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EMERGENCE OF CONDITIONAL STIMULUS RELATIONS AND TRANSFER OF RESPONDENT ELICITING FUNCTIONS AMONG COMPOUND STIMULI

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Previous research has demonstrated that conditioned elicitation functions can transfer via stimulus equivalence classes. However, thus far investigations in this area have been limited to stimulus equivalence classes involving single element stimuli. This study attempted to demonstrate the transfer of eliciting functions via emergent relations involving compound stimuli. Eight college students participated in this study. Six of these participated in all experimental procedures, while the remaining two served as controls and did not receive some phases of the experiment. The experimental participants were first taught nine conditional relations of compound stimuli and unitary stimuli (AC-B & BC-A) using match-to-sample training. They were then tested for the emergence of untrained relations involving different combinations of the previously learned compound-single element relations and compound-compound relations (AC-AC or AB-AB or BC-BC). A classical conditioning procedure was then performed in which one compound stimulus from one class was paired with mild electric shock (1.0-2.0 mA) while two other compounds from two different classes were presented in the absence of shock. Participants were then presented with other compounds from the appropriate classes to assess whether the eliciting function had transferred to stimuli which were members of the same class as the originally conditioned stimulus. The control participants received the same procedures except for the initial conditional discrimination training of the compound-single relations and the testing for the emergence of compound-single relations. Four of the six experimental participants demonstrated transfer of the eliciting function. An analysis of the performance of both of the individuals who failed to demonstrate the transfer revealed that they may have failed to maintain the classes throughout the experiment. One participant discontinued the experiment before further procedures

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could be performed. The second participated in retraining and subsequently demonstrated the transfer of the eliciting function. Neither of the control participants demonstrated the transfer of the conditioning in the absence of the conditional discrimination training. The results of this experiment show that respondent eliciting functions can transfer via emergent compound-compound relations. These results extend previous findings within the areas of emergent compound relations and transfer of function via stimulus equivalence classes.

Although the majority of research within the field of stimulus equivalence has focused on the emergence and transfer of function within classes consisting of single-element stimuli, there is growing interest in the emergence of conditional stimulus relations and stimulus control involving compound or complex stimuli (e.g., Dougher & Markham, 1994, 1996; Lowenkron, 1998; Markham & Dougher, 1993; Serna, 1991; Smeets, Schenck, & Barnes, 1994, 1995; Stromer, McIlvane, Dube, & MacKay, 1993; Stromer, McIlvane, & Serna, 1993; Stromer & Stromer, 1990a, 1990b). Important issues have been raised by these studies regarding the nature of stimulus control by compound stimuli and their individual elements. An adequate analysis and explanation of the stimulus control exerted by complex or compound stimuli may be necessary to provide a complete account of the emergence of equivalence relations from stimulus-stimulus relations (Dougher & Markham, 1994, 1996; Stromer, McIlvane, & Serna, 1993).

Researchers in this area have traditionally used the term "compound stimulus" to define a stimulus that consists of multiple elements that are inseparable such that they function as a unitary stimulus. However, Stromer and his colleagues have suggested that in some cases the elements of compound stimuli may be separable, and the substitution of elements can occur without diminishing discriminative control (Stromer, McIlvane, & Serna, 1993). There is no presumption of hierarchical controlling relations among the elements of such compound stimuli, and individual elements could serve different functions in different contexts. These functions might also transfer to the other elements of the compound. This alternative definition of compound stimuli provides a means to account for the results of studies using match-to-sample procedures with compound stimuli (i.e., Markham & Dougher, 1993; Serna, 1991) and might, in some cases, also account for the emergent performance that defines stimulus equivalence.

Using multielement stimuli as samples and unitary stimuli as comparisons such that nine baseline AB-C relations were trained within the standard match-to-sample procedure (see Table 1), Markham and Dougher (1993) found that college students reliably matched elements of compound stimuli to novel compound samples. The design was balanced such that, within participants, neither element of the compound sample (A or B) could control participants' selection of correct comparison stimuli.

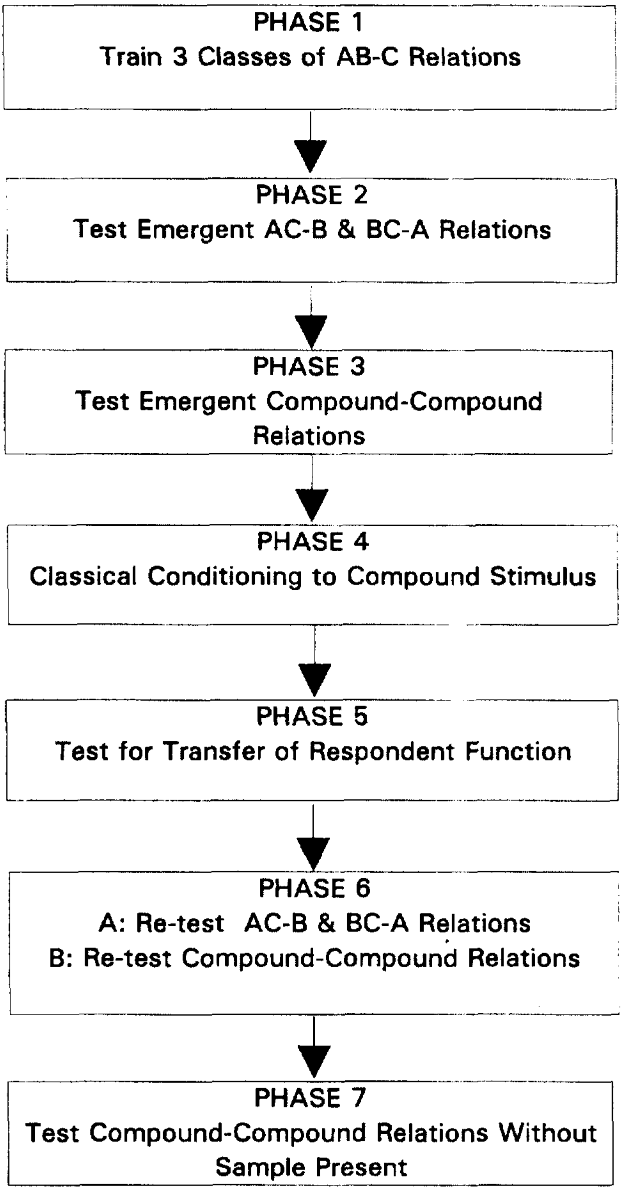

Figure 1. Schematic overview of procedural phases for the experiment.

For example (see Table 1), in the baseline relations, A1 is matched to C1 in the compound A1B1, C2 in the compound A1B3, and C3 in the compound A1B2. Thus, choice of any particular C stimulus cannot be controlled by A1, nor any other A stimulus, alone in the trained relations. The same is true for the tested relations. Similarly, the selection of any particular C stimulus cannot be controlled by any B stimulus alone. Thus, the training procedures established the matching of multiple compound samples to each comparison, and the tested relations demonstrated matching of three novel compound samples to each comparison stimulus.

