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THE TRANSFER OF RESPONDENT ELICITING AND EXTINCTION FUNCTIONS THROUGH STIMULUS EQUIVALENCE CLASSES

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Two studies investigated the transfer of respondent elicitation through equivalence classes. In Experiment 1, match-to-sample procedures were used to teach 8 subjects two four-member equivalence classes. One member of one class was then paired with electric shock, and one member of the other class was presented without shock. All remaining stimuli were then presented. Using skin conductance as the measure of conditioning, transfer of conditioning was demonstrated in 6 of the 8 subjects. In Experiment 2, similar procedures were used to replicate the results of Experiment 1 and investigate the transfer of extinction. Following equivalence training and conditioning to all members of one class, one member was then presented in extinction. When the remaining stimuli from this class were then presented, they failed to elicit skin conductance. In the final phase of the experiment, the stimulus that was previously presented in extinction was reconditioned. Test trials with other members of the class revealed that they regained elicitation function. These results demonstrate that both respondent elicitation and extinction can transfer through stimulus classes. The clinical and applied significance of the results is discussed.

Key words: stimulus equivalence, transfer of function, classical conditioning, extinction, skin conductance, fear, humans

Stimulus equivalence has attracted a good deal of interest recently among behavior-analytic researchers. Much of the interest stems from the contention that stimulus equivalence may provide the basis for a behavior-analytic account of symbolic behavior, language, and apparently novel behavior (e.g., Hayes, 1991; Hayes & Hayes, 1989; Sidman, 1986; Sidman & Tailby, 1982; Spradlin & Saunders, 1984). One particularly interesting aspect of stimulus equivalence is the transfer of function through stimulus equivalence classes. In short, transfer of function refers to the acquisition of stimulus function by virtue of membership in an equivalence class (Dougher & Markham, 1994; Hayes, 1991; Hayes & Hayes, 1989; Sidman & Tailby, 1982).

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There is a growing body of empirical support for the transfer of stimulus function through equivalence classes. For example, the transfer of discriminative functions has been reported by Green, Sigurdardottir, and Saunders (1991), Lazar (1977), Lazar and Kotlarchyk (1986), and Wulfert and Hayes (1988). Gatch and Osborne (1989), Kohlenberg, Hayes, and Hayes (1991), and Lynch and Green (1991) have demonstrated the transfer of contextual control, and Hayes, Kohlenberg, and Hayes (1991) have shown conditioned reinforcement and punishment functions to transfer through equivalence classes.

One stimulus function that has not yet been shown to transfer through equivalence classes, but that has important theoretical and applied implications, is respondent elicitation. If the transfer of eliciting functions can be demonstrated, it not only would increase the range of stimulus functions that have been shown to transfer across equivalence classes, but it would also increase substantially our understanding of human emotional responding and the development of fear or anxiety disorders. When we refer to fear or anxiety disorders, we are speaking of the effects of certain stimuli that have come to elicit a set of covarying private and public responses. These responses include certain physiological reactions (e.g., accelerated heart rate, increased skin conductance, and increased blood pressure) that often evoke or at least accompany verbal reports of fear and avoidance behavior that can be extremely disruptive and troublesome.

Traditional behavioral accounts of emotional responding have relied on simple classical conditioning explanations. However, these accounts have recently been cogently challenged and criticized. Among these criticisms is the apparent absence of conditioning histories for many anxious clients in which feared stimuli were paired with aversive events (Rachman, 1977). Moreover, it has been argued that conditioning theories do not adequately explain why anxiety reactions often do not extinguish over time, even with repeated exposure (Marks, 1981). The disenchantment with traditional conditioning theories is exemplified by Marks (1987), who states,

> the powerful human capacity for abstract representation creates special problems in translating the rules of stimulus generalization worked out in animals. Fear and avoidance spread in animals from one context to another based on simple sensory cues. In humans, this spread may be on the basis of complex feelings. (p. 234)

Based on these criticisms, many psychologists have turned to explanations that rely on cognitive mechanisms, such as beliefs and expectancies (e.g., Mineka & Tomarken, 1989; Reiss, 1980). Such accounts, however, are considered to be incomplete from a behavior-analytic perspective because they leave the expectancies and beliefs, themselves behavior, unexplained. Although this perspective does not deny the existence or significance of cognitive events (read covert verbal processes), it does require that their occurrence and their functional significance be explained (Hayes & Brownstein, 1986).

It seems reasonable that the transfer of eliciting functions through equivalence classes may begin to suggest a more complete explanation of the findings that have challenged traditional conditioning accounts of emotional disorders. Just as stimuli that have never been associated with particular operants can come to serve as discriminative stimuli by virtue of their membership in equivalence classes, stimuli that have never been associated with aversive experiences may come to elicit emotional responses. The purpose of the present experiment was to determine whether the respondent-eliciting properties of a stimulus will transfer through stimulus equivalence classes.

An important methodological issue concerning this study is how best to measure respondent conditioning. Respondent conditioning in humans has been effectively assessed via psychophysiological measures (Stern, 1972). Among these, skin-conductance measures are widely used (Cook, Hodes, & Lang, 1986; Dawson, Schell, & Banis, 1986; Gale & Stern, 1967; Geer, 1966; Kimmel & Bevill, 1991; Lovibond, Siddle, & Bonds, 1988; Schell, Dawson, & Marinkovic, 1991). When using skin-conductance measures, the relevant literature suggests measuring both tonic (skin-conductance level) and phasic (skin-conductance response) changes (Venables & Christie, 1980). For this reason, changes in both skin-conductance level and skin-conductance response were chosen as measures of conditioning.

EXPERIMENT 1

METHOD

Subjects

Eight female undergraduates taking introductory psychology courses were recruited through in-class and bulletin board announcements. All subjects had normal vision and were free of serious health risks. Subjects received course credit and $10.00 for their participation, as well as a chance to win a $20.00 bonus awarded to the subject who earned the most points on the operant task described below. At the beginning of the experiment, the general procedures were explained and all subjects read and signed a statement of informed consent. They were explicitly told that they could discontinue participation at any time during the experiment, although none of the subjects chose to do so. Upon completion of the study, all subjects were thoroughly debriefed.

Setting, Apparatus, and Stimuli

Subjects worked in an experiment room (1.8 m by 1.2 m) equipped with a one-way mirror for observation. Each subject was seated at a table upon which was a personal computer and three telegraph keys. The computer was used to present stimuli and record data during all phases of the experiment. The telegraph keys

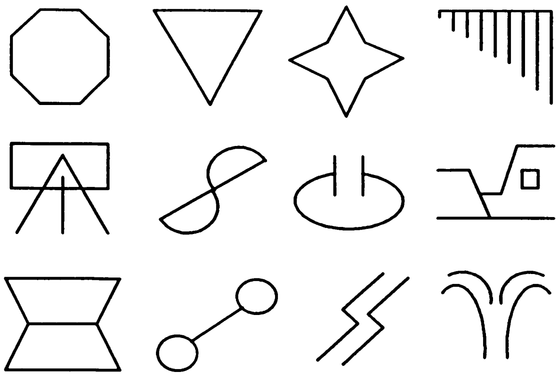

Fig. 1. Stimuli used in Experiments 1 and 2.

were used to select stimuli in the conditional-discrimination training phase of the experiment. In addition, the middle key served as the operandum for an operant task used during the conditioning procedure. Skin-conductance level and skin-conductance response 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 were specifically manufactured for this study and consisted of two 64-mm nickel-plated electrodes fastened 64 mm apart to a piece of Plexiglas (3.8 cm by 5.1 cm). The Plexiglas was strapped to the subject's right forearm with a Velcro® strip.

Stimuli used in the experiment consisted of 12 abstract figures arbitrarily divided into three classes (see Figure 1). The stimuli comprising the three classes varied randomly across subjects so that actual class membership was different for each subject. For convenience, stimuli are alphanumerically designated (e.g., A1, B2, C3), although these designations were not seen by the subjects. All stimuli were white on a black background.

Procedure

All procedures were reviewed and approved by the University of New Mexico Human Subject and Review Committee. The committee did establish some procedural and parametric constraints that included limitations on shock levels, as described below.

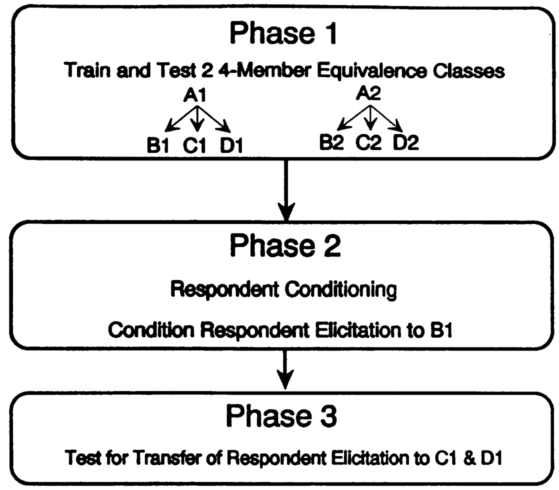

Fig. 2. Schematic overview of procedural phases for Experiment 1.

