STIMULUS-STIMULUS PAIRING, MATCHING-TO-SAMPLE TESTING, AND EMERGENT RELATIONS

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Procedures other than matching-to-sample may be used to establish the conditional discriminations necessary to establish equivalence classes. One procedure, stimulus-stimulus pairing, may have particular relevance in accounts of the stimulus relations involved in language. Stimulus-stimulus pairing is a type of paired associate learning that uses a simultaneous presentation of two or more stimuli without explicit reinforcement of responding. This study explored the possibility that equivalent stimulus classes can be formed by simultaneous stimulus-stimulus pairings. Pairs of stimuli were presented according to three classes of stimuli derived by the experimenter. Matching-to-sample tests for combined symmetry and transitivity between these classes revealed that the stimuli were responded to as equivalent. Control conditions revealed, however, that classes formed only when stimulus pairing was alternated with matching-to-sample testing in which the contingencies for test performance were described to the subjects. The results are discussed in terms of how test conditions restrict and select responding to produce equivalence.

The stimulus equivalence paradigm (Sidman, Rauzin, Lazar, Cunningham, Tailby, & Carrigan, 1982; Sidman & Tailby, 1982) has proved to be of great value both as a method for producing complex behavior in a laboratory setting and as a basis for generating theoretical discussion. The stimulus equivalence model focuses on the emergence of responding to reflexive, symmetric, and transitive relations among stimuli. These relations are generally trained and tested using matching-to-sample (MTS) procedures.

The findings of the stimulus equivalence literature have led to much debate concerning the importance of emergent relations and the formation of new stimulus classes (see Sidman, 1994, for a review).
area of interest to many investigators is the application of stimulus equivalence to the process of language acquisition (e.g., Chase & Danforth, 1991; Hall & Chase, 1992; Hayes, 1991; Lazar, 1977). In fact, many of the early studies used stimuli that were directly related to verbal classes and had a direct goal of instructing aphasics or individuals with developmental disabilities to read and speak (Sidman, 1971; Sidman & Cresson, 1973).

The stimulus equivalence paradigm answers many questions regarding the formation of broad verbal stimulus classes without explicit instruction or reinforcement. One kind of verbal stimulus class that might be accounted for by stimulus equivalence is a simple semantic class involving a spoken word, a written word, and the object that these words are used to reference. For example, if a child hears the word “dog” and points to the written word DOG, and then sees the written word DOG and points to a picture of a dog, with enough practice and the appropriate consequences, all three stimuli may form a stimulus class such that “dog,” the written word DOG, and the picture of a dog are equivalent.

The standard procedure used for both instructing and testing the various relations in the equivalence experiment has been MTS. MTS has long been considered one of the most robust and reliable research methods used by behavioral experimenters (Mackay, 1991). MTS also is related to many standard teaching procedures used by parents and others. For example, when children begin formal language training many instructional sequences involve asking the student to match pictures or point to pictures or words in the presence of a word (e.g., “Which one is the dolly?”).

The MTS procedure, however, is only one of the many ways that parents, siblings, and other children present the stimuli that seem important for acquiring language in the real world. For example, the parent presents a piece of cake to a child and says, “Have some cake.” The parents also may read to the child and point out the word CAKE. After many instances of this type of experience the child can often match the written word CAKE to an actual cake.

Some examples of these kinds of training have been systematically observed in the interactions of children and others. Collis (1977) found that vocalizations by mothers are often paired explicitly with an object the child is observing and this is thought to be related to the child learning to respond to the names of objects. Tomasello and Farrar (1986) showed that when both caregiver and child were observing the same object or event, enhanced language interaction and acquisition occurred. Golinkoff, Hirsh-Pasek, Cauley, and Gordon (1987) reported that infants tended to look longer at objects and actions that had just been named for them. In all of these cases, the object or action was paired simultaneously with a distinguishable verbal topography. The question arises, could a system of simultaneous stimulus pairing also produce emergent relations like those found in stimulus equivalence?

One of earliest studies acknowledged as investigating stimulus
equivalence, Peters (1935), used simple stimulus pairing procedures rather than MTS procedures. Bugelski and Scharlock (1952) used a procedure similar to the one used by Peters (1935). The subjects learned the word pairs in fewer trials if the words had previously been associated with a common stimulus (Jenkins & Palermo, 1964). Similarly, stimulus pairing has been used to establish transfer of performance similar to equivalence in sensory preconditioning experiments (Brogden, 1939; Honey & Hall, 1991).