Using this procedure, Markham and Dougher (1993) demonstrated the emergence of a variety of relations not predicted by the standard definition of stimulus equivalence (i.e., reflexivity, symmetry, and transitivity; see Sidman & Tailby, 1982). Among others, these relations involved the emergence of control by novel AC and BC compound stimuli. That is, after participants were taught to match unitary stimuli to

Table 1

Stimulus Relations Trained (left panel) and Tested (right panel) in Markham and Dougher (1993)

Trained Relations			Tested Relations					
A1B1	A1B2	A1B3	A1C1	B1C1	A1C3	B2C3	A1C2	B3C2
C1	C3	C2	B1	A1	B2	A1	B3	A1
A2B1	A2B2	A2B3	A2C3	B1C3	A2C2	B2C2	A2C1	B3C1
C3	C2	C1	B1	A2	B2	A2	B3	A2
A3B1	A3B2	A3B3	A3C2	B1C2	A3C1	B2C1	A3C3	B3C3
C2	C1	C3	B1	A3	B2	A3	B3	A3

compound samples (see Table 1 - left panel) they were able to match elements of the compound samples to novel compound samples (see Table 1 - right panel) at high levels of accuracy during unreinforced test trials. For example, in the trained baseline relations, A1B1, A2B3, and A3B2 controlled selection of C1. In the tested relations, the novel A1C1, A2C3, and A3C2 controlled selection of B1. All 11 participants run in this experiment demonstrated the emergence of these relations.

Markham and Dougher's 1993 study did not address the potentially interesting possibility that additional relations could also emerge from the conditional discrimination training depicted in the left panel of Table 1. In looking closely at the original design, it becomes apparent that, based on the baseline relations shown in Table 1 - left panel, a variety of ways to "group" the stimuli are possible. As noted above, in Markham and Dougher's 1993 study, participants demonstrated that classes could emerge based on the training to C stimuli (i.e., Class One = C1, A1B1, A2B3, A3B2) and that the C stimulus and the A and B stimuli within a given compound were substitutable for one another. It seems likely, therefore, that participants should also demonstrate the emergence of classes based on the relations between elements of a compound during unreinforced test trials. The specific novel classes of stimuli which emerge would seem to depend on the particular relation between the elements of the compounds presented as samples and those presented as

Table 2

Potential Classes of Compound Stimuli That Can Be Formed from the Basic AB-C Relations

		Classes Based on A Stimuli	
A1	B1C1	B2C3	B3C2
A2	B1C3	B2C2	B3C1
A3	B1C2	B2C1	B3C3
		Classes Based on B Stimuli	
B1	A1C1	A2C3	A3C2
B2	A1C3	A2C2	A3C1
B3	A1C2	A2C1	A3C3
		Classes Based on C Stimuli	
C1	A1B1	A2B3	A3B2
C2	A1B3	A2B2	A3B1
C3	A1B2	A2B1	A3B3

comparisons during the unreinforced tests. For example (see Table 2), B1C1, B2C3, and B3C2 might form a class based on the shared relation with the element of A1. Likewise, A1C1, A2C3, and A3C2 might form a class based on their common relation to B1. Again, as with the previous classes of compound stimuli, match-to-sample behavior cannot be controlled by any single element of the compound. Thus, after initial training in the baseline AB-C relations, participants, in the absence of any feedback, should be able to match AB compounds that controlled choices of the same C stimulus or match AC compounds that controlled choices of the same B stimuli, thereby, forming novel classes of compound stimuli.

This in itself would be an interesting finding with important implications regarding stimulus control involving compound stimuli. However, Fields, Adams, Verhave, and Newman (1993) and Spencer and Chase (1996) have suggested that transfer of function is an important measure of substitutability of stimuli (i.e., equivalence) which may provide more accurate information about the relationship between stimuli than performance on tests for emergent relations. In addition, a demonstration that transfer of respondent eliciting functions can occur following the emergence of novel compound-compound relations would further our general understanding of emotional responding in humans and add support to a stimulus equivalence based model of anxiety disorders (Augustson & Dougher, 1997; Dougher, Augustson, Markham, Greenway, & Wulfert, 1994; Roche & Barnes, 1997).

This paper describes an experiment designed to replicate Markham and Dougher's 1993 study, explore some of the additional relations that might emerge, and investigate the transfer of respondent eliciting functions that might result from match-to-sample training with compound stimuli. Six participants were trained in the 9 AB-C relations and then tested for the emergence of the 18 BC-A and AC-B relations shown in Table 1. Participants were then tested for the emergence of possible compound-compound relations shown in Table 2. Participants were also tested to see if a classically conditioned elicitation function trained to one compound stimulus would transfer to other compounds on the basis of their shared training history to a common unitary stimulus.

Method

Participants

Twelve undergraduates enrolled in introductory psychology at the University of New Mexico were recruited through in-class and bulletin board announcements. They received course credit and $20.00 for their participation. Because 4 of the participants (1 female, 3 male) discontinued their participation before the experiment was completed, the data for only 8 participants (3 female, 5 male) are reported. Participants were screened for normal vision and potential health risks including angina, asthma, cardiovascular problems, or a history of seizures. At the beginning of the experiment, the general procedures were explained and all participants read and signed a statement of informed consent in which it was emphasized that they could discontinue participation at any time during the experiment. Upon completion of the study, all participants were thoroughly debriefed. All procedures were approved by the Human Research Review Committee of the University of New Mexico.

Apparatus and Stimuli

Participants were seated before the computer in a small experiment room with a two-way mirror for participant observation. An IBM Personal Computer with a 19-cm monochrome (green on black) display was used to present stimuli and record data during the experiment. The stimuli were nine abstract forms designated randomly for each participant as A1, B1, C1, A2, B2, C2, A3, B3, and C3. The alpha-numeric designations are for purposes of description only and were never shown to the participants. Compound stimuli were pairs of stimuli (e.g., A1 and C2) presented side by side on the screen. Each compound stimulus occupied approximately 4 cm by 5 cm on the display. The elements comprising compound stimuli were randomly assigned to the left and right positions for each trial, thereby controlling for element position.

Skin conductance response (SCR) measures were recorded on a multichannel polygraph (Dynograph #R511) using a Beckman 9844 skin conductance coupler. SensorMedics skin conductance electrodes were prepared with a Unibase (Parke Davis) and 0.5% NaCl paste (Lykken & Venables, 1971). Shock was delivered by a Lafayette (Model #82404) variable amperage shock generator. The shock electrodes consisted of two .25-in. nickel-plated electrodes fastened .25 in. apart to a 1.5-in. wide by 2-in. long piece of Plexiglas. The Plexiglas was strapped to the participants right forearm with a Velcro strip.

Procedure

Overview. The experiment consisted of seven phases (see Figure 1). Phase 1 involved training of compound sample to single element relations (AB-C) using arbitrary match-to-sample procedures. In Phase 2, participants were tested for the emergence of AC-B and BC-A relations. Phase 3 tested for the emergence of compound-compound relations. The specific compound-compound relations tested varied across participants. Participants 1 and 2 received trials that tested for the emergence of AB-AB compounds. Participants 3 and 4 received trials that tested for the emergence of AC-AC compounds. Participants 5 and 6 received trials that tested for the emergence of BC-BC compounds and participated in procedures intended to determine if conditioning was restricted to the compounds or extended to the specific elements of the compounds. Participants 7 and 8 received the same test trials as Participants 5 and 6, but received no match-to-sample training. This was done in an attempt to determine whether the match-to-sample training was indeed necessary to obtain transfer of function. In Phase 4, participants underwent classical conditioning with a BC compound stimulus serving as the CS and shock as the US. Phase 5 entailed tests for transfer of the respondent eliciting function to selected compounds. The specific compounds tested varied across participants and depended on the stimuli presented to each participant in Phase 3. Phase 6 entailed a retest of the emergent relations presented in Phase 2 (Phase 6A) and 3 (Phase 6B) to determine whether participants continued to demonstrate adequate accuracy on such tests. Finally, Phase 7 consisted of trials designed to test whether selections of the emergent relations in Phase 3 and 6B were controlled by the compound comparisons rather than the sample stimuli.