The study consisted of three phases (see Figure 2). The first involved the training of two four-member stimulus equivalence classes. The second involved "on baseline" discriminated classical conditioning, with one symbol from the first equivalence class serving as a positive conditional stimulus (CS+) and one symbol from the second class serving as a negative conditional stimulus (CS−). Electric shock served as the unconditional stimulus (US). The classical conditioning procedure was presented while the subject was engaged in an operant key-press task. The operant task was used for two reasons. First, it served as a way to keep the subject's attention focused on the computer screen on which the CSs were presented. Second, we originally intended to use disruption of operant responding by the CS (conditioned emotional responding, e.g., Lyon, 1968) as a measure of classical conditioning. These data, however, proved to be very unreliable and are not reported.

The third phase tested for transfer of respondent elicitation. Subjects were exposed to other members of each equivalence class while they continued to engage the operant task. Shock followed the first presentation of the CS+ only. None of the other stimuli nor the final presentation of the CS+ were followed by shock.

Selection of shock level. Shocks were 200 ms in duration and between 1.0 and 2.0 mA in strength. Each subject set her own shock level.

Table 1
Shock levels selected by each subject for use in conditioning during Experiment 1.

Subject	Shock level (mA)
1	1.0
2	1.5
3	1.3
4	1.3
5	1.25
6	1.75
7	1.75
8	1.25

Each subject was instructed to choose a level of shock that was uncomfortable but not painful. Each was given a sample shock of 2.0 mA. If this was too strong, the level was decreased and another sample was given. Shock level was then increased or decreased in response to the subject's reactions until an uncomfortable but not painful level was found or until the level reached 1.0 mA. We were concerned that shock levels below 1.0 mA would be too weak to produce conditioning or might result in rapid habituation. Accordingly, we decided to exclude subjects who selected shock levels below 1.0 mA. However, none of the subjects was excluded on this basis. Subjects' selected shock levels are presented in Table 1.

Phase 1: Stimulus Equivalence Training and Testing

During this phase, subjects were taught six conditional stimulus relations (A1B1, A1C1, A1D1, A2B2, A2C2, and A2D2) using match-to-sample procedures (Sidman, 1986, 1987) and were then tested for the emergence of two four-member stimulus equivalence classes (Class 1 = A1, B1, C1, D1; Class 2 = A2, B2, C2, D2). The third set of stimuli (A3, B3, C3, D3) served only as incorrect comparisons during match-to-sample trials, and specific relations among them were neither trained nor tested.

During equivalence training and testing, a sample appeared at the top center of the computer monitor screen, followed 2 s later by three comparisons 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 positions at the bottom of the screen. Subjects selected one of the comparisons by pressing the corresponding telegraph key below the comparison. After a key was pressed, the screen cleared and, during training, responses to the correct comparison produced the word "Correct" on the monitor, and other choices produced the word "Wrong." The screen cleared again after a 5-s delay. After a 2-s intertrial interval, a new trial began. During test trials, no feedback in the form of written words appeared. Subjects were given the following instructions:

> When the experiment begins, you will see sets of four symbols on the screen; one at the top and three at the bottom—one on the left, one in the middle, and one on the right. Your task is to choose the correct symbol at the bottom of the screen by pressing the left, middle or right telegraph key. During the first part of the experiment you will get feedback on every choice. Later in the experiment you will not get feedback every time. However, there is always a correct answer. During the first part of the experiment the task will be easy and it is tempting not to pay attention. However, the experiment will increase in difficulty, and choosing the correct symbols in the latter part of the experiment will depend on the knowledge you gain during the early parts of the experiment. Things that you learn in this part of the study may be important later on. Do you have any questions?

The six baseline relations were presented in blocks of six trial types, each consisting of one sample and its appropriate comparison array (see Table 2). Within each block of training trials, trial types were presented in a random order. Training continued until subjects reached a performance criterion of 46 trials correct over eight consecutive trial blocks (48 trials).

After subjects reached the training criterion, tests for symmetry were conducted by presenting the six trial types shown in Table 2. During symmetry tests, blocks of these six trial types were presented. Within each block, trial types were presented in a random order. Symmetry tests continued until subjects reached a performance criterion of 46 trials correct over eight consecutive trial blocks (48 trials).

Once the symmetry criterion was reached, equivalence tests were introduced in blocks of 18 trial types consisting of 12 equivalence tests and six symmetry tests (see Table 2). Within each block, trial types were presented in a quasirandom order. Testing continued until subjects reached a criterion of 103 trials correct over six consecutive trial blocks (108 trials).

Phase 2: Classical Conditioning

To start this phase, the skin-conductance sensors were attached with a self-adhesive collar to the thenar and hypothenar eminences of the palm of the subject's left hand. The shock electrode was then attached with the Velcro® strip to the outside of the subject's right forearm. The subject was asked to sit quietly for a 10-min period, the last minute of which served as the comparison baseline for skin-conductance level change scores. This comparison baseline was calculated by averaging the peak responses (in microsiemens, mS) during each of the six 10-s intervals of the baseline period.

After the baseline skin-conductance level data were collected, the subject was instructed to begin the operant task, which was intended to maintain the subject's attention to the monitor. The specific instructions were as follows:

> In this part of the experiment, you will be trying to earn points by pressing this middle key. Only the middle key can be used during this part of the experiment. The object is to try to earn as many points as you can. At the end of the semester the person who has earned the most points will win $20.00. You will need to figure out how to earn points using the key. I can't tell you how, but it does involve pressing the middle key. It may take you a while to figure out how to earn points so try not to get frustrated.
>
> While you are doing this, symbols will occasionally appear on the screen one at a time. We want you to watch the symbols carefully. It is important that you pay close attention to the screen. At times you may receive a shock. The shock level is the one that you set when you received the test shocks. Again, pay attention to what happens on the screen. You will never receive a shock without first seeing a symbol appear on the screen.
>
> A message will appear on the screen to tell you when to start the key-pushing task. You will be performing the task for a while before the symbols appear on the screen. After you begin the task, it is also important that you try to remain as still as you can because if you move around too much it can disrupt the readings from the sensors on your arm.
>
> Remember, you can discontinue the experiment at any time by knocking on the window or telling me over the intercom. Do you have any questions about what you will be doing?

Table 2

Trial types used in training and testing two four-member equivalence classes.

	Comparisons		
Sample	Correct	Incorrect	Incorrect
Training trials			
A1	B1	B2	B3
A1	C1	C2	C3
A1	D1	D2	D3
A2	B2	B1	D3
A2	C2	C1	C3
A2	D2	D1	D3
Symmetry tests			
B1	A1	A2	A3
C1	A1	A2	A3
D1	A1	A2	A3
B2	A2	A1	A3
C2	A2	A1	A3
D2	A2	A1	A3
Equivalence tests			
B1	C1	C2	C3
B1	D1	D2	D3
C1	B1	B2	D3
C1	D1	D2	D3
D1	B1	B2	B3
D1	C1	C2	C3
B2	C2	C1	C3
B2	D2	D1	D3
C2	B2	B1	B3
C2	D2	D1	D3
D2	B2	B1	B3
D2	C2	C1	C3

The operant task was a key press for which points were awarded on a fixed ratio (FR) 250 reinforcement schedule. The points were tallied on the computer monitor and were visible to the subject throughout the task. A 5-min baseline on the operant task was taken before classical conditioning began.

For classical conditioning, B1 served as the CS+ and B2 served as the CS−. Stimulus duration varied randomly between 20 and 40 s to minimize temporal conditioning (Sachs & May, 1969). A delayed conditioning procedure (Kamin, 1965) was used, in which B1 terminated with the onset of the shock. The stimuli were presented in a semirandom order, with the constraint that no more than two B1 or B2 presentations could occur sequentially. The interstimulus interval varied from 90 to 150 s to minimize temporal conditioning effects, and the stimuli were always presented within 10 s of point delivery via the operant task. There was a total of six B1 and six B2 presentations. 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 pilot work indicated that 12 trials was sufficient to produce differential conditioning in most subjects.

Phase 3: Test for Transfer

To start this phase, all subjects received the following instructions:

> This part of the experiment will not take as long as the previous phases. You will be performing the same task as before and trying to earn points by pressing the key. You may also be shocked during this phase of the experiment. The shock level will be the same one that you set at the beginning of the experiment. Symbols will also be appearing one at a time on the screen, but this time you will see more than just the two you have already seen. As before, it is important that you pay close attention to what happens on the screen and that you try to remain as still as possible.
>
> Do you have questions about what you will be doing? Remember that you can discontinue the experiment by knocking on the window or telling me on the intercom.

With the exception of the A stimuli, all of the stimuli from Classes 1 and 2 were presented while the subject continued to perform the operant task. The A stimuli were not presented because a response to them could be interpreted as higher order conditioning rather than transfer of function, inasmuch as they had been directly associated with the B stimuli during equivalence training.