Some studies have combined MTS training procedures with other procedures for establishing stimulus control. For example, Lazar (1977) showed that equivalence relations established through MTS procedures could be used to expand functional classes that were established through a sequence training procedure. Imam and Chase (1988) showed that equivalence classes formed through MTS could be expanded through sequence training procedures. Recent work by Dougher, Augustson, Markham, Greenway, and Wulfert (1994) has shown that respondent elicitation could be transferred through equivalence classes. Roche and Barnes (1997) demonstrated that a respondent conditioning procedure could be used to expand classes of equivalent stimuli. Further, Barnes, Smeets, & Leader (1996) used a respondent-type procedure to establish equivalence relations. Leader, Barnes, and Smeets (1996) and Smeets, Leader, and Barnes (1997) also used a respondent-like procedure to establish emergent equivalence classes. These studies showed that a pairing procedure was an extremely effective method for producing these relations and that both training and MTS testing appeared to be necessary to produce the desired results. Taken as a whole these studies give strong support for equivalence relations being established or expanded through procedures that combine MTS with other methods of stimulus presentation.

The question the current research attempted to answer was whether simultaneous stimulus-stimulus pairing without explicit reinforcement can be used to establish equivalence relations. This differs from the procedure used by Leader, Barnes, and Smeets (1996) and Smeets et al. (1997) in that those studies used a successive pairing procedure. Further, as other studies have combined stimulus-pairing procedures with MTS, we wanted to investigate whether the SS pairings could be separated from the MTS procedure to obtain equivalence without alternating between procedures. Leader et al. (1996) and Smeets et al. (1997) reported that both training and testing appeared to be necessary to produce emergent relations, but those studies did not directly examine this question.

Five experiments were conducted. Experiment 1 simply tested whether we could establish equivalence relations using a simultaneous stimulus-stimulus (SS) presentation procedure and a MTS test procedure that alternated across sessions. Experiment 2 controlled for the alternation between SS presentation trials and MTS test trials with subjects who had already learned to respond to the equivalence relations trained and tested in Experiment 1. Experiment 3 controlled for the
procedure of alternating between SS and MTS procedures with subjects who did not have a history of such alternations. Experiment 4 controlled for the effects of repeated testing to see if testing alone could produce emergent relations. Finally, Experiment 5 determined that the relations established by the pairing procedure could be reversed.

Experiment 1

Method

Participants. Four undergraduate college students, two male and two female, served as subjects. They were contacted via a subject recruitment board in the Psychology Department at West Virginia University. Students who wished to participate in the study wrote their names and telephone numbers on the announcement. The first subjects contacted were selected for the study. Subjects were required to read and sign a consent agreement that specified the length of the study, method of payment, and the particulars of the experiment (see Appendix). Daily sessions lasted no longer than 50 min and were broken into blocks of trials that were separated by short breaks. Subjects were paid $2.00 for each 50-min session completed and were also paid $0.10 for every correct answer. Subjects received $1.00 per session if they completed the entire study. Although subjects were told that they would receive payment every 3 weeks, no subject took more than 3 weeks to complete the entire study. Therefore, subjects were not informed of their earnings until the entire experiment had been completed.

Apparatus and setting. Stimuli were displayed on a 19-cm by 14-cm color VGA monitor of a computer with a 386 Intel processor and 1 MB of memory. The keyboard was a Zenith ZHB-3 that had the arrow keys separated from the other keys and grouped in an inverted T configuration with the up arrow key above the left, down, and right arrow keys. For SS presentations, the monitor display consisted of two 3-cm red squares 2 cm apart that were presented near the middle of the screen on a dark blue background. During MTS testing, one red 3-cm square was presented on the center of the screen (the sample box) and three red 3-cm squares were presented in a line just below the center of the screen (the comparison boxes). All squares were presented on a dark blue background with 2 cm separating them. White arbitrary symbols (see Figure 1) or Greek letters were presented inside the red boxes. The symbols and letters were approximately 2.5 cm by 2.5 cm.

The computer was placed on a desk inside a small air-conditioned room with all outside windows covered with black shade material. A waiting room where interviews were conducted was located just outside the experimental room.

Response mode. Subjects were instructed via the computer screen to advance through the SS presentations by pressing the up arrow key of the keyboard. The stimuli were presented for a minimum of 3 s and responding on the up arrow key had no effect until 3 s had passed. During
MTS testing, subjects were instructed via the computer screen to press the right arrow key if the symbol in the right square was the correct choice for the symbol in the sample square, to press the down arrow key if the middle square was the correct choice, and to press the left arrow key if the correct choice was in the left square. All other keys on the keyboard had no programmed consequence.

Stimuli. Figure 1 illustrates one set of stimuli that were used (the arbitrary symbols series). Each of the stimuli was assigned a letter and a number although the subjects were not given these letter-number combinations. The letters designate stimuli that were presented together as comparisons during the test phases of the experiment (all MTS trials). For example, when A1 was used as a comparison stimulus, A2 and A3

![Figure 1](image-url)

*Figure 1.* The nine symbols used in the experiment. The letters designate stimuli that were presented together as comparisons during the test phases of the experiment. The numbers designate stimuli that were selected by the experimenters to be part of the same class. The B series made up the common member stimuli. The Greek letters used were organized in a similar fashion, but are not shown.
were used as comparisons. The numbers designate stimuli that were selected by the experimenters to be part of the same class. For example, A1, B1, and C1 were all part of the same class. The Greek letter series was arranged in a similar manner.