Specific Procedure

Shock level selection. Shocks were 200 ms in duration and between 1.0 and 2.0 mA in strength. Each participant set his/her own shock level. Participants were instructed to choose a level of shock that was uncomfortable, but not painful. They were given a sample shock of 2.0 mA. If this was too strong, the level was decreased by .25 mA and another sample was given. Shock level was then increased or decreased in response to participants' reactions until an uncomfortable but not painful level was found or until the minimum level of 1.0 mA was reached.

Stimulus relations training and testing. All stimulus relations training and testing phases used arbitrary match-to-sample procedures. During training and testing of the AB-C relations, the compound sample (AB) appeared at the top center of the screen, followed 2 s later by the three unitary comparisons (C1, C2, C3) at the bottom right, bottom left, and bottom center of the screen. For each trial, the comparisons were randomly assigned to the left, middle, or right position at the bottom of the screen. Participants selected one of the comparisons by pressing the "1," "2," or "3" key on the computer keyboard to select the left, middle, or right comparison, respectively. After a key was pressed, the screen cleared and, during the training phase, selection of the correct comparison produced the word "Correct" on the monitor, while other choices produced the word "Wrong." The screen cleared again and after a 2-s intertrial interval, a new trial began. During testing, no feedback appeared, and the comparison array consisted of three compound stimuli with a unitary or compound sample.

Phases 1 and 2. The first three phases of the experiment involved training and testing of the stimulus relations. In Phase 1, the nine AB-C relations shown in left panel of Table 1 were trained until participants reached a training criterion of 70 correct out of 72 consecutive trials (eight nine-trial blocks). These baseline relations were presented in blocks of nine trial types, each consisting of one compound sample and the comparison array of C1, C2, and C3. Once the baseline relations had been established, Phase 2 began without interruption. During Phase 2, participants were tested for the emergence of 18 AC-B and BC-A relations. Three blocks of 18 trials were presented. Following this, Phase 3 began without interruption.

Phase 3. Phase 3 constituted the test for the emergence of 18 compound-compound relations. The specific 18 compound-compound relations tested varied across participants (see Table 2). Participants 1 and 2 were tested for the emergence of AB-AB relations, CA-CA relations were tested for Participants 3 and 4, and BC-BC relations were tested for by Participants 5 and 6. Participants 7 and 8 served as controls. They also underwent tests of the BC-BC relations, but did not receive the initial stimulus equivalence training and testing of Phases 1 and 2. This allowed for the assessment of the necessity of prior stimulus equivalence training and testing on the emergence of the compound-compound relations. Ten blocks of 18 trials each were presented for each participant. Within each block of 18 trials, trial types were presented in a random order.

Classical conditioning - Phase 4. At the start of this phase, the SC sensors and shock electrodes were attached with a self-adhesive collar to the thenar and hypothenar eminences of the palm of the participants' left hands. Participants were asked to sit quietly for a 10-min baseline period to acclimate to the testing environment.

For classical conditioning, B2C3 served as the CS+ and B1C2 and B3C1 served as the CS-. BC compounds were chosen for use during conditioning because they were not used in the initial stimulus equivalence training. These specific stimuli were selected because each belongs to a separate class (see Table 1) and none of the specific compounds share any common elements. The left or right position assignment of the specific elements within the compound varied across trials. Stimulus duration varied randomly between 5 and 10 s to minimize temporal conditioning. A delayed conditioning procedure was used where the CS+ terminated with the onset of shock. The intertrial interval varied from 20 to 40 s to minimize temporal conditioning effects. There were eight presentations of the CS+ and six presentations of each CS-. Two of the eight CS+ presentations served as probe trials to assess conditioning in which the CS+ was presented without the shock (Augustson, Markham, & Dougher, 1994). This was a relatively small number of conditioning trials, but given the low shock intensity levels, we were concerned that habituation would occur with a larger number of trials. Previous research (Augustson & Dougher, 1997; Augustson et al., 1994; Dougher et al., 1994) indicated that this was a sufficient number of trials to produce differential conditioning in most participants.

Test for transfer - Phase 5. Following the conditioning trials in Phase 4, the test for transfer occurred without interruption. Table 3 lists the specific stimuli presented on the test for transfer trials. Stimuli presented were determined by the type of test trials participants received during Phase 3. That is, participants were presented with compound stimuli from the classes which were predicted to have emerged during Phase 3 (see Table 2). For example, Participant 1 was presented with the compounds A2B1 and A3B3 as potential S+ stimuli to which transfer of the respondent function might be demonstrated. These specific compounds were potentially related to B2C3, the CS+, by virtue of their membership in the emergent AB-AB class via C3 (see Table 2). The S- stimuli, to which

Table 3

Stimuli Presented for Each Participant During Phase 5

P#	CS+	S+	CS-	S-
1 & 2	B2C3	A2B1, A3B3	B1C2, B3C1	A2B3, A3B1
3 & 4	B2C3	A2C2, A3C1	B1C2, B3C1	A3C2, A2C1
5 & 6	B2C3	B1C1, B3C2	B1C2, B3C1	B3C3, B1C3, B2C2, B2C1
7 & 8	B2C3	B1C1, B3C2	B1C2, B3C1	B3C3, B1C3, B2C2, B2C1

no transfer of the respondent function was predicted, were selected because they shared the same individual elements as the S+ stimuli, but as compound stimuli were not members of the same class. In the case of Participant 1, the S- stimuli were A2B3 and A3B1. Thus each participant was exposed to two S+ stimuli related to the CS+ by a relationship demonstrated in Phase 3 and two S- stimuli consisting of the different combinations of the S+ elements. Participants 5-8 also received two additional trials of S- stimuli as two additional combinations of stimuli could be formed from these elements.

The stimuli were presented exactly as in the classical conditioning phase of the experiment, except that shock did not follow any of the stimuli. The sequence of the transfer test trials was presented twice in succession for each participant in an attempt to account for possible SCR elicited by the novelty of the stimuli and data recorded during the second trial block served as the measure of transfer of the respondent function (Augustson et al., 1994).

Retest of equivalence classes - Phase 6. The next phase of this experiment was broken into two subphases, 6A and 6B, and consisted of the retesting of previously presented trials in order to assess whether the classes had remained intact throughout the experiment. Phase 6A consisted of the retesting of the trials presented in Phase 2 involving the AC-B/BC-A relations. Phase 6B consisted of retesting trials presented in Phase 3 involving the compound-compound relations. Both of these subphases consisted of five blocks of 18 trials presented consecutively in extinction.