The stimuli were presented after a 5-min operant baseline, exactly as in the classical conditioning phase of the experiment. All data-recording procedures remained the same. Shock still followed the first presentation of B1 but did not follow the other stimuli. After all other stimuli had been presented, a second presentation of B1 in the absence of the US served as a probe trial to assess conditioning to B1. The exact order in which the figures were presented varied across subjects as follows: Subjects 1 and 5 received B1, B2, C2, C1, D2, D1, B1; Subjects 2 and 6 received B1, B2, C2, D1, D2, C1, B1; Subjects 3 and 7 received B1, B2, D2, C1, C2, D1, B1; and Subjects 4 and 8 received B1, B2, D2, D1, C2, C1, B1. This arrangement of presentations was intended to facilitate the clearest demonstration of the transfer of function. Presenting B1 first and B2 second was intended to be a reminder to subjects that the previously learned relations between these stimuli and shock were still in effect. Pilot data suggested that when a member of the CS+ class was presented in extinction before any members of the CS− class were presented, the latter tended to elicit strong respondents. It was as if the extinction trials served as a signal that the contingencies had shifted, and the CS− and related stimuli would now precede shock. In order to avoid this, after the initial presentation of B1 two members of the B2 equivalence class (Class 2; B2, C2, and D2) were presented before any members of the B1 class (Class 1) were presented. One arbitrarily selected member from Class 1 was then presented, followed by the remaining member of Class 2 and then the remaining member of Class 1. The specific stimuli presented under these constraints were simply counterbalanced across subjects. Finally, B1 was presented again.

Results

Stimulus Equivalence

All 8 subjects eventually demonstrated the formation of two four-member classes. Six of the 8 subjects (Subjects 1, 2, 3, 6, 7, and 8) moved from training directly through both stages of testing with minimal errors. The data for these 6 subjects are presented in Figure 3. For these subjects, the number of conditional-discrimination training trials ranged from 53 (Subject 8) to 137 (Subject 3), and the number of symmetry testing trials ranged from 48 with no errors (Subjects 1, 2, 3, 7, and 8) to 54 with four errors (Subject 6). The final phase of testing, with both mixed symmetry and transitivity probes, was completed in 108 trials for all 6 of these subjects, and errors ranged from zero (Subjects 2, 7, and 8) to four (Subject 3).

Subjects 4 and 5 demonstrated considerably more variation in their performance. Their data are presented in Figure 4. Subject 4 had particular difficulty in acquiring the baseline conditional discriminations, requiring 154 trials to reach the training criterion. She then performed well on the symmetry tests (46 trials with no errors), but she made 20 errors in 198 trials during the mixed symmetry and equivalence tests. She was returned to baseline training and reached training criterion in 54

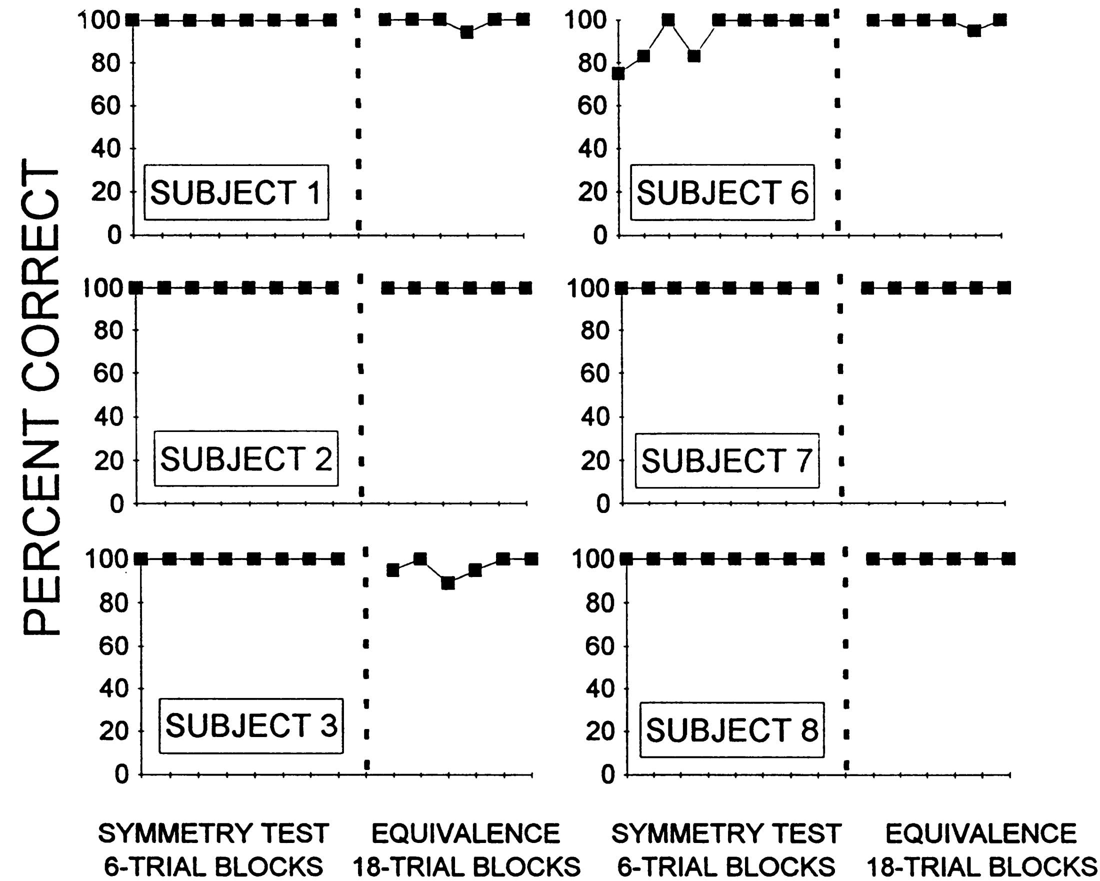

Fig. 3. Data for Subjects 1, 2, 3, 6, 7, and 8 from Phase 1 symmetry and equivalence tests. Percentage correct over successive blocks of testing.

trials with three errors. In the subsequent symmetry tests, she reached criterion in 46 trials with no errors. During her second exposure to the mixed symmetry and transitivity tests, she reached criterion in 108 trials with five errors.

Subject 5 learned the initial conditional discriminations in 72 trials with eight errors. However, during her first symmetry test, she made 15 errors in 102 trials and was returned to conditional discrimination training. She then reached criterion in 46 trials with no errors. During her second symmetry test, she reached criterion in 46 trials with no errors. She then went on to the third phase of testing and reached criterion within 103 trials with no errors.

Skin Conductance

As mentioned earlier, both skin-conductance level and skin-conductance response were used to assess conditioning and the transfer of conditioning. Change in skin-conductance level was calculated by subtracting baseline skin-conductance level (as described earlier) from the peak skin-conductance level obtained during the assessment interval. An increase was defined as a skin-conductance response only if it reached its peak within 5 s of the start of the response and reached a magnitude of at least 0.2 mS (Levis & Smith, 1987). Evidence for conditioning was assessed by examining skin-conductance level changes and skin-conductance response at the offset of B1 during the probe trial and at the offset of B2 during the test for transfer. This is a commonly used measure of conditioning and is generally considered to be more appropriate with human subjects than responding during the CS–US interval because it measures responding at the time at which the US had previously been

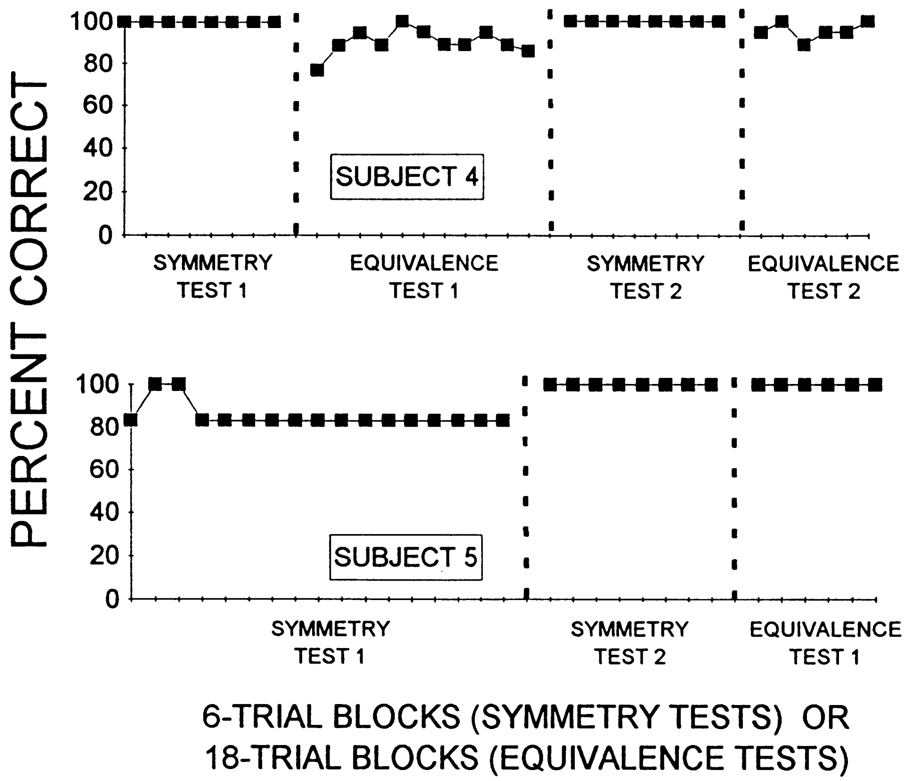

Fig. 4. Data for Subjects 4 and 5 from Phase 1 symmetry and equivalence tests. Percentage correct over successive blocks of testing.

presented. Conditioning was said to occur if the respective responses occurred within 4 s of the termination of the stimuli and were greater to B1 on the probe trial than to B2 in the test for transfer.

