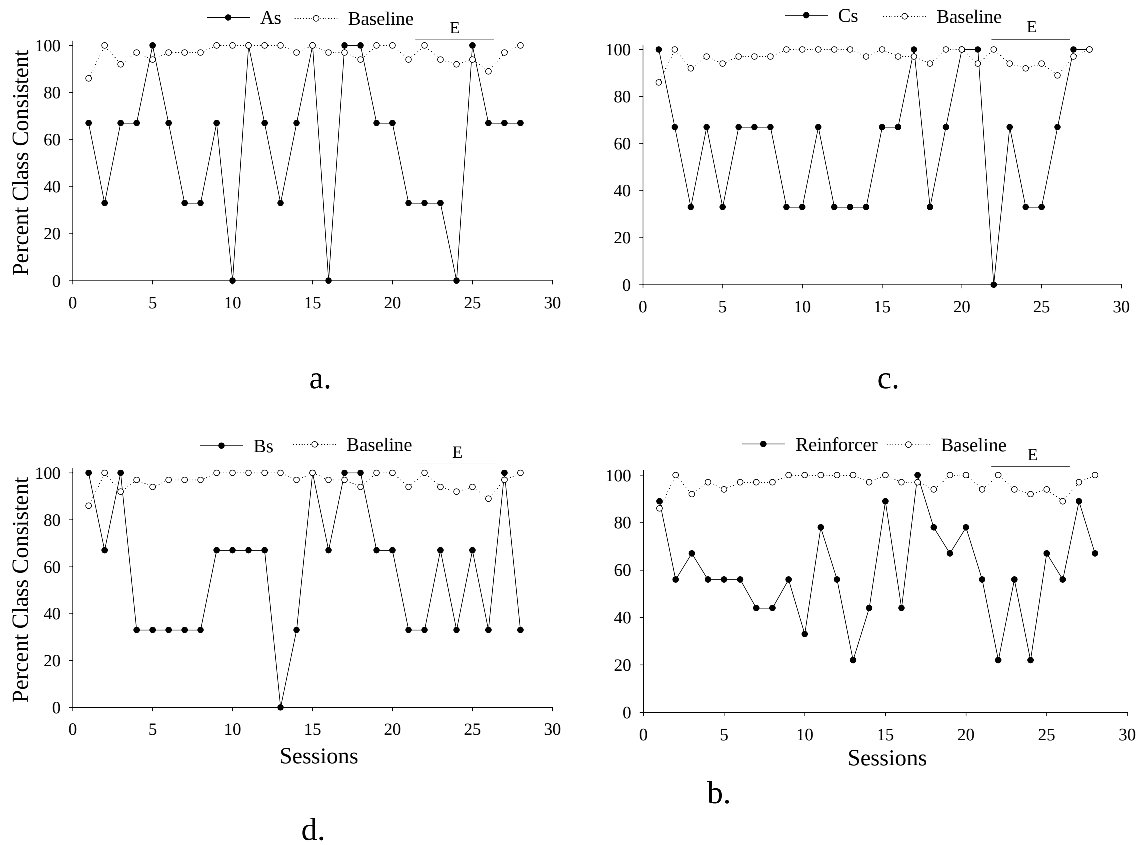


Figure 32. a., b., c.) A, B, and C reinforcer-probe performances for Participant MH during Experiment 4. Consequential stimuli served as comparisons during odd-number sessions and as samples during even-number sessions. Data points under horizontal lines labeled E indicate sessions in which baseline trials were presented on extinction.

d.) Combined A, B, and C reinforcer-probe performances for Participant MH during Experiment 4. Consequential stimuli served as comparisons during odd-number sessions and as samples during even-number sessions. Data points under horizontal lines labeled E indicate sessions in which baseline trials were presented on extinction.

responses on reinforcer probes were indicative of the delayed emergence of reinforcer relations (i.e., A1R1, B1R1, C1R1, A2R2, B2R2, C2R2, A3R3, B3R3, and C3R3). Thus, their responses pointed to the expansion of equivalence classes to include the class-specific reinforcers. For Participant MH, however, responses on reinforcer probes were not highly class consistent.