Tests for control by the comparisons - Phase 7. In order to use a three-comparison procedure (Sidman, 1987) in the Phase 3 tests for compound-compound relations, it was necessary that the compounds used as comparisons had at least one element in common. This was because only six stimulus elements were available and eight elements were necessary in order to have compounds with no shared elements. As a result, it was possible for participants to select the correct comparison based only on the composition of the comparison arrays and with no regard for the sample stimulus. For example, in testing for the emergent AB-AB relations, Participants 1 and 2 received a trial in which the sample stimulus was A2B3 and the comparison array was A3B2, A3B1, A1B2. The correct comparison (A3B2) shares each of its elements with an incorrect comparison. Thus, the correct comparison is unique because it is the only compound in the comparison array that shares stimulus elements with the other two comparisons. Therefore, the selection of this comparison might be controlled by this unique feature rather than its relation to the sample. In order to determine whether participants would, in fact, reliably select the "correct" comparison on this basis, Phase 7 consisted of the presentation of 18 trial types consisting of only the comparison arrays. Using the above example, Participants 1 and 2 received a trial in which only the comparison array A3B2, A3B1, A1B2 was presented in the absence of any sample stimulus. If participants failed to reliably select the "correct" comparisons during this phase, it could be argued that responding in subsequent match-to-sample arrangements was, in fact, controlled by the sample stimuli. Five blocks of 18 trials each were presented (90 trials total). The order of trial types was randomized within each block of 18 trials. Phase 7 ended after the presentation of all 90 trials.

Results

Participants 1, 2, 4, and 6 completed the experiment in one session lasting between 4 and 6 hours. Because Participants 3 and 5 had scheduling conflicts, they required three sessions and two sessions, respectively. These were scheduled on consecutive days. Participant 3 completed the experiment in approximately 8 hours, and Participant 5 completed the experiment in approximately 6 hours. The controls, Participants 7 and 8, completed the experiment in approximately 2 hours.

Shock level selection. Shock levels selected by participants ranged from 1.0 to 1.75 mA. Participants 2 and 6 selected 1.75 mA. Participants 1, 5, and 7 selected 1.5 mA. Participants 3, 4, and 8 selected 1.0 mA.

Phases 1, 2, and 3 - Stimulus equivalence training and testing. Data for Participants 1-6 in Phases 1, 2, and 3 are presented in Figures 2 and 3. The results are graphed as percent correct over blocks of 18 trials. As can be seen, all participants acquired the baseline relations and met criteria in Phases 2 and 3. Participants generally demonstrated high accurate and reliable performances in testing except for Participants 3 and 5 where some variability was seen.

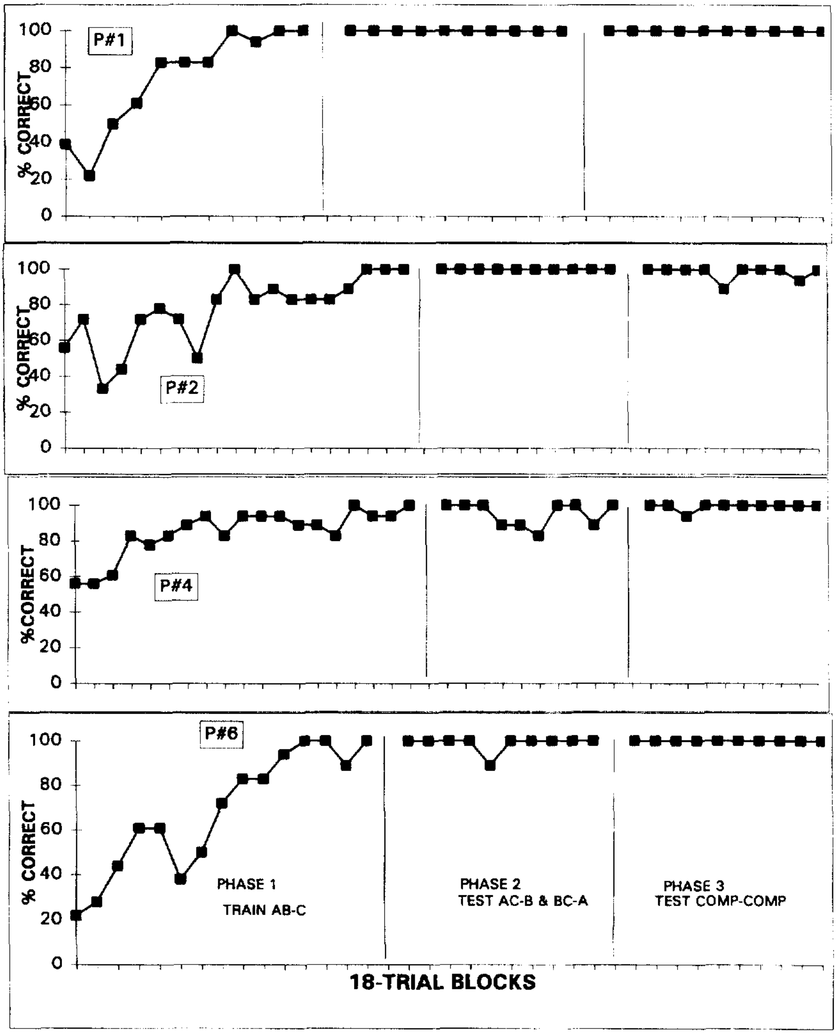

Figure 2. Data for Participants 1, 2, 4, and 6 for Phases 1, 2, and 3 in percent correct for 18-trial blocks.

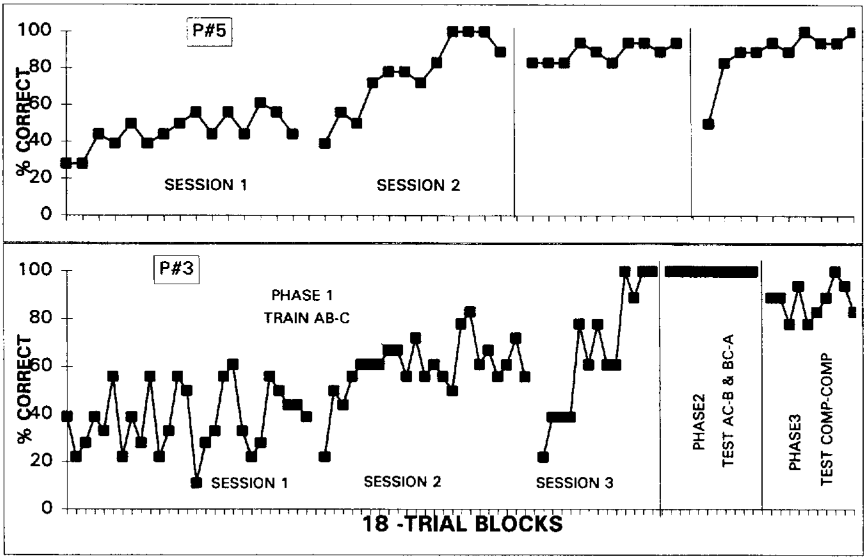

Figure 3. Data for Participants 3 and 5 for Phases 1, 2, and 3 in percent correct for 18-trial blocks.

Phase 4 and 5 - Classical conditioning and test for transfer. An important methodological issue concerning this study is how best to measure respondent conditioning. On the basis of previous research (Dougher et al., 1994), change in skin conductance response (SCR), measured in Microsiemens (mS), was chosen as the measure of conditioning. Conditioning was assessed at stimulus offset during the probe trials in Phase 4 and during the test for transfer trials in Phase 5. Changes in skin conductance were scored as a SCR only if they began within 4 s of the CS termination, reached peak within 5 s of onset of the response, and had a magnitude of at least .2 mS (Levis & Smith, 1987). The criterion for transfer of the respondent function was that participant's peak SCR to the CS+ and both S+ stimuli had to be greater than the peak SCR to any of the CS- and S- stimuli. This was considered a conservative measure of transfer inasmuch as the probability of this pattern occurring by chance for any subject is 1/120.