These data are presented in Figures 5 and 6. Using this measure, 7 of the 8 subjects showed evidence of conditioning in that their skin-conductance level changes and skin-conductance responses were greater to B1 on the probe trial than to B2 in the transfer test. Only Subject 7 failed to show conditioning by this definition.

Transfer of respondent elicitation was assessed in a similar manner. For both skin-conductance level change and skin-conductance response, transfer was said to occur if the respective measures were greater to all of the members of the B1 class than to any of the members of the B2 class. This was considered a conservative measure of transfer inasmuch as the probability of this occurring by chance for any subject is 1/120. Data from the tests for transfer are presented in Figures 5 and 6. Six of the 8 subjects (Subjects 1, 2, 3, 4, 5, and 6) met the criterion as defined by skin-conductance level change, and 5 of the 8 (Subjects 1, 2, 3, 5, and 6) met the criterion as defined by skin-conductance response. Only Subjects 7 and 8 failed to show any evidence of transfer. These results demonstrate that respondent eliciting functions can transfer through stimulus equivalence classes.

Discussion

Skin-conductance levels and skin-conductance responses to the B1 probe trial relative to the responses to B2 demonstrated differential conditioning in 7 of the 8 subjects. The results of the test for transfer clearly demonstrate that conditioned elicitation can transfer across stimulus equivalence classes. When skin-conductance level changes were used as the measure of elicitation, 6 of 8 subjects showed evidence of the transfer of function, and 5 of

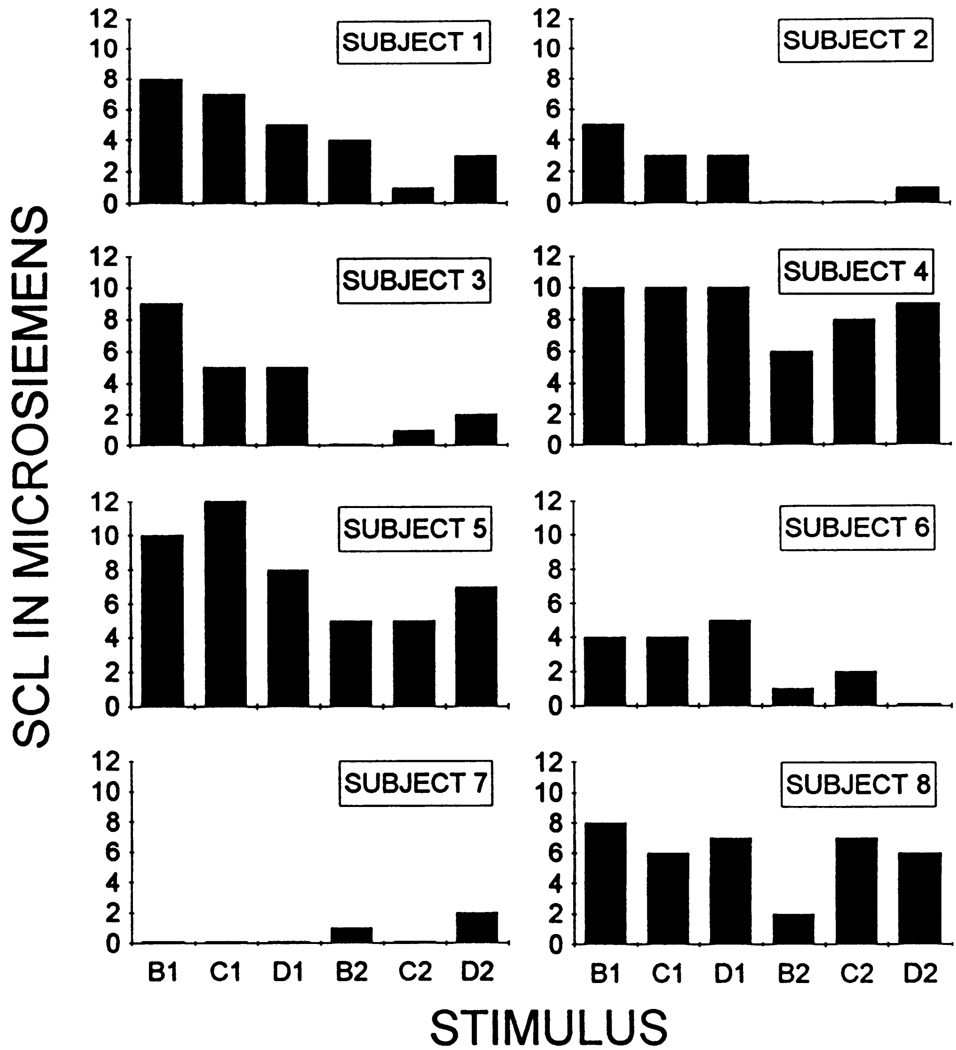

Fig. 5. Peak skin-conductance levels for the B1 probe trial and during the test for transfer to all other stimuli for all subjects.

8 showed transfer when skin-conductance response was used as the measure of elicitation.

The failure of 1 subject to show conditioning and another to show transfer may be due in part to the relatively weak shock that was used as the US. However, it also may have been due to the failure of the equivalence classes to be maintained for these subjects. Unfortunately, a test for class maintenance subsequent to the test for transfer was not conducted.

A related and important issue with regard to respondent elicitation is the process by which emotional responses are extinguished or reduced. Just as elicitation may transfer through equivalence classes, so may extinction. Experiment 2 was conducted to address this issue. In addition, Experiment 2 served as a replication of Experiment 1, with modifications designed to reduce the variability in stimulus equivalence performance and to retest for class maintenance following the tests for transfer.

EXPERIMENT 2

Extinction is widely believed to be the basis for a variety of behavioral treatments of anxiety disorders, such as flooding and systematic desensitization (e.g., Leitenberg, 1976; Levis,

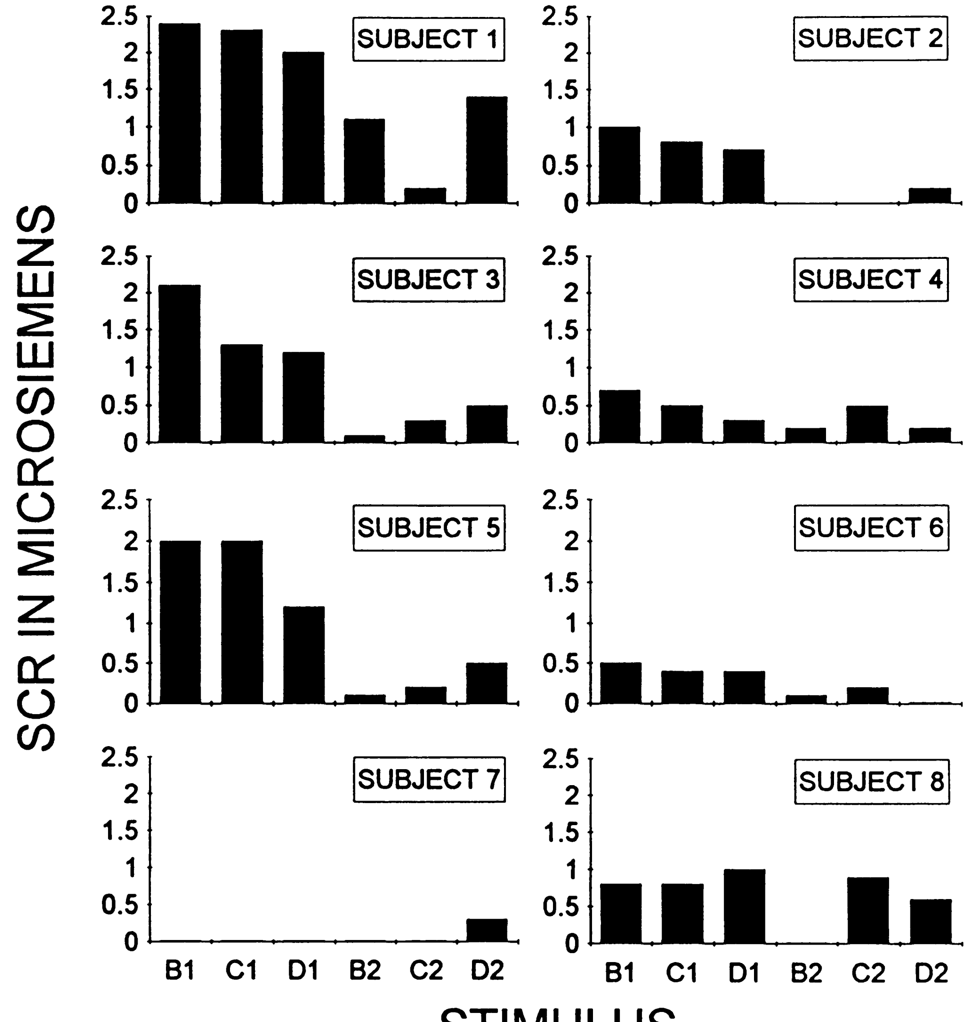

Fig. 6. Peak skin-conductance responses for the B1 probe trial and during the test for transfer to all other stimuli for all subjects.