Instructions. The consent form contained a general outline of the experiment, but gave no specific instructions. At the beginning of the experiment the subjects were shown the following instructions:

Please observe the computer screen. Follow the instructions you see there. Advance through the program by pressing the **up arrow key**. At the end of each presentation period, which will take only a few minutes, you will be asked to match the symbol at the top of the screen with one of the three symbols below it. You can earn 10 cents for every correct answer you choose. Periodically the program will need to be reset and you will be asked to leave the room. There will be several presentation and testing periods per session.

If a subject had a question about the instructions, the pertinent portion of the instructions was re-read to the subject. After the first pair of stimuli was presented during the SS presentation phases the computer reminded the subject to advance through the program by the instruction: “Press the up arrow to continue.”

At the end of the presentation phase and before the testing portion of the session, the MTS format was drawn on the screen and the test instructions were written at the top: “use the arrow keys to select the correct response.” Arrows going the appropriate direction were drawn in the appropriate sample squares and the words; left, down, and right were written in the sample boxes also. At the bottom of this screen “Press the up arrow to continue” was written. Once the up arrow was pressed the testing phase began, the three other arrow keys became active, and the up arrow became inactive.

**Presentation phase.** Each SS presentation phase consisted of the presentation instructions and six pairs of stimuli (see Figure 2, top) presented in a random order. A minimum of 12 trials was required to present each pair of stimuli twice, once with each member on the right and the left of the screen. Besides these 12 presentations no other instructions or information were given to the subjects.

**Test phase.** Once the subject had finished a presentation phase, the MTS trials began. The dotted lines on the top of Figure 2 show the relations that were tested. The correct choice was defined as the symbol that was class consistent according to transitive logic (e.g., if A1 is paired with B1 and B1 is paired with C1, then Comparison C1 should be matched to A1) or a combination of transitive and symmetric logic (e.g., if A1 is paired with B1 and B1 is paired with C1, then Comparison A1 should be matched to C1). Six testing trials were necessary to test for both relations among the A and C stimuli. These trials are shown in the bottom panel of Figure 2 and were presented in random order. Once the
Figure 2. The top portion of the figure shows the nine stimuli organized into six pairs with common members in three separate sets. The solid lines represent the trained relations, the dotted lines represent the possible emergent relations. The bottom portion shows how these stimuli were arranged to test for equivalence in the matching-to-sample testing procedure.

subject had finished a test phase another presentation phase began. This presentation phase was followed by another test phase. SS presentation and MTS test phases of the experiment alternated until either the subjects met the criterion of two test sessions of six correct responses (experimenter defined class consistent responding) or until they had received a large number of trials with no upward trend in the number of correct responses. Although responding correctly for two test sessions was a minimum stability criterion, it seemed sufficient to determine whether the stimulus-stimulus pairs and tests would establish equivalence responding. The current experiments did not address whether responding would maintain under extinction conditions, or whether there were differences in responding across types of test trials (Pilgrim & Galizio, 1995).

At no time were any of the subjects informed as to whether a choice was correct or not. If the subject responded through six presentation-
testing cycles without reaching the terminal criterion the computer halted the program and asked the subject to leave the room and take a short break. Presentations and testing resumed shortly thereafter. Usually the breaks lasted no longer than 5 min.

Results

Figure 3 shows the number of correct responses made on the MTS tests after each block of SS presentations. The Y axis shows the number of correct responses made during the MTS test, thus six correct responses are 100% performance. The X axis shows the number of presentation-testing cycles provided. A presentation-testing cycle was defined as 12 stimulus pair presentations followed by a battery of six MTS test trials. As seen in Figure 3, 3 of the 4 subjects reached the terminal criterion. The fourth subject's responding (DP) remained at stable chance levels from Cycle 13 through 96. The subjects who reached criterion did so quite rapidly. The smallest number of presentation-test cycles presented before the criterion was met for the first time was 6 (JM) and the largest was 12 (AH). All subjects who reached criterion did so in one 50-min session. Both JM and AH were required to reach criterion on three consecutive cycles because they first reached criterion just before a break.

Discussion

Three of the subjects responded in ways that suggested the formation of three equivalence classes. Even though the MTS procedure
did not test all of the relations necessary for establishing an equivalence class (Sidman, 1994) it did test equivalence unambiguously. The MTS trials can be described as testing combined transitive and symmetric relations. If the MTS trials are responded to as combined symmetry and transitivity, then as argued by Sidman (1992), they test equivalence. The subjects, however, could have responded to the MTS trials as two kinds of transitive trials. For example, given that A1 is presented with B1 and B1 is presented with C1 during the SS presentations, the A1C1 relation tested during MTS is a transitive relation. Similarly, given that B1 is presented with A1 and C1 is presented with B1 during the SS presentations, the C1A1 relation is transitive. Transitive relations by themselves, however, do not unambiguously show equivalence as other relations, for example sets of greater than and less than relations are also transitive. In the current experiment, however, the two transitive relations are symmetric to each other and if both are true then the relation must be equivalent.