Data from Phases 4 and 5 are shown in Figures 4 and 5. These figures show clear SCR evidence of conditioning for all six experimental participants: peak SCR was greater to B2C3 than to either B1C2 or B3C1 for all participants.

Evidence for transfer of the eliciting functions during the tests for transfer in Phase 5 was seen for four of the six experimental participants. Participants 1, 2, 4, and 6 consistently demonstrated higher peak SCR for all of the stimuli that were members of the class containing the CS+ than to any member of the class which was not classically conditioned. In addition, the transferred conditioned responses were of approximately the same level as the conditioned response to the CS+.

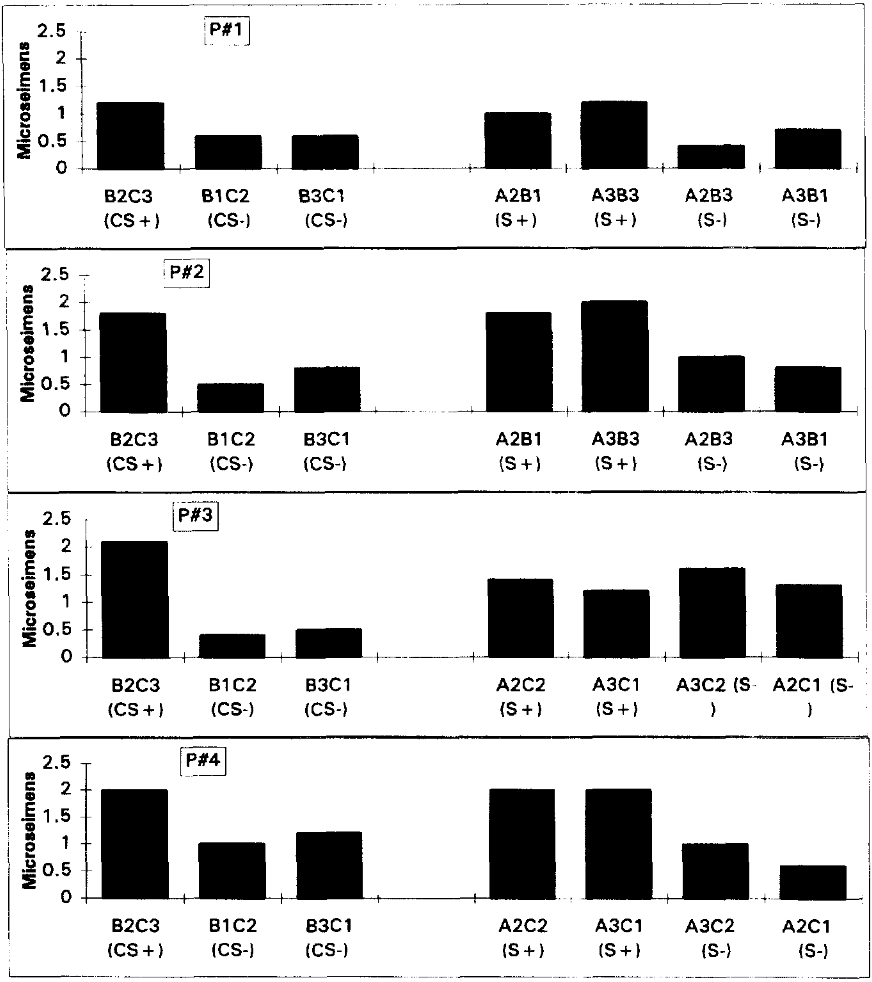

Figure 4. Conditioning (Phase 4) and test for transfer (Phase 5) data in SCR for Participants 1, 2, 3, and 4.

Phase 6 and 7 - Retesting of equivalence classes and tests for control by single elements. Data for all experimental participants are shown in Figure 6. Responses in Phases 6A (Retesting of Phase 2 trials) and 6B (Retesting of Phase 3 trials) indicate that Participants 1, 2, 4, and 6 maintained the emergent AC-B, BC-A, and compound-compound relations. With regards to Phase 7, which assessed the possibility of control by the elements of the comparison stimuli by presenting three compounds to chose from but no sample stimulus, selection of the "correct" comparison occurred at or below chance level for all six participants. This supports the assertion that performance in Phase 3 was under the joint control of sample and comparison stimuli.

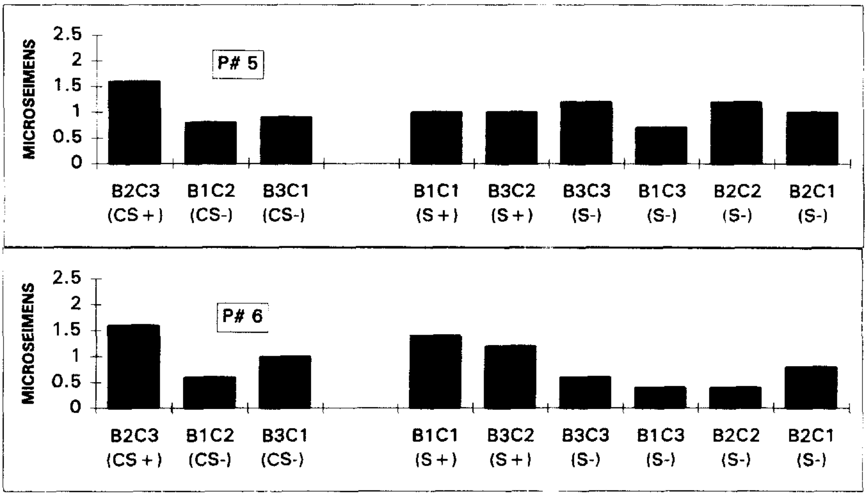

Figure 5. Conditioning (Phase 4) and test for transfer (Phase 5) data in SCR for Participants 5 and 6.

Data from Participant 3 in Phase 6 suggest that she may have failed to maintain the classes established during Phases 1-3 (see Figure 6). This participant also demonstrated more difficulty in meeting criteria during the initial training (see Figure 3). This suggests an explanation for her failure to demonstrate the transfer of the eliciting function. Indeed when asked to describe what she thought would happen during Phase 5, the test for transfer, she stated that she thought shock would occur with other stimuli that "went with" the CS+, but that she had become confused about which stimuli went together. Participant 3 decided to discontinue her participation in the experiment before a complete set of retraining data could be collected. It is therefore unknown what effect retraining and testing would have had on her performance.

Participant 5's data during Phase 6 is also suggestive of potential problems in maintaining the classes (see Figure 6). Although his response accuracy is higher than that demonstrated by Participant 3, his percentage correct is lower than optimal, and again indicates a possible reason for his failure to demonstrate transfer. To explore this possibility, Participant 5 was asked to repeat the experiment and agreed to do so. Data for Phases 1R, 2R, and 3R are shown in Figure 7. An examination of this data shows that he quickly relearned the initial training and responded with high levels of accuracy in the tests for emergent relations. Data from the repetition of the conditioning trials and test for transfer are also shown in Figure 7. Participant 5 met the criteria for transfer of function during these phases indicating that his earlier failure may have been caused by a failure to maintain the classes. Data from Phases 6AR and 6BR reveal an improvement in performance during the tests for the AC-B, BC-A, and compound-compound relations.