1966; Rosen & Leitenberg, 1982; Stampfl & Levis, 1967). However, these interventions typically result in a reduction in responding to a set of stimuli, not just to the specific stimuli targeted in the intervention. A fundamental question here is why the reduction in fear spreads to stimuli that are not specifically included in treatment and that bear no physical or formal similarity to the target stimulus. One possibility is that the set of fear-eliciting stimuli are members of an equivalence class, and extinction to one member of the class transfers to the other members. Experiment 2 investigated this possibility.

In order to test for the transfer of extinction, it was decided to condition all of the members of an equivalence class, present one member in extinction, and then test for the transfer of extinction to the other members. In an attempt to replicate Experiment 1, after the test for transfer of extinction, one member of the class used in the original conditioning procedure was selected for reconditioning. Subsequently, the transfer of the reconditioning effects to the other members of the class was examined. Because the transfer of respondent elicitation to the Class 1 stimuli was examined subsequent to the initial conditioning and transfer of extinction procedures, the present study is not a direct replication of Experiment 1. Neverthe-

Table 3
Shock levels selected by each subject for use in conditioning during Experiment 2.

Subject	Shock level (mA)
9	1.3
10	1.0
11	1.5
12	1.3
C1	1.25
C2	1.5
C3	1.5
C4	1.75

less, the transfer of respondent elicitation is assessed.

An issue that is raised by including multiple stimuli in the classical conditioning procedures is that the conditioning procedures themselves might create a functional class. If this were the case, then it could be argued that whatever transfer of function is observed may result from the creation of the functional class rather than from the stimulus equivalence training. To assess this possibility, 4 control subjects were exposed to the same classical conditioning and test for transfer procedures, but were not given equivalence class training.

In addition to modifications in the stimulus equivalence training and testing procedures, there were also modifications in the conditioning procedures used in Experiment 2. Based upon pilot research, shorter CS presentation intervals were used in the second experiment.

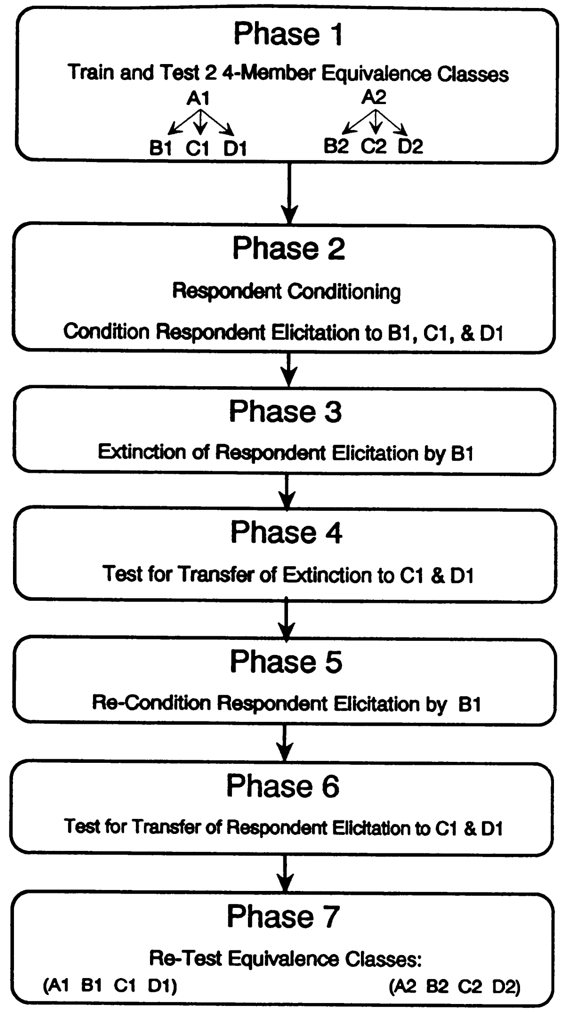

Fig. 7. Schematic overview of procedural phases for Experiment 2.

METHOD

Subjects

Subjects were 8 undergraduates enrolled in introductory psychology courses. Four subjects (2 females, Subjects 10 and 12; and 2 males, Subjects 9 and 11) served as experimental subjects, and 4 (2 females, Subjects C1 and C2; and 2 males, Subjects C3 and C4) served as controls. They were recruited, compensated, and debriefed as described in Experiment 1.

Setting, Apparatus, and Stimuli

The experimental setting, apparatus, and stimuli were identical to those in Experiment 1.

Procedure

All procedures were reviewed and approved by the University of New Mexico Human Subject and Review Committee. As in Experiment 1, each subject received one to three 200-ms sample shocks to determine an acceptable level of shock for each subject. No subject selected a shock level below 1.0 mA (see Table 3).

For the experimental subjects, the study consisted of the seven phases shown in Figure 7. All seven phases were completed within a single session. Subjects were allowed a 5-min break following completion of Phases 1, 2, 4, and 6. Subjects were taught two four-member stimulus equivalence classes (Phase 1). Then, B1, C1, and D1 were paired repeatedly with mild electric shock, and B2, C2, and D2 were presented without shock (Phase 2). Following this, the conditioned reaction to B1 was extinguished (Phase 3). Tests for the transfer of extinction were then performed (Phase 4). In Phase 5, B1 was reconditioned, and then transfer of reconditioning to C1 and D1 was tested (Phase 6). Finally, tests were performed to see if the stimulus equivalence classes had been maintained (Phase 7). Control subjects received only Phases 2, 3, and 4.

Phase 1: Stimulus Equivalence Training and Testing

The same basic procedures used in Experiment 1 to train and test equivalence classes were used with the following modifications. The baseline and testing criteria were made more stringent in an attempt to reduce performance variability among subjects. The baseline training criterion was increased to 97% over 17 trial blocks (99 correct out of 102 consecutive trials). The criterion for symmetry was increased to 97% correct over 17 trial blocks (99 correct out of 102 consecutive trials), and the criterion for mixed symmetry and equivalence was increased to 97% correct over 11 trial blocks (192 of 198).

Phase 2: Classical Conditioning with B, C, and D Stimuli

To start this phase, the skin-conductance sensors and shock electrodes were attached as described in Experiment 1. Skin-conductance measures of conditioning and transfer were the same as those used in Experiment 1. Before these data were recorded, subjects read the following instructions and began an operant task intended to maintain their attention to the monitor.

> In this part of the experiment, you will be trying to earn points by pressing this middle key. Only the middle key can be used during this part of the experiment. The object is to try to earn as many points as you can. At the end of the semester the person who has earned the most points will win $20.00. You will need to figure out how to earn points using the key. I can't tell you how, but it does involve pressing the middle key. It may take you a while to figure out how to earn points so try not to get frustrated.
>
> While you are doing this, symbols will occasionally appear on the screen one at a time. We want you to watch the symbols carefully. It is important that you pay close attention to the screen. At times you may receive a shock. The shock level is the one that you set when you received the test shocks. Again, pay attention to what happens on the screen. You will never receive a shock without first seeing a symbol appear on the screen.
>
> A message will appear on the screen to tell you when to start the key-pushing task. You will be performing the task for a while before the symbols appear on the screen. After you begin the task, it is also important that you try to remain as still as you can because if you move around too much it can disrupt the readings from the sensors on your arm.
>
> Remember, you can discontinue the experiment at any time by knocking on the window or telling me over the intercom. Do you have any questions about what you will be doing?

The operant task was a key press for which points were awarded on an FR 100 reinforcement schedule. The points were tallied on the computer monitor and visible to the subject throughout the task. The subject responded on the operant task for 5 min before classical conditioning began.

For classical conditioning, B1, C1, and D1 served as CS+ and B2, C2, and D2 served as CS−. A delayed conditioning procedure was used, in which presentations of the CS+ terminated with the onset of the shock. Stimuli were presented in four blocks of six trials, each consisting of one presentation of each stimulus. Within each block of trials, the order of stimulus presentation was randomized. Stimulus duration varied randomly between 5 s and 10 s. The interstimulus interval varied from 50 s to 70 s, and the stimuli were always presented within 10 s of point delivery via the operant task.

In order to assess conditioning to B1, C1, and D1 prior to the tests for transfer, three probe trials were presented in the third trial block. Each probe trial consisted of the presentation of one of the CS+ in the absence of shock. Probe trials occurred in the third block so that there would be another block of conditioning trials before the test for transfer.

Phase 3: Extinction of B1

Before beginning Phase 3, subjects were given the following instructions:

> You will again be performing the same task as before. Again, you will be trying to earn points by pushing the key. You may also be shocked during this phase of the experiment.