During Experiment 3, the responses of Participant ZM on reinforcer probes remained similar to those during Experiment 2. That is, although his responses were not always consistent with the expected equivalence classes, he continued to respond in a manner mostly consistent with the original-class outcomes (see Table 12). His responses during Experiment 4 however, were indicative of the delayed emergence of reinforcer relations (see Table 12 and Figure 30). Thus, at the completion of probe testing, ZM's responses indicated the formation of the following equivalence classes: A1B1C1R1, A2B2C2R2, and A3B3C3R3.

Although a number of GM's reinforcer-probe responses during Experiment 2 were consistent with the original-class outcomes, during Experiment 3, his responses became more closely in line with the original equivalence classes (see Table 12). During Experiment 4, his responses became even more consistent with the original-class outcomes, indicating the delayed emergence of reinforcer relations (see Table 12 and Figure 31). Thus, at the completion of reinforcer-probe testing, the responses of GM were indicative of the formation equivalence classes A1B1C1R1, A2B2C2R2, andA3B3C3R3 (due to experimenter error, approximately two months occurred between GM's final two reinforcer-probe sessions and previous reinforcer-probe sessions).

During Experiment 4, the reinforcer-probe responses of Participant MH (see Figure 32) were very similar to those during the previous two experiments. That is, although her responses were not always consistent with the expected equivalence classes, throughout each of the experiments, she responded in a manner mostly consistent with the original-class outcomes (see Table 12). Interestingly, during the present experiment however, MH's responses showed more variability. For example, while her responses on most probe sessions showed only intermediate accuracy, her responses on at least four probe sessions were highly class consistent (89% or higher). In attempt to bring the reinforcers more in line with the expected classes, during Sessions 22-26, both baseline and probe trials were presented on extinction. However, this manipulation appeared to have little effect on MH's performance, as her performance on the next two sessions continued to show variability. At this time reinforcer-probe testing was discontinued.

Post-Sort Task Performances

Table 10 shows post-sort data for each of the participants during Experiments 2, 3, and 4. Although the responses of Participants ZM and MH on the post-sort task point to the formation of equivalence classes A1B1C1, A2B2C2, and A3B3C3, the responses of Participant GM do not. Moreover, only the responses of Participant ZM were indicative of the expansion of those classes to include the reinforcer stimuli (i.e., A1B1C1R1, A2B2C2R2, and A3B3C3R3).

During Experiment 2, responses on the post-sort task by Participant ZM were indicative of multiple sources of stimulus control (i.e., control by both the original and the outcome-reversal training contingencies). ZM's responses during Experiment 4 however, were entirely consistent with the expected equivalence classes, as he sorted the cards into the following groups: A1B1C1R1, A2B2C2R2, and A3B3C3R3. When prompted to explain his sorts, in reference to the A1B1C1R1 group, ZM said, "They look alike." Of the A2B2C2R2 group, ZM stated, "They look the same." Finally, regarding the A3B3C3R3 group, ZM again responded, "They look alike."

As was the case during Experiment 3, for Participant MH, responses on the post-sort task did not prove to be entirely consistent with the expected equivalence classes, as she sorted the cards into the following groups: A1B1C1R1, A2B2C2R3, and A3B3C3R2. Upon being prompted to explain her sorts, MH pointed to each of the three groups and stated, "I saw these on the computer together."

Participant GM initially sorted the cards into four groups as follows: A1B1R1, A2C2R3, A3B3R2, and B2C1C3. After receiving a prompt to sort the cards into three groups, GM sorted as follows: A1A2A3R3, B1B3R1R2, and C1C2C3B2. Once again, as in the previous two experiments, GM's sorting bared little resemblance to the experimenter programmed equivalence classes (i.e., A1B1C1, A2B2C2, and A3B3C3). Upon a prompt to explain his sorts, in reference to the A1A2A3R3 group, GM said, "They all look like letters." Of the B1B3R1R2 group, GM stated, "These are all shapes." Regarding the C1C2C3B2 group, GM said, "These are not letters or shapes." These explanations are similar to those he provided during Experiments 2 and 3 in that they are based on the physical similarities between the stimuli.

Discussion

Two of the participants (MH and GM) acquired the new conditional discriminations rapidly, and although Participant ZM received specialized training prior to mastering the AB conditional discrimination, he then acquired the AC conditional discrimination quickly. These findings are consistent with previous studies (e.g., Sidman & Tailby, 1982) that have reported that after a first conditional discrimination is acquired, the acquisition of subsequent conditional discriminations occurs rapidly.