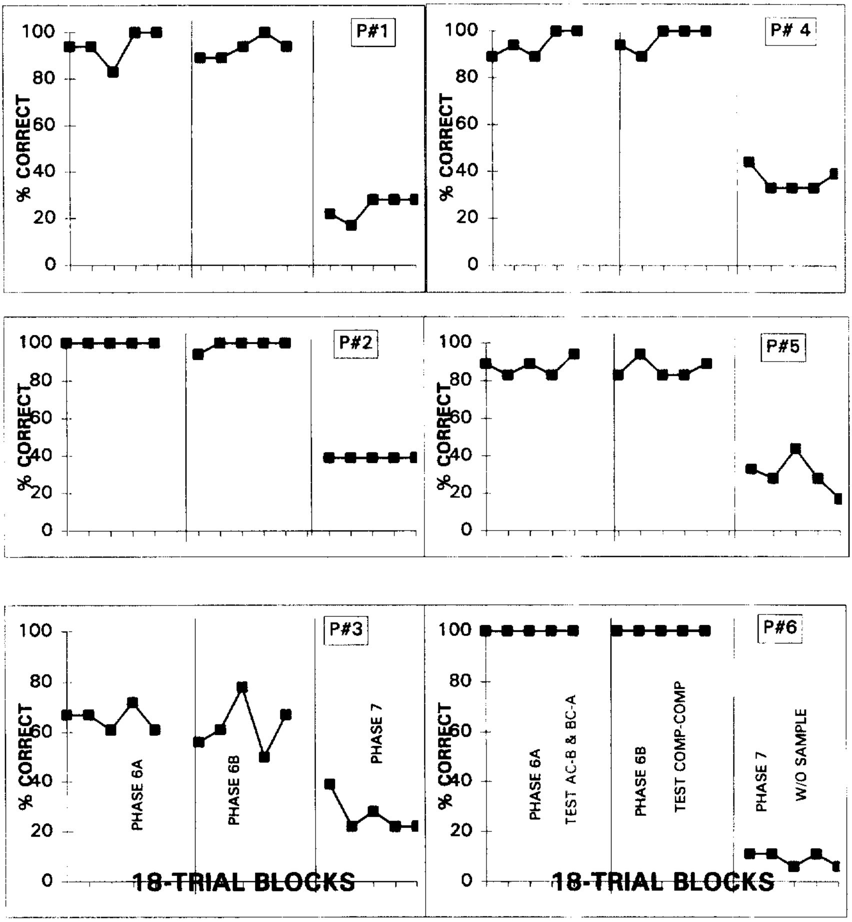

Figure 6. Data for Participants 1-6 for Phases 6A, 6B, and 7 in percent correct for 18-trial blocks.

Control participants. Participants 7 and 8 served as controls for the possibility that transfer of function could have occurred in the absence of stimulus equivalence training. These two participants received the tests for the emergence of compound-compound relations (Phase 3) and the conditioning and test for transfer trials (Phases 4 and 5). Data for Phase 3 are presented in Figure 8. Neither participant responded consistently to the "correct" compound. Data from Phases 4 and 5 are also shown in Figure 8. Both of these participants showed evidence for classical conditioning in that SCR to B2C3 were greater than that to either B1C2 or B3C1. However, neither of these participants meet the criteria for transfer of the conditioned function. Interestingly, the S- that elicited the largest SCR for both Participants 7 and 8 contained elements of the CS+ (C3 or B2).

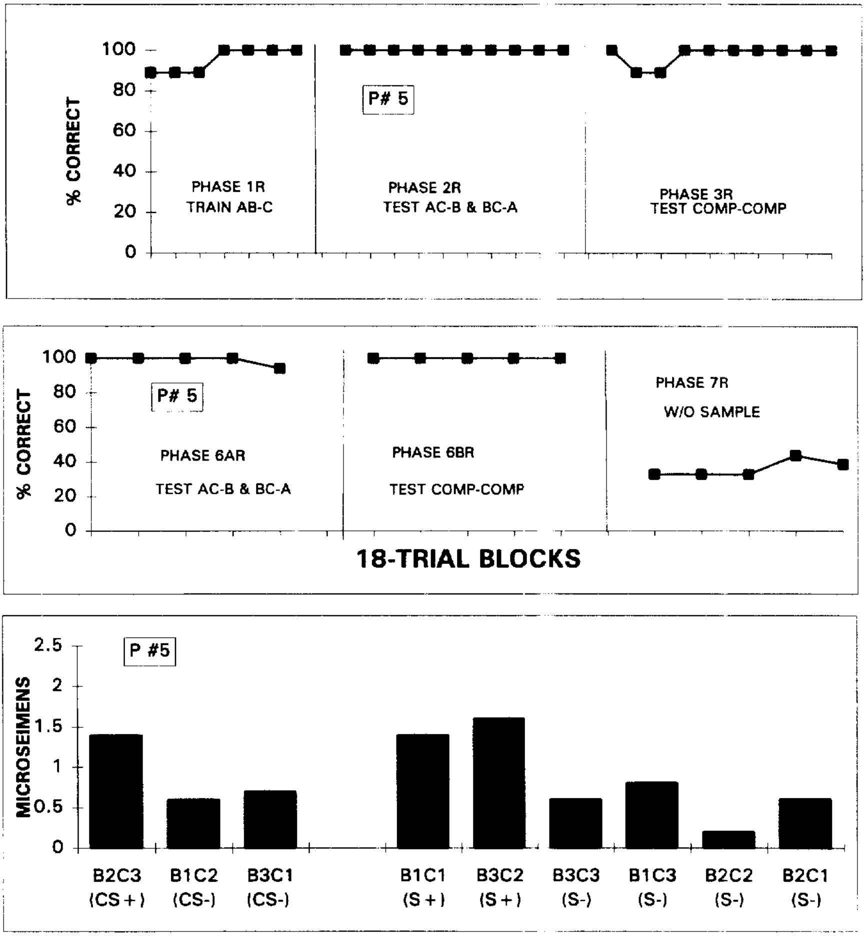

Figure 7. Retraining and testing data for Participant 5.