> The shock level will be the same one that you set at the beginning of the experiment. Symbols will also be appearing one at a time on the screen again. During the first part of this phase, you will see only two symbols. Toward the end of this phase, symbols will still be appearing one at a time on the screen, but you will see more than just the two you have seen in the early part of this phase. What you learned in the first part of the experiment may be important for this phase. As before, it is important that you pay close attention to what happens on the screen and that you try to remain as still as possible. Before that starts I need to have you sit quietly again for a few minutes to get a baseline. A message will appear on the screen telling you to begin the task.
>
> Do you have questions about what you will be doing? Remember that you can discontinue the experiment by knocking on the window.

Phase 3 began with a 5-min baseline during which skin-conductance measures were recorded. After this, subjects again performed the operant task while B1 was presented six times in the absence of shock. Six presentations of B2 were randomly interspersed with the B1 presentations. The interstimulus interval varied between 50 s and 70 s, and the stimuli were presented within 10 s of point delivery via the operant task.

Phase 4: Test for Transfer of Extinction to C1 and D1

Phase 4 immediately followed Phase 3, with no indication to subjects that a change in the procedure was forthcoming. The B, C, and D stimuli from both equivalence classes were presented in extinction while the subject continued to perform the operant task. All data-recording procedures remained the same. The phase began with the presentation of B1 and B2, respectively, followed by the remaining stimuli. Presentations of the B stimuli constituted probe trials to assess extinction to these stimuli. The exact order in which the remaining stimuli were presented varied unsystematically across subjects.

Phase 5: Reconditioning of B1

Before beginning Phase 5, subjects were given the same instructions as in Phase 3. Phase 5 began with a 5-min skin-conductance baseline exactly as in Phases 2 and 3. During this phase, B1 served as the CS+ and B2 served as the CS−. The conditioning procedures remained the same as in Phase 2. The stimuli were presented in a semirandom order, with the constraint that no more than two B1 or B2 presentations were presented sequentially. There was a total of six B1 and six B2 presentations.

Phase 6: Test for Transfer of Conditioning to C1 and D1

Phase 6, which tested for the transfer of conditioning to C1 and D1, was introduced immediately upon completion of Phase 5, with no indication to subjects that a change in procedure would occur. The B, C, and D stimuli from both equivalence classes were presented as described in Phase 2, except that shock followed the first presentation of B1 only. Shock did not follow the second presentation of B1, which served as a probe trial to assess conditioning to B1. All data-recording procedures remained the same as in earlier phases. The exact order in which the figures were presented varied across subjects as follows: Subject 1 received B1, B2, C2, C1, D2, D1, B1; Subject 2 received B1, B2, C2, D1, D2, C1, B1; Subject 3 received B1, B2, D2, C1, C2, D1, B1; and Subject 4 received B1, B2, D2, D1, C2, C1, B1. As mentioned in Experiment 1, these orders were selected in an attempt to facilitate the demonstration of transfer.

Phase 7: Retest of Stimulus Equivalence

In order to assess whether the stimulus equivalence classes were maintained, symmetry and equivalence were retested in Phase 7. Subjects were given the following instructions:

> This is the final phase of the experiment and will not take long. This phase is a repeat of the original task that you did of matching the symbols, but this time you won't get any feedback. Like the first time you completed this task, there is always a correct answer.

Procedures for this phase were exactly the same as those used to test symmetry and equivalence during Phase 1. These tests were presented in blocks of 18 trial types, consisting of 12 equivalence tests and 6 symmetry tests (see Table 2). Within each block, trial types were presented in a quasirandom order. Testing continued until subjects reached a criterion of 192

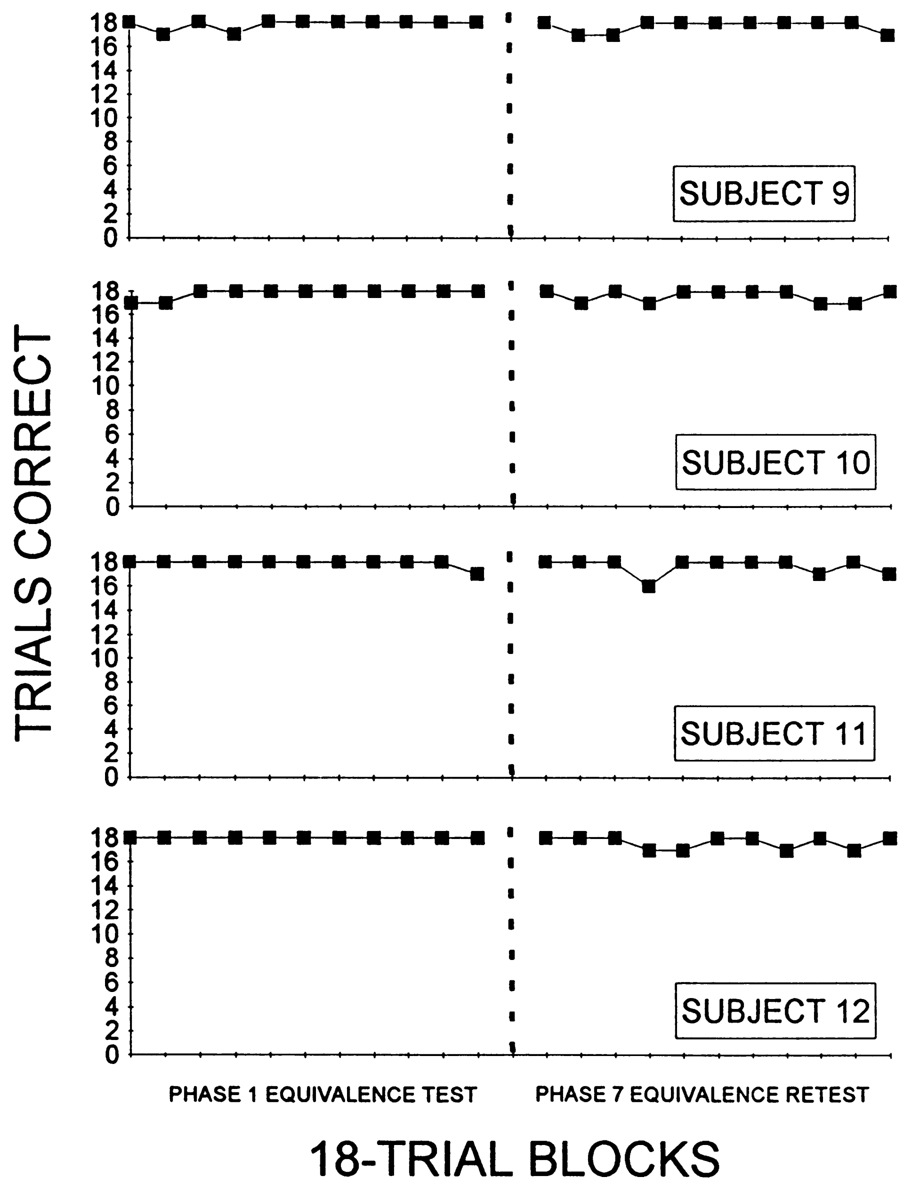

Fig. 8. Data for Subjects 9, 10, 11, and 12 for Phase 1 equivalence test (left panel) and Phase 7 equivalence retest (right panel). Number of trials correctly completed over consecutive test blocks.

trials correct over 11 consecutive trial blocks (198 trials).

Results

Stimulus Equivalence Training and Testing

As a result of the increased number of baseline training trials and more stringent training criterion, there were relatively few errors made in testing, and no retraining was required. Data for all subjects during tests for equivalence are shown in Figure 8. Subjects 9, 10, 11, and 12 required 161, 117, 125, and 186 training trials, respectively, to reach the training criterion. All subjects met the testing criterion for symmetry trials after 102 test trials, except for Subject 11, who required 150 trials. All subjects performed at near-perfect accuracy throughout tests for equivalence.

Skin Conductance

Experimental subjects' skin-conductance levels for Phases 2, 4, and 6 are shown in Figure 9. Skin-conductance response data are shown in Figure 10.

Phase 2: Conditioning

Conditioning data represent skin-conductance level and skin-conductance response to the probes presented during the third trial block of Phase 2 in which no US was delivered. As these data indicate, all subjects' skin-conductance levels and skin-conductance responses for all Class 1 stimuli were greater than their skin-conductance levels and skin-conductance responses for any Class 2 stimuli. On the basis of these data, all subjects showed evidence of differential conditioning to Class 1 stimuli.

Phase 4: Transfer of Extinction

The criteria for transfer of extinction were: (a) a decrease in skin-conductance level and skin-conductance response for C1 and D1 relative to skin-conductance level and skin-conductance response for those stimuli during the conditioning phase, and (b) roughly equivalent skin-conductance level and skin-conductance response for Class 1 and Class 2 stimuli. By these criteria, Figures 9 and 10 indicate that all subjects demonstrated transfer of extinction.