Therefore, the establishment of equivalence relations seems to have been accomplished with this procedure. This was achieved without using standard MTS training and without differential reinforcement being applied to correct versus incorrect answers. The presentation of the stimulus pairs, without any type of information given to the subject concerning choice strategies or without direct contingencies appeared to be sufficient to produce these results. Thus, the results suggest that equivalence relations were produced by alternating between the simple simultaneous pairing of stimuli and the test for equivalence. These results were accomplished with an instruction that the subjects would be tested, but without differential reinforcement or knowledge of results, or a direct instruction concerning the emergent relations. This interpretation of the results is consistent with Leader et al. (1996) and Smeets, et al. (1997) and extends their findings to pairs of stimuli that are presented simultaneously.

The critical conditions that led to equivalence in all of these studies, however, were not isolated. It is not clear whether alternating between the SS pairings and MTS testing was necessary for establishing stimulus equivalence classes. Further experimentation was needed to separate the effects of alternating between SS pairings and MTS tests. Experiment 2 partially controlled for the alternation between SS presentation trials and MTS test trials by providing the subjects with training on a new set of stimuli for repeated blocks of trials prior to the MTS tests. The same subjects who had learned to respond to the equivalence relations trained and tested in Experiment 1 participated.

Experiment 2

Method

Participants. Subjects for this experiment were 3 subjects, two female and one male from Experiment 1, who had responded correctly to the three stimulus classes and associated equivalence relations.

Apparatus, setting, and instructions. The apparatus, setting, and
instructions were the same as Experiment 1. The response mode was also the same.

Stimuli. The stimuli were arranged in the same manner as described in Experiment 1. In Experiment 1 subjects were shown either arbitrary symbols or Greek letters. The set of stimuli that the subjects did not view in Experiment 1 was used in Experiment 2.

Presentation and testing. The presentation phase of Experiment 2 differed from that of Experiment 1 in that many blocks of SS presentations were given before testing began. The number of blocks viewed by each subject before testing began was the same as the number of cycles of SS and MTS presentations in Experiment 1 that were necessary for the subject to reach 100% accuracy for the first time. For example, JM reached 100% accuracy after six alternations of SS presentations and MTS tests in Experiment 1 and received six blocks of SS presentations before the first MTS test was given in Experiment 2.

Once the subjects had viewed the initial number of presentation blocks and the first MTS test had been administered, the alternating presentation-test cycle that was used in Experiment 1 was used. This cycle of presentations and testing continued until the subjects had reached 100% accuracy on two consecutive tests.

Results

Figure 4 shows that all 3 subjects rapidly reached the terminal criterion. Two of the subjects, AH and JM, were 100% accurate on the very first match-to-sample test administered. JN was correct on five out of the six trials on the first test and required just one more SS presentation before the 100% accuracy criterion was met.

Discussion

Using a new set of stimuli for each subject, Experiment 2 replicated the results of Experiment 1, but with quicker acquisition of the stimulus classes. Of the 3 subjects, 2 reached criterion on the very first MTS test (the third subject reached criterion on the second MTS test). These data appear to support the use of a simple pairing of events to produce emergent relations without repeating the pairing and testing cycle.

This experiment also points out that historical variables may be important in determining whether equivalent responding occurs. Leader et al. (1996) wrote:

One interesting follow-up study, therefore, might be to establish responding in a group of subjects using the respondent training, and then repeat the procedure with novel stimuli. If exposure to the first set of stimuli was functioning as an important contextual cue for equivalence, we would expect most subjects to demonstrate more rapid emergence of equivalence responding with the second set than with the first. (p. 704)

Given the rapidity of acquisition of equivalence responding shown in these results the effect of historical variables can not be dismissed.
Figure 4. Data from 3 subjects showing the number of correct responses to MTS test trials across presentation-test cycles. The number of SS presentations prior to the first MTS test varied across subjects, but was yoked to the number of presentations that had to be shown to that subject in Experiment 1 before 100% accuracy was achieved. After the initial test of MTS trials, SS presentations where alternated with MTS testing.
What was still unclear was whether subjects who do not have an experimental history of alternating between SS pairs and MTS testing will show equivalence after being exposed only to the stimulus pairs. It is possible that the alternation of SS presentations and MTS testing provided during Experiment 1 was necessary to establish equivalence in this experimental context and once established with one set of stimuli the relations transferred to other sets of stimuli. We do not know whether it is possible for the presentation of the stimulus pairs alone to produce emergent equivalent relations. In addition, neither Experiment 1 nor Experiment 2 tested whether subjects who have an experimental history of equivalence will show equivalence with a new set of stimuli through MTS testing alone. Experiment 3 was designed to answer these questions.