Discussion

The present experiment examined the transfer of classically conditioned respondent functions via emergent relations in complex stimulus equivalence classes consisting of compound stimuli. In this experiment, six participants were taught nine AB-C relations using a conditional discrimination procedure. Participants were then tested for the emergence of AC-B, BC-A, and certain compound-compound relations. Following this, participants then received training in a classical conditioning paradigm involving a selected compound stimulus as the CS+. Two additional compound stimuli served as CS-. Additional compound stimuli were then presented to assess the transfer of the

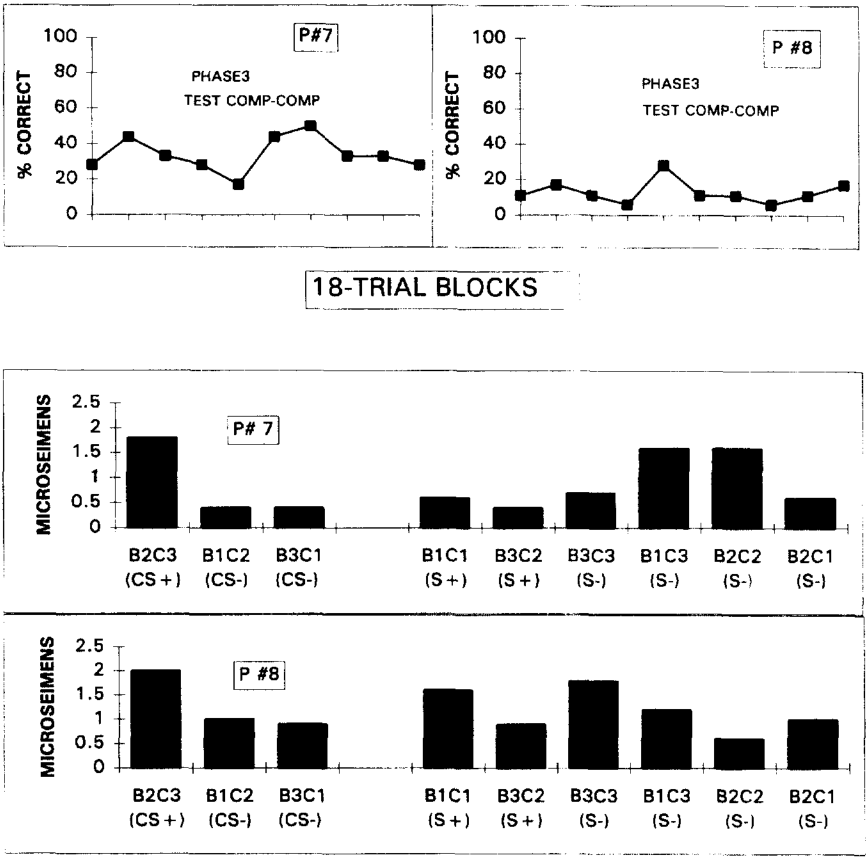

Figure 8. Data for Participants 7 and 8 (control participants) for Phase 3, 4, and 5.

conditioned respondent function to other stimulus class members.

All six experimental participants were able to learn the initial AB-C relations and demonstrated evidence of the emergence of the AC-B, BC-A, and compound-compound relations. All six participants demonstrated evidence of classical conditioning, and four of the six met the criteria for transfer of the conditioned function to other members of the appropriate stimulus class. Analysis of the remaining two participants' performance during tests which assessed the maintenance of the emergent functions indicated possible problems in their performance on the tested relations. One participant, #3, chose to discontinue participation in the experiment and further experimental analysis regarding her performance was not possible. Participant 5 repeated the initial testing and training phases of the experiment and subsequently demonstrated the transfer of the conditioned SCR elicitation function to the appropriate class members.

Two additional participants, #7 and #8, served as controls to assess the necessity of the stimulus equivalence training for the transfer of the respondent elicitation function. These participants were tested for the emergence of compound-compound relations, but received no prior training in the relations necessary to form stimulus equivalence classes. Neither participant responded in a manner suggesting systematic stimulus control or control by the comparison elements. Both participants demonstrated evidence of conditioning, but neither participant showed evidence of transfer of the conditioned function to other compound stimuli in a manner consistent with transfer via equivalence classes.

The data from this study support the contention that humans can be classically conditioned to compound stimuli in which the same elements in different combinations can come to serve either CS+ or CS- functions. Although true for all participants, this was particularly evident for Participants 5 and 6 who were tested with a greater number of compounds than other subjects. The performance of these two participants clearly demonstrated conditioning to the compound stimulus B2C3, but not to other compound stimuli containing those same elements; B2C2, B2C1, B3C3, or B1C3. This suggests that it was the specific combination of stimuli that controlled the conditioned response, rather than the individual elements of the compound.

It appears that the prior conditional discrimination training was a necessary condition for the compounds, rather than elements, acquiring control of the eliciting function. Control participants received classical conditioning training to the compounds in the absence of stimulus equivalence training. When these participants were then exposed to compound stimuli consisting of the CS+ and CS- elements in different combinations, they demonstrated a pattern of responding which indicated conditioned elicitation to the elements of the original CS+ compound. This data suggests that it was the match-to-sample training that rendered the compounds, rather than the elements, effective as conditioned stimuli.

Although the conditioning data is of interest, of greater importance is the transfer of function data in which participants were presented with compound stimuli that had never been directly paired with an aversive stimulus, but which were related to the CS+ via derived relations. These results are important for several reasons. First, they serve as a replication of earlier work demonstrating that conditioned emotional responses can transfer via stimulus equivalence classes (Augustson & Dougher, 1997; Dougher et al., 1994; Roche & Barnes, 1997). Second, the transfer of respondent functions via compound-compound relations represents a significant increase in the difficulty and complexity of experimental procedures which have produced transfer of function effects. It should be acknowledged that the formation of stimulus equivalence classes involving emergent compound-compound relations is a difficult task. That functions can transfer under these conditions is impressive and lends validity to the idea that such laboratory analogs may be useful in understanding the complex contexts of the natural environment where behavior is often controlled by multiple stimuli in varying combinations (Stromer, McIlvane, & Serna, 1993). In addition, the observation that transfer of function continues to occur within such complicated classes indicates to some extent that transfer of function may be a primary process in stimulus equivalence (Barnes, 1994; Barnes & Roche, 1996; Dougher & Markham, 1994, 1996; Hayes, 1991, 1994; Hayes & Barnes, 1997).

One aspect of the present data which is worth highlighting is that the transfer of function clearly occurred to the specific combinations of stimuli, not to single elements. As with the classical conditioning, no single element could control the elicitation of the respondent function during the test for transfer in that the same elements combined with other elements formed the various compound stimuli which served different functions. For example, in the case of Participant 1, A2B1 and A3B3 served as the S+ stimuli in the test for transfer. The S- stimuli for Participant 1 during the test for transfer contained these same elements in different combinations: A2B3 and A3B1. Five of the six participants demonstrated different SCR for the S+ and S- stimuli indicating that it was the specific combination of stimuli in the presence of each other that controlled the respondent function, not any specific stimulus by itself.

By suggesting additional processes by which stimuli can come to elicit respondents despite the absence of direct classical conditioning, these results extend previous findings (Augustson & Dougher, 1997; Dougher et al., 1994; Roche & Barnes, 1997) exploring the possible clinical implications of stimulus equivalence in the acquisition and generalization of respondent functions. Specifically, these findings point to a process by which combinations of stimuli, that do not produce anxiety when presented alone or in combination with other stimuli, can come to evoke fear and by which similarities in conditioning histories can lead to different stimuli acquiring respondent eliciting functions. In doing so, the results of this study add to a growing body of literature which addresses criticisms of conditioning models of emotional responding, such as anxiety disorders.