Phase 6: Transfer of Respondent Elicitation

The criterion for transfer of respondent elicitation was that skin-conductance level and skin-conductance response to every Class 1 stimulus had to be greater than the skin-conductance level and skin-conductance response for all of the Class 2 stimuli. Again, this is considered to be a conservative criterion given that the chance probability of this pattern of results is 1/120 for any subject. As Figures 9 and 10 indicate, all subjects met this criterion. All subjects, then, can be said to have demonstrated the transfer of respondent elicitation.

Phase 7: Retest of Equivalence Classes

Data for all subjects during retesting for equivalence are shown in Figure 8. All subjects maintained the initially trained equivalence classes at the end of the experiment.

Control Subjects

Skin-conductance levels for the control subjects are presented in Figure 11. All of the control subjects showed conditioning to B1, C1, and D1. The extinction procedures resulted in skin-conductance levels to B1 that were comparable to B2, C2, and D2. Of critical importance, however, is the finding that this reduction in responding did not transfer to C1 or D1, both of which continued to elicit relatively high skin-conductance levels. Only skin-conductance levels are presented here because the results for skin-conductance responses were similar and added no new information.

Discussion

The present results support the contention that Pavlovian extinction effects can transfer through stimulus equivalence classes. Following extinction of responding to B1, all 4 experimental subjects demonstrated extinction to both C1 and D1. This was not the case, however, for the 4 control subjects, who did not receive stimulus equivalence training. In addition, the results replicate those of Experiment 1, showing that respondent elicitation can transfer through stimulus equivalence classes. When respondent elicitation by B1 was reestablished subsequent to extinction, elicitation reliably transferred to both C1 and D1 for all subjects.

One reason for the greater consistency in transfer in this study relative to Experiment 1 may have been the initial conditioning of all Class 1 stimuli during Phase 2. In general, reacquisition of a conditioned response after extinction occurs more readily than original acquisition (Bullock & Smith, 1953; Davenport, 1969). The present results suggest that this may be true even when reacquisition occurs through transfer.

These results suggest a process by which stimuli can acquire and lose their ability to elicit emotional responding in the absence of direct conditioning. Accordingly, these findings may have implications for our understanding of the development of emotionally based clinical disorders and certain clinical interventions.

GENERAL DISCUSSION

Experiment 1 demonstrated that respondent elicitation can transfer through stimulus

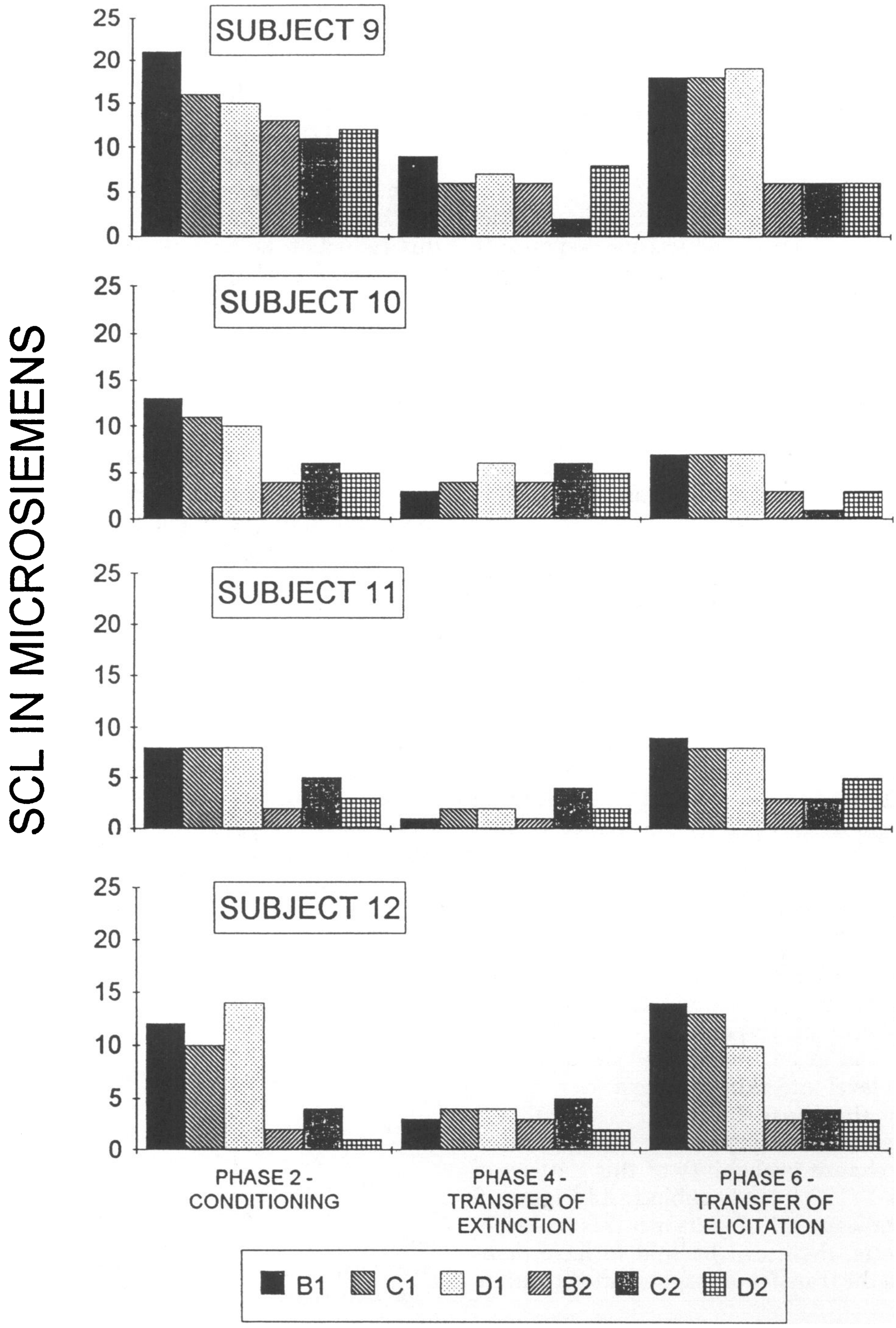

Fig. 9. Skin-conductance levels during conditioning, the test for transfer of extinction, and the test for transfer of respondent elicitation for Subjects 9 through 12.

equivalence classes. However, there was some inconsistency across subjects. The data suggested that the variability may have been due to the stimulus equivalence training and conditioning procedures. In a second experiment, modifications were made that appear to have resulted in more consistent stimulus equivalence performance and conditioning. Experi-

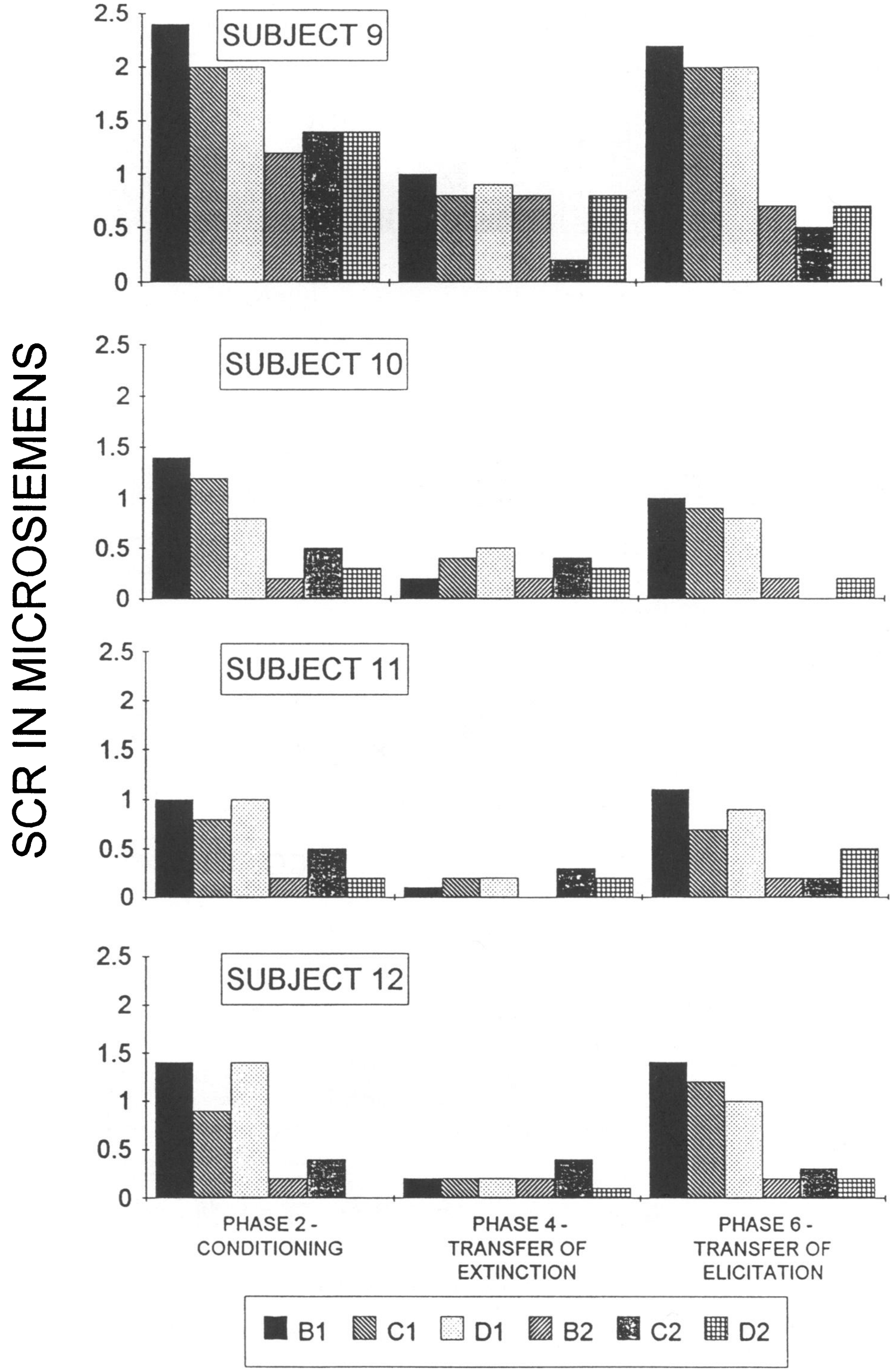

Fig. 10. Skin-conductance responses during conditioning, the test for transfer of extinction, and the test for transfer of respondent elicitation for Subjects 9 through 12.