Experiment 3

Method

Participants. Subjects for this experiment, two male and two female, were selected in the same manner as the subjects in Experiment 1.

Apparatus, setting, and instructions. The apparatus, setting, and instructions were the same as Experiment 1. The response mode was also the same.

Presentation and testing. Experiment 1 had determined that no more than 12 SS presentation and MTS test cycles were necessary for 3 subjects to show equivalence. Thus, in the current experiment 12 blocks of SS presentations, that is 144 SS presentation trials (SS condition) were shown to the subjects prior to the MTS test phase. Immediately afterward, the subjects received the first MTS test. None of the subjects responded correctly to more than four of the MTS trials on the first test (see Figure 5). Then, SS presentations and MTS tests were alternated as in previous experiments (P+T1 condition). The same criterion for demonstrating equivalence was used as in Experiment 1.

Once equivalence had been established, the second condition (Condition T) was introduced at the beginning of the next session. Condition T involved presenting one SS set using the second set of stimuli and then 12 MTS tests in order to examine the effects of testing alone after an experimental history of obtaining equivalence. Only those subjects who demonstrated equivalence responding in condition P+T1 were exposed to Condition T. After the 12 MTS tests were given, if subjects were not consistently accurate on the MTS tests, they were exposed to the alternation of SS presentations and MTS testing (Condition P+T2) until the terminal criterion had been reached.

Results

Figure 5 shows the number of correct responses during the MTS tests across three conditions. Unlike Experiment 2, the 144 SS presentations alone did not produce criterion performance for any subject on the first series of MTS tests. Subjects AN, FM, and JJ did, however,
achieve criterion performance after repeated alternations of the SS and MTS testing. Subject AN took five alternations, FM took 16 alternations, and JJ took 11 alternations to reach criterion performance.

Figure 5 Condition T shows performance on the 12 MTS tests after the single SS presentation with new stimuli. Subject AN reached criterion rapidly in Condition T. The terminal criterion was met in the minimum of two MTS tests. FM and JJ did not meet the criterion during Phase T. They then were given a number of alternations of SS presentations and MTS testing before the criterion was met in Condition P+T2.

Subject PG did not show equivalence responding in any form and continued to perseverate on one particular pattern of responding throughout the experiment.

Discussion

This experiment further tested the relation between alternating SS presentations and MTS tests by presenting two new conditions. Data from condition P+T1 show that emergent relations did not occur as quickly as they occurred for the subjects in Experiment 2. These results indicate the importance of having an experimental history of alternations with at least one set of stimuli. This provides support for the idea that a history of forming equivalent relations is an important factor in the rapid production of equivalent relations.
The second new condition (Condition T) provided the MTS testing alone with a new set of stimuli after a history of responding accurately to equivalence relations. Of the 3 subjects, 2 could not respond to equivalent relations after one presentation of the stimulus pairs followed by repeated testing. These data showed that testing alone was not sufficient to produce the emergent relations.

As in Experiment 2, the rapidity at which subjects reached criterion with a new set of stimuli when provided with repeated instances of the stimulus pairs is shown in Condition P+T2. These data suggest that once an experimental history of equivalence responding has occurred, new emergent relations can be established quite readily. The failure of presentations alone and testing alone, even after a history of equivalence, shows the value of alternating between SS presentations and the MTS testing.

The results of Experiments 1, 2, and 3 did not rule out the possibility that testing may have been sufficient to produce equivalence with these stimuli. The second condition of Experiment 3 (testing alone) was conducted after the subjects had a history of emergent relations with one set of stimuli. This history may have interfered with producing equivalence after a single alternation between the stimulus pairs and the MTS tests. These observations suggested further experimentation was needed. Experiment 4 controlled for the effects of repeated testing without a history of emergent responding to see if testing alone could produce emergent relations.

Experiment 4

Method

Participants. Subjects for this experiment were selected from an Introductory Psychology class at West Virginia University. The first 5 subjects, three male and two female, who contacted the experimenter, were chosen for the study. The same procedure was followed for this experiment as in the first three experiments for subject consent and payment, except that the subjects also received extra credit (one point for every half hour of participation) in Introductory Psychology.

Apparatus, setting, and instructions. The apparatus, setting, and instructions were the same as Experiment 1. The response mode was also the same.

Presentation and testing. As in Experiment 3, 12 blocks of SS presentations were shown to the subjects prior to any testing. Immediately afterward, the subjects received 12 MTS test phases. As in Experiment 1, 6 MTS tests were provided, then a short break and then 6 additional MTS phases. Two consecutive test phases with 100% correct accuracy were used as a criterion for equivalence. After the 12 MTS test phases had been administered, the subjects were exposed to the same alternation of SS presentation and MTS test phases as used in Experiment 1. The same criterion for assessing equivalence was in effect for this condition.
Results

Figure 6 shows that none of the 5 subjects reached criterion during the testing condition (T). Of the 5 subjects, 4 reached criterion once the alternating presentation and testing cycles were introduced (Condition P+T). The number of SS-MTS cycles necessary to reach criterion varied among the 4 subjects from 1 to 28 with a mean of 14.75. SM was removed from the study after 12 MTS tests and 70 SS-MTS cycles produced chance performance (see Figure 6).