Although it would have been most interesting to examine the equivalence performances of the participants who had previously performed poorly on tests for equivalence, these children were not available. During Experiment 3, Participants GM, ZM, and MH all showed clear evidence of equivalence-class formation. During the present experiment, the responses of Participants GM and ZM again provided strong evidence of the formation of equivalence classes A1B1C1, A2B2C2, and A3B3C3.   In contrast, the responses of Participant MH on one probe type (equivalence), called equivalence-class formation into question. It is unclear why her responses on equivalence probes were not more class consistent. Nonetheless, for all of the participants, the majority of responses on equivalence probes were indeed class consistent, which supports the findings of previous studies (e.g., Ashford, 2003; Schomer 2001) showing stable class-consistent responding in children who have received training with two interrelated arbitrary conditional discriminations and class-specific reinforcement.

According to Sidman (2000), as long as the training contingencies and the equivalence relations do not come into conflict, equivalence classes may come to include all elements of the analytic unit, including the reinforcer. In the previous study however, most participants did not show unequivocal evidence to support the notion that the reinforcers had become equivalence-class members. In large part, it was thought that the previous training with outcome reversals had prevented those specific reinforcer stimuli from joining the equivalence classes. Indeed, for at least two of the participants (ZM and GM), it appeared that implementing new stimulus sets in conjunction with consistent class-specific reinforcement arrangements facilitated the expansion of the equivalence classes to include reinforcer stimuli. These results support the findings of previous studies that have shown that the reinforcers in conditional discriminations can join the equivalence classes (e.g., Dube & McIlvane, 1995; Dube et al., 1989; Dube et al., 1987).

Once more, the responses of Participant GM on the post-sort task were not consistent with those on either his equivalence or reinforcer probes. Again, it seems likely that Dube and

McIlvane's (1996) account of conflicting SCTs offers the best description of the inconsistent pattern of responses demonstrated across these experimental tasks (equivalence and reinforcer probes versus the post-sort task). In fact, GM's explanations for the way in which he grouped the cards supports the notion that the post-sort task set the occasion for a different SCT (e.g., matching based on the absolute properties of the stimuli) than that occasioned by either equivalence or reinforcer-probe trials.

For Participant MH, whose responses (on reinforcer probes and on the post-sort task) were not indicative of the emergence of reinforcer relations, it is possible that her previous reinforcement history (which included training with outcome reversals) had a role in the lack of emergence of these relations. In other words, the fact that outcome-reversal training did not occur with the stimuli used in the present study does not eliminate the possibility that MH's previous reinforcement history might have influenced her responses during the present study. For example, if during the previous experiments, Participant MH learned that the relations between specific stimuli and the reinforcers were irrelevant, her pattern of responses on reinforcer probes during the present study should perhaps not come as a surprise.

CHAPTER 7. GENERAL DISCUSSION

Previous studies conducted with class-specific reinforcement have reported enhanced acquisition of conditional-discrimination performances in humans (e.g., Litt & Shreibman, 1981; Schomer, 2001). Although Experiment 1 was not designed to address this issue specifically, results do not support these findings. Only 1 out of 26 children acquired the initial arbitrary conditional discrimination (AB) with class-specific reinforcement alone. The remaining 8 children who met acquisition criteria did so only after receiving specialized training. Certainly, it seems that class-specific reinforcement can play a role in conditional discrimination acquisition (e.g., Schomer, 2001). Nevertheless, these results remind us that competing sources of stimulus control may influence conditional discrimination acquisition even when class-specific reinforcers are programmed.

One of the primary findings from this series of experiments is that preserving the specific stimulus-reinforcer relations arranged during training is not necessary for the maintenance of conditional discriminations, at least for these particular children. In contrast to the findings of similar studies conducted with pigeons (e.g., Honig et al., 1984), most participants (six out of nine) showed no decline in accuracy on their conditional-discrimination performances following training with reversed outcomes. For the three participants who did show some disruption, declines in accuracy were either very minimal or could be accounted for by other variables (see discussion in Experiment 1).