Although classical conditioning is seen as an integral part of many models of emotional responding and conditioning processes are considered a crucial aspect of a variety of treatments for anxiety, a number of salient criticisms have been raised regarding the adequacy of such models and a number of alternative models have been proposed (Bond & Siddle, 1996; Clark, 1988; Menzies & Clark, 1995; Ohman, Dimberg, & Ost, 1985; Rapee, 1996). Among the most significant problems for conditioning models are the apparent absence of conditioning histories for many individuals who experience anxiety and the results of research which has demonstrated that humans can learn fear without direct conditioning (see discussions by Barlow, 1988; Eifert, 1987; 1990; Forsyth & Eifert, 1996). The results of this experiment, especially when coupled with previous research in this area (Augustson & Dougher, 1997; Dougher et al., 1994; Roche & Barnes, 1997; see also

Staats & Staats, 1957, 1958; Staats, Staats, & Crawford, 1962; Staats, Staats, & Heard, 1959), suggest a process by which stimuli can acquire and lose their ability to elicit emotional responding in the absence of direct conditioning. Thus, as members of an equivalence class with other fear-inducing stimuli, stimuli which have never been associated with aversive experiences can come to evoke avoidance behavior and elicit emotional responses. An individual could thereby demonstrate avoidance and anxiety in the presence of stimuli which had never been paired with aversive consequences. Consequently, the results from studies in this area may have implications for our understanding of the development of emotionally based clinical disorders and certain clinical interventions and may suggest an important process which is part of a more complete model of human emotional responding which includes verbal-symbolic processing (Hayes & Hayes, 1992; Hayes & Wilson, 1993; Staats, 1990, 1995; see Forsyth & Eifert, 1998, for discussion).

It should be noted that the stimuli used in this experiment were not clinically relevant and the levels of arousal were lower than one finds in clinical populations. No study in this area has yet to directly apply these procedures to a clinical population or to assess if such processes exist within such a population. Also, it was not possible to test all combinations of elements because of practical and methodological constraints in the conditioning procedure and so conclusions about additional possible patterns of transfer of function are tentative.

The results of the match-to-sample training and testing are themselves of significant importance in that they extend previous findings concerning the complex stimulus relations that can emerge from conditional discrimination training involving compound stimuli (e.g., Dougher & Markham, 1994, 1996; Markham & Dougher, 1993; Serna 1991; Smeets et al., 1994, 1995; Stromer, McIlvane, Dube, & MacKay, 1993; Stromer, McIlvane, & Serna, 1993; Stromer & Stromer, 1990a, 1990b) and demonstrate the emergence of complex stimulus relations following conditional discrimination procedures involving compound stimuli. There are several alternative interpretations which might be used to account for these results. One possible interpretation is that the emergent stimulus relations from this and previous experiments (i.e., Markham & Dougher, 1993; Stromer, McIlvane, & Serna, 1993) might be described as contextually controlled conditional stimulus relations. For example, it is possible that in the nine trained AB-C relations, one element of the compound sample served as a contextual stimulus for the conditional function of the other element (e.g., Bush, Sidman, & DeRose, 1989; Lynch & Green, 1991). However, this account is problematic because it is not possible in these experiments to determine functionally which element of the compound serves a contextual function and which stimulus served a conditional function. If we ignore the relation between the elements and simply assume that the compounds functioned as conditional stimuli for the selection of the unitary and compound comparisons, we are left to explain the demonstrated interchangeability of the elements of the compounds. It is, after all, precisely this interchangeability of elements that results in the emergence of stimulus control by novel BC and AC compounds.

In the present study all stimuli served multiple stimulus functions depending on stimulus combinations and no single element controlled any particular stimulus function. It was only in combination with other stimuli that the function of a stimulus could be determined. That is, participants' choices were controlled by specific configurations (compounds) of stimuli which allows for highly flexible topographies of stimulus control in that each element of the compound was both a unique and yet replaceable part of the compound. Therefore, the current data are more appropriately seen as lending further support to ideas put forth by Stromer and others (see Dougher & Markham, 1994, 1996; Stromer, McIlvane, & Serna, 1993) suggesting that, at least in some contexts, stimulus equivalence performance may be the result of stimulus control by multielement stimulus compounds in which the elements are separable and substitutable. Combinations of stimulus elements come to acquire specific control over participants' behavior based on previous training which establishes particular stimulus relations (Markham & Dougher, 1993). For example, in the case of the present experiment, the *nature of the emergent compound-compound relations is based on the* initial AB-C training. Subsequent patterns of responding are predictable based on these training histories.

This alternative account, first presented by Stromer, McIlvane, and Serna (1993), suggests that participants' selections are under the discriminative control of multielement stimulus compounds with separable and substitutable elements (see Dougher & Markham, 1994, and Stromer, McIlvane, & Serna, 1993, for a more detailed description of this account). These multielement (compound) discriminative stimuli can result from match-to-sample procedures and other procedures where more than one stimulus must be present to evoke an appropriate response. One question raised by this account is how the appropriate combination of stimulus elements gains control on any particular trial, especially in the present study where every stimulus element was in some manner related to every other stimulus element. The task presented to participants in the test trials of the present experiments could be interpreted as requiring participants to select the comparison that completes a particular combination of stimuli. The appropriate combination is determined by previous training which specifically establishes particular stimulus relations. Thus, if A1B1-C1 and A2B1-C3 are trained, and then A1C1 is presented as a sample with the comparison array B1, B2, and B3, the selection of B1 completes the originally trained multielement compound stimulus A1B1C1. Similarly, if A2C3 is presented as a sample with the comparison array B1, B2, and B3, selection of B1 is controlled by the trained multielement compound stimulus A2B1C3. In the case where the test trial consists of the sample A1C1 and the comparison array, A2C3, A2C2, and A3C3, the substitution of A2C3 for B1 might lead participants to choose A2C3, thus completing the multielement compound A1B1C1. What appears to be necessary for appropriate responding on test trials, then, is the presence of a critical number of related stimuli.

Taking this account further, a critical distinction between various topographies of stimulus control (e.g., simple discriminations vs. conditional discriminations) might be the number of stimulus elements necessary to gain systematic stimulus control of behavior, without regard to whether stimulus control is hierarchical. In the case of simple discriminations, only one stimulus element is necessary to control behavior. Conditional discriminations require two stimulus elements to control responding, and higher order discriminations require three or more. For example, in Phase 1, three elements were necessary to control the appropriate selection. In order to select the proper C comparison in the presence of a particular AB sample, the two elements of the sample and the appropriate comparison element had to be considered together. In Phase 3, four elements were necessary to determine the appropriate selection: both elements of the sample and both elements of the comparisons. Thus, although the training procedures established control by arrangements of three stimuli, results of tests indicated the emergence of control by arrangements of four stimuli.

Despite the importance of the present data, there remain numerous unanswered questions regarding stimulus equivalence in general and its involvement in the acquisition and generalization of conditioned emotional responses. Fundamental questions concerning the nature of stimulus control exerted by compound stimuli (Lowenkron, 1998; Markham & Dougher, 1993; Serna, 1991; Stromer, McIlvane, Dube, & MacKay, 1993; Stromer, McIlvane, & Serna, 1993), the relation between emergent stimulus relations and transfer of function (Barnes, Smeets, & Leader, 1996; Dougher & Markham, 1994, 1996; Dube, McDonald, & McIlvane, 1992; Dymond & Barnes, 1995; Hayes & Barnes, 1997; Hayes, Gifford, & Wilson, 1996; Sidman, 1994; Sidman, Wynne, Maguire, & Barnes, 1989), and whether emergent relations with compound stimuli and stimulus equivalence are necessarily the result of the same behavioral process (Dougher & Markham, 1994, 1996; Markham & Dougher, 1993; Saunders & Green, 1992; Serna, 1991; Sidman, 1994; Smeets & Streifel, 1994; Stromer & Stromer, 1990a, 1990b) have become a focus of recent research, but have yet to be resolved.

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