Discussion

Experiment 4 examined whether testing alone could produce emergent equivalence relations. To that end, testing was administered repeatedly after one presentation of the stimulus pairs. Experiment 4
showed that in all likelihood testing alone in the format used here was not sufficient to establish the emergent relations. In addition, Experiment 4 showed that once the alternation between SS pairs and MTS testing was implemented the subjects learned the relations necessary to demonstrate equivalence. One subject, CH, even reached criterion performance with just one presentation of the stimulus pairs after the testing condition (see Figure 6, CH). These results are consistent with the observation that MTS testing is necessary, but not sufficient for the relations to be established.

A criterion of 100% correct performance on two consecutive trials was used throughout the first four experiments to judge if equivalence relations had been established. There is a small possibility that this criterion was not sufficient to assure the stability and reliability of the emergent performances. Pilgrim and Galizio (1995) reported that subjects did not reverse all of the equivalence relations tested after reversal training. They argued that when all the tested relations do not reverse, it is evidence for a lack of stability of the stimulus classes. Conversely, complete reversals would be evidence that the behavior of the subjects was under the control of the stimulus relations required for emergent performance.

Thus, Experiment 5 examined whether the equivalence relations would reverse using a procedure that alternated between SS presentations and MTS testing. Two stimulus pairs were altered for the subjects who participated in Experiment 4. This was accomplished by pairing B1 with C3 and B3 with C1 (see Figure 7) during the stimulus pairs presentations. This produced four new potential test relations (A1 to C3, A3 to C1, C3 to A1, and C1 to A3) and left two of the test relations (A2 to C2 and C2 to A2) intact.

Experiment 5

Method

Participants. The 4 subjects, two male and two female, who had showed equivalence relations in Experiment 4 participated in Experiment 5.

Apparatus, setting, and instructions. The apparatus, setting, and instructions were the same as Experiment 1. The response mode was also the same.

Stimuli. The same stimulus set was used that the subject had used in the previous experiment to reach the established criterion. The stimuli were arranged in the manner described in Figure 7.

Presentation and testing. The SS presentation phase of Experiment 5 did not differ from that of Experiment 1. The MTS testing phase was also the same and the same criterion for equivalence was used. Once the criterion had been reached with the first set of stimuli, the other set of stimuli (e.g., Greek letters instead of symbols) was presented in the same manner as in Experiment 1. The configuration of these stimulus pairs was the same as the configuration of stimulus pairs shown in Figure 2. Once the criterion had been reached with this new set of stimuli a second reversal was attempted by transposing the stimuli in accordance with the
Figure 7. The stimuli arranged after C1 and C3 were exchanged in the reversal series. The solid lines represent the trained relations, the dotted lines represent the possible emergent relations. Four of the emergent relations were then changed. Note that middle series did not change.

pattern shown in Figure 7. Thus, Experiment 5 conducted two stimulus class reversals to see whether emergent responding also reversed.

Results

Figure 8 shows the results of reversing some members of each stimulus class. Condition R1, the first reversal, was introduced on the session immediately following the termination of Experiment 4. Of the 4 subjects, 3 reached criterion on the reversal in that session. The fourth, SB, did not show the reversal effect even after 48 SS presentation/MTS testing cycles. On subsequent testing with a new set of stimuli (Condition P+T) this subject did not reach criterion and was dropped from the experiment after another 45 SS/MTS cycles. For the 3 subjects who showed the reversal effect (AJ, CH, and JW), subsequent presentations

Figure 8. Data from 4 subjects shows the number of correct responses in MTS testing across presentation-test cycles. In Phase R1 the same stimuli and procedure were used as in Phase P+T of Experiment 4, but with reversed class membership for the stimuli. In Phase P+T, the SS presentations and MTS testing alternated with a new set of stimuli. Finally in Phase R2, class membership for the second set of stimuli was reversed.
of a new set of stimuli (Condition P+T) and the reversal of those relations (Condition R2) occurred without failure.

Discussion

Experiment 5 demonstrated that the emergent relations were established reliably and these relations changed in accordance with changes in the relations among the stimuli. One subject, SB, who reached criterion during the P+T condition of Experiment 4, did not show the reversal effect nor did he reach criterion with the new set of stimuli. It is possible that guessing or some kind of different, but effective, choice produced the attainment of criterion during Experiment 4. It seems more likely, however, that the subject changed from correct responding to incorrect responding across experiments because the experimental sessions continued without the subject receiving knowledge of the results of test performance (a postsession interview supports this notion, e.g., "I thought I was doing something wrong"). In any event, this subject's data suggested the utility of using a second set of stimuli or at least a reversal procedure to check for the reliability and stability of equivalence relations.