What remains to be determined, however, is the source for the differences in the outcome-reversal performances of pigeons and humans. Dube, Rocco, et al. (1989) have pointed to interspecies behavioral differences as evidence to suggest that pigeons and humans might perform conditional-discrimination tasks in a qualitatively different way. For example, previous studies (e.g., Brodigan & Peterson, 1976) conducted with class-specific reinforcement have reported the development of sample-specific responses in pigeons similar to those emitted during reinforcer consumption. Some researchers have suggested that pigeons' simultaneous and delayed matching is mediated by these sample-specific responses (e.g., Carter & Werner, 1978). Thus, in contrast to humans, comparison selection for pigeons may be conditional upon a response chain (which includes a sample-specific response) that is occasioned by the sample stimulus. Certainly, it is possible for human subjects to emit sample-specific behaviors. However, the children in the present study did not (at least not overtly), suggesting that their responses were in fact conditional upon the sample stimulus alone. Following from this discussion, it seems that different SCTs may be a significant contributor to the differences observed in the outcome-reversal performances of pigeons and humans. A slight modification of the procedure used in Experiment 1 could address this possibility. For example, experimenters could train participants to emit a sample-specific behavior prior to making a comparison selection. To accomplish this, one might train a conditional discrimination between a set of sample stimuli and a set of reinforcer stimuli (e.g., A1R1, A2R2, and A3R3). Next, during subsequent AB conditional-discrimination training (conducted with reinforcers R1, R2, and R3), upon the presentation of a sample stimulus, experimenters could train participants to point to the corresponding reinforcer stimulus on one of three index cards (each containing a picture of either R1, R2, or R3) prior to making a comparison selection. Of course, one would then need to conduct outcome-reversal tests. In addition, it might be interesting to conduct outcome-reversal tests with humans utilizing primary in addition to conditioned reinforcers.

One goal of the present study was to determine the impact of outcome reversals on children's subsequent equivalence-probe performances. Taken together, these four experiments leave much to be determined with respect to this question. Four of eight participants in Experiment 2 showed a lack of equivalence-class formation on one or more probe types (i.e., equivalence, symmetry, and reflexivity). However, because our primary goal was to determine the effects of outcome reversals on baseline conditional-discrimination performances, equivalence tests were not conducted immediately after training with class-consistent outcomes (i.e., prior to exposure to outcome reversals). Thus, the possibility that the outcome-reversal training contingencies were directly responsible for the negative outcomes on tests for equivalence is speculative. Future research may address this issue by assessing equivalence immediately following training with class-consistent outcomes, and again after training with outcome reversals.

In addition, only one (Participant GM) of the four participants who performed poorly on tests for equivalence in Experiment 2 completed equivalence testing in Experiment 3. Although Participant GM showed positive outcomes on tests for equivalence in Experiment 3, it is unclear whether or not the reinstatement of class-consistent outcomes played a role in these findings. After all, the delayed emergence of equivalence relations is not an uncommon finding, and there is no reason to discount this possibility for Participant GM.

During Experiment 4, it would have been most interesting to examine the equivalence performances of the participants who had previously performed poorly on tests for equivalence. However, these children were not available. All three of the children who participated in Experiment 4 had shown clear evidence of equivalence-class formation in Experiment 3. This fact, in addition to the aforementioned issues, makes it hard to determine exactly what role outcome reversals had on equivalence performances.

Another goal of the present study was to determine the impact of outcome reversals on children's reinforcer-probe performances. Overall, we found little evidence of the reinforcers becoming class members following outcome reversals. However, arranging class-consistent reinforcement contingencies brought reinforcer-probe performances more closely in line with the original equivalence classes for three of six participants (BS, TK, and GM). For Participants BS and TK, responses on reinforcer probes became nearly perfectly class consistent. Participant GM showed significant improvement, but his responses still showed some variability. During the final experiment, implementing new stimulus sets in conjunction with consistent class-specific reinforcement appeared to facilitate the expansion of the equivalence classes to include the reinforcers for two of three participants (GM and ZM). These results are consistent with previous studies conducted with class-specific reinforcement, which reported that the reinforcers could become equivalence-class members (e.g., Dube et al., 1987).