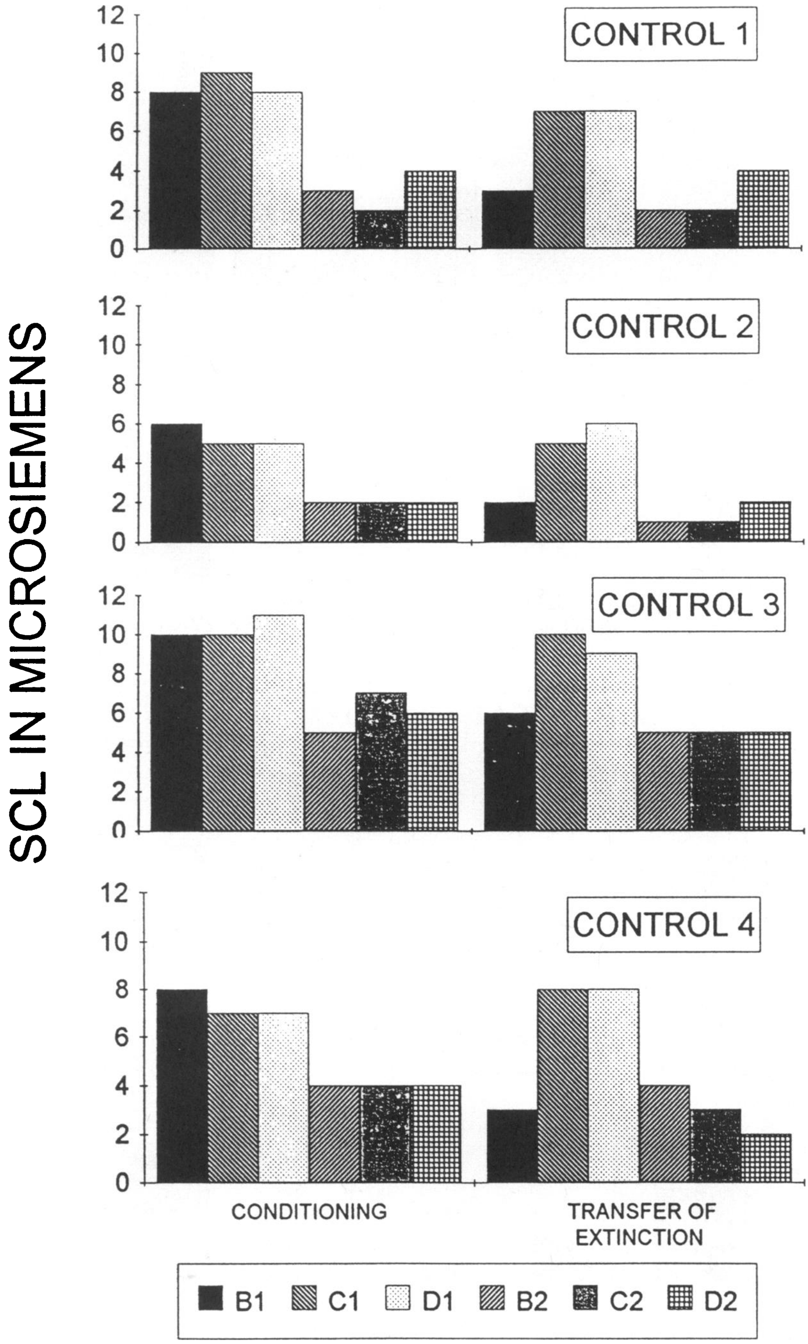

Fig. 11. Skin-conductance levels during conditioning and test for transfer of extinction for Control Subjects 1 through 4.

ment 2 demonstrated the transfer of extinction through stimulus equivalence classes and confirmed the findings of Experiment 1.

The transfer of functions associated with stimulus equivalence is one of the most interesting and important findings in the stimulus equivalence literature. It provides an account of how stimuli can acquire psychological functions in the absence of "direct" training and how it is that humans can behave appropriately in novel situations. The present results extend the range of stimulus functions that have been shown to transfer to include respondent elicitation and extinction. In addition, they have clear and important clinical implications. They suggest a process by which individuals can come to fear stimuli to which they have never been exposed or that have never been associated with aversive experiences. The results of Experiment 2 suggest a possible explanation for how a class of fear-inducing stimuli can lose their eliciting properties when only one member of that class is targeted in treatment.

Taken together, these findings suggest a behavior-analytic response to criticisms of traditional conditioning theories of the etiology and treatment of emotional responding. Moreover, to the extent that stimulus equivalence provides an adequate account of such complex behavior as language and other symbolic processes, the transfer of function through equivalence classes may begin to provide some answers to the questions raised by Marks (1987) and others concerning the complex interaction between verbal behavior and emotional reactions. It must be remembered, however, that the strength and stability of the emotional reactions conditioned in the present study were not comparable to those in clinical populations, and the procedures by which subjects' emotional responses were acquired may not be directly analogous to those that lead to clinical disorders. Accordingly, generalizing from the present results to clinical disorders is premature. More research is needed to determine the extent to which these processes play a role in the development of human emotional responding in general and clinical disorders in particular.

One question that can be raised in regard to the results of Experiment 1 is whether stimulus equivalence was actually responsible for the transfer of function. Because we did not test for transfer effects among subjects who were not exposed to the equivalence training procedures, it is not possible to say with absolute certainty that stimulus equivalence was responsible for the results of the transfer of function tests. It may be, for example, that similar results would have been obtained if subjects' responses to the match-to-sample trials had been without programmed consequences. Although there is evidence that subjects presented with match-to-sample tasks do tend to form classes even when no explicit reinforcement is given for their choices (Harrison & Green, 1990; Hayes et al., 1991), this seems to be an implausible explanation for the present results. As we stated earlier, the criterion for transfer used in the present study was quite conservative. Subjects had to show greater skin-conductance changes to all of the Class 1 stimuli than to any of the Class 2 stimuli. The probability of this occurring by chance for any given subject is 1/120, a rather unlikely occurrence. Moreover, although Hayes et al. (1991) found that match-to-sample procedures without explicit reinforcement did result in the development of stimulus classes and the transfer of conditioned consequential functions across these classes, these procedures did not result in the specific pattern of transfer that was obtained for almost all of the subjects exposed to stimulus equivalence training.

The failure of the control subjects in Experiment 2 to show a transfer of extinction argues against the possibility that transfer was due to the creation of functional classes rather than stimulus equivalence classes. It does, however, raise some interesting questions about the conditions under which functional classes occur. It appears that simply conditioning a function to a number of stimuli is insufficient. It may be that the shared stimulus functions must covary, as is the case in studies using repeated reversal procedures (e.g., Vaughan, 1988), before classes are formed. In that regard, it would have been interesting to have conditioned *and* extinguished the eliciting functions of B1, C1, and D1 for a group of control subjects in Experiment 2, and then tested for the transfer of reconditioning B1 to C1 and D1. It would also have been interesting to test for the emergence of stimulus equivalence classes among these subjects.

Although we and others have described functions as transferring through equivalence classes, this way of talking about the relations between transfer of function and equivalence may be premature and even misguided. We have not yet reached an understanding of the relation between these two phenomena (Dougher & Markham, 1994; Dube, McDonald, & McIlvane, 1992; Sidman, Wynne, Maguire, & Barnes, 1989). In fact, we have not yet adequately explained stimulus equivalence (Dugdale & Lowe, 1990; Hayes, 1991; Sidman, 1991). For all we know, the relation between transfer of function and stimulus equivalence might be just the opposite from that which is assumed in transfer of function studies. That is, stimulus equivalence might be the result rather than the cause of transfer of function. Alternatively, both might be the result of some other behavioral processes. Issues such as these must be addressed before we can say that we have an understanding of stimulus equivalence and the behavioral phenomena related to it.

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