General Discussion

These five experiments explored the possibility that equivalent stimulus classes can be formed by simultaneous stimulus-stimulus pairings. The data revealed, however, that classes formed only when stimulus pairing was alternated with matching-to-sample testing in which the contingencies for test performance were described to the subjects. In addition the studies revealed that (a) presenting SS pairs alone after the subjects had an experimental history of equivalence responding could produce emergent relations, (b) testing with MTS alone did not produce emergent relations, and (c) established emergent relations could be reversed.

Leader et al. (1996) raised the issue of whether repeated exposure to training and testing was necessary to produce emergent equivalent relations. The answer is not a simple one. As evidenced from the data presented here it seems that without a prior experimental history of equivalence responding that both training and testing are essential for producing these relations, but once such a history has been established, presentations alone will produce emergent equivalent relations.

These findings are important because they demonstrate relations that may correspond to those existing when language is acquired. Stimuli are constantly being paired with stimuli that may or may not be related to other stimuli, but it is assumed that until individual relations are reinforced new classes may not emerge. Thus, stimuli are not likely to become part of a stimulus class without a contingency to do so. This is what Skinner (1957) referred to as abstraction. Stimuli have many different dimensions and relations between dimensions, but Skinner claimed that responding consistently to classes of stimuli does not occur until there is a contingency of reinforcement for responding in the presence of a particular property or
set of properties of a set of stimuli. In accordance with this view one would not expect relations to emerge in the current experiments until testing begins because no contingency is present until that time.

The nature of the contingency in this case is interesting, however, because it is not a direct contingency. There were no differential consequences for responding on the test. This observation implicates the role of instructions. The instructions concerning the payment contingency for correct MTS test performance and the alternation between SS presentations and MTS testing may have produced instruction following critical to the results of the experiment.

The function of instructions, if it exists in the current experiments, is in the relation between the presentations, the tests, and the test instructions. As in other studies of equivalence, it was not until the subjects had responded to the MTS testing trials repeatedly that their responding came under control of the relations among the stimuli (Devaney, Hayes, & Nelson, 1986; Lazar et al., 1984; Sidman, Cresson, & Willson-Morris, 1974). Sidman (1992) refers to the finding that testing may facilitate the establishment of emergent relations as “a winnowing process” whereby responses are eliminated during testing because they are not consistent from trial to trial. According to Sidman this requires a special reinforcement history in which the subject has learned that every trial has one and only one correct answer. This special learning history is likely to be particularly germane when the subjects, like in this experiment, are told that they will be asked to match stimuli.

One way to discuss this winnowing process is in terms of any procedure, including instructions, that makes it likely that subjects respond to MTS in accordance with equivalence relations. Such procedures include tests that restrict responding, instructions to determine which stimuli go together, or alternations between SS pairs, instructions, and MTS tests. Andronis (1991) described these examples as establishing operations (Keller & Schoenfeld, 1950, Michael, 1982), potentiating variables (Goldiamond & Dyrud, 1968), or function-altering stimuli (Blakely & Schlinger, 1987).

Instructions, alternations, and repeated testing establish or change the function of responding in a particular way. When the subjects first see the stimulus pairs, even though they are told they will be tested, there are many aspects of the stimuli that could control responding. The instructions for the test tell the subjects that there is a form of responding that will be reinforced. This instruction may establish the importance of the test, but it still does not alter the function of the stimulus pairs specifically in the direction of equivalence classes. The test itself displays the range of stimuli to the subjects. The test also constrains the possible responses because the comparison stimuli are always selected from a particular set. For example, when presented with Stimuli A1, A2, and A3 as samples, subjects always see Stimuli C1, C2, and C3 as comparisons. After seeing these instructions, the range of stimuli, and particular sets of comparisons, the subjects are then presented with the stimulus pairs again. Although the A and C stimuli are not presented together, they are both presented with the B stimuli. The function of these SS presentations is then changed, they are no longer just pairs of
stimuli, but relations among stimuli tested during the MTS tests. The only basis for responding consistently on the test is a relation among relations, namely that the B stimuli are common to the A stimuli and the C stimuli.

The function-altering aspect of alternating between stimulus pairs and testing is suggestive of how the relations among verbal stimuli are learned. Experiences and procedures that take the individual back and forth between older more established relations and new relations might produce emergent relations, like equivalence, relevant to language development. This may mean that the history of the learner can be combined with stimulus equivalence procedures to produce the more complex forms of stimulus relations that exemplify sophisticated verbal behavior.