Clearly, results were mixed with respect to the impact of outcome reversals on children's reinforcer-probe performances. While some of the participants demonstrated the reinforcer relations, others did not. Perhaps this is to be expected in participants who have a training history that makes more than one response pattern possible. After all, in the present study, we systematically established two SCTs and yet we did not provide any form of contextual control. Without a contextual cue (e.g., a high versus a low tone) to specify which SCT is relevant (during probe trials) there is no logical reason to assume that one SCT should take priority over the other during any given moment (McIlvane & Dube, 2003). Following from this analysis, one might expect to see any one of three response patterns on reinforcer probes: responses consistent with the original class-consistent outcomes, responses consistent with the reversed outcomes, or responses consistent with both outcomes. In addition, Sidman's (2000) theory suggests another possible response pattern. That is, if the reinforcers had dropped out of the equivalence classes, responses might be random. In this case, one would expect to see responding across all three-response categories (i.e., original, outcome reversal, and neither training arrangement). In any case, the variety of response patterns observed in the participants of the present study fits nicely with both theoretical possibilities.

Although the present study was not specifically designed to test Sidman's (2000) theory of stimulus equivalence, the data discussed here are certainly consistent with his analysis. This does not hold true for the other major theories of equivalence (Hayes et al., 2001; Horne & Lowe, 1996). Certainly, reinforcement procedures are critical to the establishment of conditional discriminations. However, it is not necessary to preserve the specific stimulus-reinforcer relations for conditional discriminations in order to maintain those behaviors. Sidman has stated that when two outcomes of the reinforcement contingency come into conflict (i.e., when the establishment of an analytic unit is juxtaposed against the emergence of an equivalence relation), the analytic unit takes priority. Training with a common reinforcer or with overlapping reinforcers (i.e., as was the case during outcome-reversal training) presents such a conflict. For most of the participants, it seems that the analytic units did take priority: Accuracy on the conditional discriminations did not decline after the training contingencies were shifted from the original-outcomes procedure to the outcome-reversal procedure.

According to Sidman (2000), class-specific reinforcers should greatly facilitate the emergence of equivalence relations in that they prevent the initial conflict (between the equivalence relation and the establishment of analytic units) that arises from the use of a common reinforcer. Without a common reinforcer to create a large equivalence class, which then has to break down to provide for the establishment of the analytic units, many participants who fail to demonstrate, or take a long time to demonstrate equivalence relations, should show improvement. Indeed, two of the children (Participants TK and GM) did show improvement on their equivalence performances following the implementation of class-consistent reinforcers (and the discontinuation of training contingencies which included overlapping reinforcers). Moreover, while Participant GM did not show equivalence with the reversed outcomes, he readily demonstrated equivalence relations with novel stimuli and class-consistent reinforcers.

The reinforcer-probe performances of four of the participants indicated the emergence of reinforcer relations. These results are consistent with Sidman's (2000) theory of stimulus equivalence, which maintains that equivalence relations consist of the ordered pairs of all the contingency related elements, including the reinforcer, and that they arise directly from the reinforcement contingency (p. 132-133). In contrast, the remaining participants did not demonstrate the emergence of reinforcer relations. In keeping with Sidman's analysis, these data could be interpreted as evidence that the reinforcers had dropped out of the classes due to the overlapping reinforcers.

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APPENDIX

Appendix A. Parent-permission packet.

Dear Parent,

Drs. Carol Pilgrim and Mark Galizio of UNCW are currently conducting research to study children's learning patterns, and in particular, to evaluate strategies designed to facilitate children's learning via computers. Computerized instruction is becoming more and more important in today's educational systems and in order to facilitate this, it is important to study the ways in which educational software can take advantage of basic learning and developmental principles. Our work was begun with a grant form the National Institute of Child Health and Human Development.

One goal of this work has been to develop a group of standard tasks or games that can be used to study learning with children of a wide range of ages. Another goal is to identify the ways in which young children's learning patterns differ from those of older children or adults. Because we are comparing the learning and memory patterns shown by children of different ages, it can be especially useful to work with individual children over an extended period of time, to see if their patterns change. A third goal will be to examine features of the teaching programs that can improve student interest in learning.

We feel very fortunate to have been able to conduct some of this project at Wilmington area preschools and after-school child care programs. Drs. Pilgrim and Galizio have more than 15 years of experience studying children's learning. Over the years, a number of parents from our local schools have been most helpful in giving permission for their child to participate in this project. Currently, we are looking for approximately 10 children from 3 to 8 years of age to take part in the study. This letter comes as a request for your permission to include your child in this important study of how children learn.

The specifics of your child's participation would be as follows. All study sessions will be held at your child's school or after-school program at times that do not interfere with planned activities for the children. Your child would work with one or two of our advanced undergraduate or graduate students for about 15 minutes a day over a period of time as short as one week or as long as several months, depending on your child's age, interest and learning level.

We tell each child that we are going to play a game with a computer. The kinds of games vary according to the child's age and the particular study from simple picture recognition to problem solving, to language and math games. We would be happy to demonstrate these games to parents before their child participates. One of our students sits with the child on one side of a small table facing the computer screen. This student teacher then will instruct and monitor the child's use of either a computer mouse or touchscreen. Learning these basic computer skills should be of lasting value to your child. With your permission, we will sometimes give the children fruit treats or small toy prizes (but never enough to spoil the appetite).

These learning games are fun for children. Each day's lesson is short, so they don't get bored. Further, your child is free to decline to participate on any given day, or to withdraw from the study at any time, with absolutely no repercussion. The only possible risk of participation is that for the 15-minute lesson time, your child will not be engaging in other activities (e.g. playing with friends, watching videos). Benefits of participation include the fact that children seem to enjoy the attention that comes from interacting with our students, and they get some experience working at a structured task. Importantly, your child will benefit from learning basic computer skills as well as the concepts developed by the instructional software itself. In addition, your child will be contributing to important findings on how learning styles change with age, with possible implications for improving educational practices in the future.

We would like to point out that this project has been approved by the National Institute of Child Health and Human Development and the UNCW Institutional Review Board for research with human participants, and by the directors of your child's school or after-school program. Your child's performance will not be compared with that of any other individual child. Instead, we are seeking to find the range of learning patterns that may be shown in specific age groups. At no time will a child's name be used to identify his or her diagnosis or performance. At the end of the project, we will be very happy to send you a summary of our findings.

If you have any questions at all about this research, what it means, or how it is handled, please feel free to call us at the University at 962-3288 (Dr. Pilgrim) or 962-3813 (Dr. Galizio). If you have questions about the University's procedures for ensuring the rights of volunteer research participants, please call Dr. Neil Hadley, Dean of Research Administration (962-3884). If you would allow your child to participate, please sign the attached permission slip and return it to your child's teacher as soon as is convenient. We appreciate your consideration of this project.

Thank you for your support,

Carol Pilgrim, Ph.D.
Professor of Psychology

Mark Galizio, Ph.D.
Professor of Psychology

Permission for Participation

I give my permission for my child to participate in the Computer Learning Project being conducted at their school.

Parent's Name___________________________________ Date___________________

Phone Number_________________________________

Child's Name__________________________________ Child's Birth Date___________

Does your child have access to a computer at home? ___Yes ___No

If yes, does your child use a joystick? ___Yes ___No

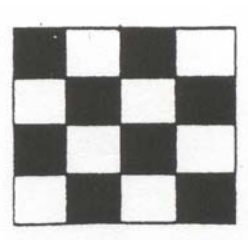
a mouse? ___Yes ___No

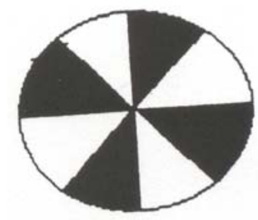
Are there software programs that your child uses frequently? ___Yes ___No

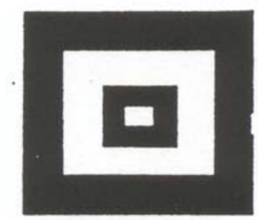
If yes, please list the names of those you know:

Appendix B. Tally sheet for Experiments 1, 2, and 3.

TALLY SHEET

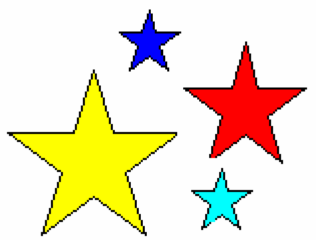


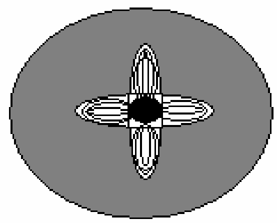




Appendix C. Tally sheet for Experiment 4.

TALLY SHEET





Correct