The results of Experiment 2 shows how this might work. These results confirmed that presentations alone with a small amount of testing could produce equivalent relations with a novel set of stimuli once at least one set of relations had already been established. Experiment 2 showed that once relations are established through alternations between MTS and SS (Experiment 1), simply presenting the SS trials may be sufficient to produce the acquisition of new equivalence relations in subsequent trials. This can be likened to the histories built by the presentation of stimulus pairs during language acquisition. Once the general contingency for responding to relations among stimuli presented in pairs is established, subsequent relations can be established simply by repeatedly presenting pairs of stimuli in a similar fashion. As a child receives more trials of this type of relation, the more effectively future relations are formed.

In summary, these data suggest that SS pairings were insufficient to produce equivalence classes. These classes were formed when the MTS testing procedures instructed the subjects about the contingency and then the subject alternated between tests for equivalence and SS pairings. New relations were also established and reversed as long as subjects had an experimental history of alternating between SS presentations and MTS testing. No differential reinforcement or feedback about results or instruction that directly concerned the emergent relations was necessary to establish these relations. The alternation of SS presentations and MTS testing procedures may have altered the functions of the SS pairs necessary to allow the establishment of the equivalent relations. The data, thus, support the idea that stimulus pairing procedures, like those found in the natural environment of language development, can be used to produce equivalence responding, but only as long as there is a contingency, even an indirect contingency, to respond to the relations.

References


Appendix

Performance Influenced by Pre-exposure to Instructional Sets

Introduction

I, ____________________________, have volunteered to participate in this research study conducted by Michael Layng and Dr. Philip Chase of the Psychology Department. The study was explained to me by one of the experimenters _________________.

Purpose of the Study

The purpose of this study is to evaluate a teaching procedure for language learning. This procedure involves exposing the subject to various stimulus sets before a testing series that assesses changes in performance is presented. The stimulus sets are comprised of symbols that are presented in such a manner that relations may exist between them. After the assessment procedure has been completed a re-exposure and retest phase may be implemented. Data will be analyzed to determine the similarities between the acquisition of relations between symbols and the acquisition of language relations.

Description of Procedure

My participation in this study will require that I attend five 50-minute sessions per week for up to 8 weeks. In each session I understand that I will be presented with symbols and asked to match them to other symbols. I understand that I will work on a keyboard and mouse and respond to visual and auditory stimuli presented by a computer. The total number of subjects involved in this study will number approximately 24.

Risks and Discomforts

I understand that there are no foreseeable risks involved in serving as a participant in this study.

Benefits

I understand that this study is not expected to be of direct benefit to me, but the knowledge gained may be of benefit to others. I also understand that I can earn up to $5.00 for each 50-minutes that I work. I understand that I will be paid this money in two installments. I will be paid once at the end of three weeks and once at the end of the experiment and I understand that the experimenters will keep track of my earnings. So that I may keep accurate records also, the experimenters will give me an earnings statement at the end of each week. In addition I will receive a one dollar bonus for every 50-minute session that I attend. I understand that I will only receive this bonus if I complete the experiment in its entirety. I understand that my participation in the experiment will be terminated if I fail to attend two consecutive sessions without calling one of the contact persons listed below. I also understand that I will be terminated from the experiment if I miss more than five sessions over the course of the experiment. If I am terminated from the experiment, I will lose my bonus earnings held in reserve. I know that I will not be expected to pay any costs or fees as a result of my participation in this study. I realize that I am at liberty to discontinue my participation at any time, but if I withdraw before the completion of the experiment, I will forfeit my bonus pay.
Contact Persons

If I need to inform the experimenters or research assistant that I will not be able to attend a session, or if I require more information about the study, I can contact Michael Layng (Office: 212 Oglebay Hall) at 293-2001, ext. 647 and 883 or Dr. Philip Chase (Office: 101A Oglebay Hall) at 293-2001, ext. 626. For information regarding my rights as a research participant I may contact the Executive Secretary of the Institutional Review Board at 293-7073.

Confidentiality

I understand that any information about me obtained as a result of my participation in this research will be kept as confidential as legally possible. I have been assured that all data collected concerning me will be identified by a code and will be stored in a locked file cabinet upon the completion of the experiment. I understand that all publicly presented or published reports of the data will not identify participants by name and only the investigators will have access to individual participant's data.

Voluntary Participation

I know that my participation in this study is voluntary and that refusing to participate will not affect my grades in any way. I know that I can terminate my participation as a subject at any time by informing the investigators. In addition, I understand that neither my performance in the research nor my decision to terminate will affect my grades. I also understand that my failure to attend scheduled sessions will result in the termination of my participation as outlined above; however, such action will not affect my grade in any way.

I will be given a summary of my results at the end of the experiment if I request it at that time.

I have read the above information and have been given the opportunity to ask questions about the research. I understand the purpose of the study, the extent and conditions of my participation, and my rights as a subject. By signing below I am indicating that with this understanding I voluntarily consent to participate as a subject. Upon signing this form I will receive a copy.

Signature of Participant __________________________ Date __________
Signature of Investigator or Investigator's Representative __________________________ Date __________