JOURNAL OF THE EXPERIMENTAL ANALYSIS OF BEHAVIOR 1996, **66,** 267–281 NUMBER 3 (NOVEMBER)

RESURGENCE OF DERIVED STIMULUS RELATIONS

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Resurgence has been shown in human and nonhuman operant behavior, but not in derived relational responses. The present study examined this issue. Twenty-three undergraduates were trained to make conditional discriminations in a three-choice matching-to-sample paradigm. The training resulted in three equivalence classes, each consisting of four arbitrarily configured visual stimuli. The same 12 stimuli were then reorganized, and the conditional discrimination training was repeated such that three new classes were possible. In a subsequent test of derived relations, most subjects showed response patterns that were consistent with the altered conditional discriminations. Subjects were then exposed to conditional discrimination trials under extinction. Most subjects continued to respond consistently with the most recently reinforced conditional discrimination trials. During the next phase, subjects were exposed to symmetry and equivalence trials. Responses consistent with the most recent training produced feedback saying that the responses were incorrect, whereas other responses produced no feedback. Most subjects showed a resurgence of responding that was consistent with their earlier training. Finally, subjects were exposed to conditional discrimination trials carried out in extinction. Most subjects continued to show a resurgence of responding that was consistent with their early training.

Key words: resurgence, regression, stimulus equivalence, derived stimulus relations, indirect stimulus control, key press, college students

When a given behavioral topography becomes ineffective in a situation, behavior becomes more variable (Antonitis, 1951). This variability, however, is not random. Many studies have shown that under such conditions previously reinforced topographies are particularly likely to reappear. This has been observed both in nonhuman animals (e.g., Epstein, 1987; Epstein & Skinner, 1980; Mowrer, 1940; O'Kelly, 1940; Rawson, Leitenberg, Mulick, & Lefebvre, 1977; Sanders, 1937) and in humans (Sajwah, Twardosz, & Burke, 1972; see also Pettenger, Pavlik, Flora, & Kontos, 1988). This return to earlier response patterns was at first called *regression,* owing to the influence of Freudian theory (e.g., Mowrer, 1940; O'Kelly, 1940; Sanders, 1937), but recent behavioral researchers have called the phenomenon *resurgence* (e.g., Epstein, 1985; Epstein & Skinner, 1980). We will use the latter term, because it merely describes a shift in response probabilities, and thus avoids the excess theoretical baggage of the earlier term.

One common characteristic of previous demonstrations of resurgence has been that the response topographies that reappear in the subject's behavior had been shaped previously, either by programmed contingencies or by naturally occurring contingencies. In human subjects at least, many responses are established through derived relational means, such as in equivalence relations (e.g., Sidman, 1971; Sidman & Cresson, 1973; Spradlin, Cotter, & Baxley, 1973), exclusion (e.g., McIlvane et al., 1987), opposition (Steele & Hayes, 1991), and comparatives (Dymond & Barnes, 1995).

Consider the case of stimulus equivalence. Suppose that in the presence of a particular unfamiliar stimulus (A1), a person was taught to choose another unfamiliar stimulus (B1) from an array (B1, B2, and B3) and then given B1 as a sample stimulus, to select C1 from another such array (C1, C2, and C3). With this kind of training, the person is also likely to select B1 given C1 as a sample stimulus, A1 given C1 as a sample, C1 given A1 as a sample, and A1 given B1 as a sample (e.g., Sidman, 1971; Sidman, Cresson, & Willson-Morris, 1974). This is so even though the symmetrical and transitive responses have not been directly reinforced in the experimental situation. Interestingly, once such equivalence classes have been established, stimulus functions given to one class member transfer

Preparation of this article was supported in part by Grant DA086434 from the National Institute on Drug Abuse.

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to other members of the same class without any direct training. This transfer has been shown with conditioned reinforcing functions (Hayes, Brownstein, Devany, Kohlenberg, & Shelby, 1987; Hayes, Kohlenberg, & Hayes, 1991), discriminative functions (Hayes et al., 1987), elicited conditioned emotional responses (Dougher, Augustson, Markham, Greenway, & Wulfert, 1994), and extinction functions (Dougher et al., 1994), among others.

Although the establishment of equivalence classes has been extensively studied, their stability over time, disruptability, and flexibility are less well investigated. Of particular interest for the present study are the changeability of equivalence relations and whether such changes can be predicted on the basis of previously established equivalence classes.

Some studies have addressed the longevity of experimentally established equivalence classes. Saunders, Wachter, and Spradlin (1988) showed that such classes persist over a period as long as 5 months, even when subjects have no intervening experience with the stimuli. A few studies have examined the effects of altered baseline conditional discriminations on equivalence classes. Spradlin et al. (1973) showed that changes in baseline discriminations can result in wholesale changes in both symmetrical and transitive relational responding.

Subsequent studies in this area have reported conflicting results. Saunders, Saunders, Kirby, and Spradlin (1988) provided training that was sufficient to establish two large equivalence classes. When they reversed the discrimination training for one member of each class, other derived relations were relatively unaffected unless a trial directly involved the stimulus used in the reversed conditional discriminations. Spradlin, Saunders, and Saunders suggested that large equivalence classes, once established, may be "extremely resistant to alteration" (1992, p. 37). Other studies that reversed some baseline relations in established equivalence classes have shown dissociations between symmetrical and transitive and equivalence responses (Pilgrim & Galizio, 1990, 1995). Subjects readily changed baseline discriminations and showed change on symmetry probes but not necessarily on the transitivity and equivalence probes.

These are among the few studies that have focused on the maintenance and disruption of equivalence relations rather than simply on their establishment. No studies have yet been reported on resurgence of equivalence relations. If a set of equivalence relations is established, and if, later, these stimuli enter other equivalence classes, and still later responses consistent with these new classes are punished or extinguished, we do not know whether derived relational responses that are appropriate to the original training set will reappear (i.e., resurge).

The present study addressed three issues. First, we examined the effects of major changes in baseline discriminations on symmetrical and equivalence probes. In this respect the procedure replicated that of Spradlin et al. (1973), in which all of the baseline discriminations were altered. Second, we subjected derived relational responses to a punishment contingency and assessed resurgence of previously established derived relations. Finally, we examined the effects of this punishment contingency on subsequent unreinforced probes of the baseline conditional discriminations.

METHOD

Subjects

Twenty-five undergraduate psychology students served as subjects in this experiment. Thirteen were male and 12 were female. Subjects received extra credit in their introductory psychology course as compensation for their participation. Subjects were allowed to withdraw from the experiment at any time, without penalty. Subjects 4 and 5 did not complete the experiment, and were excluded from the analysis. No subjects were numbered 6, 14, 23, or 27. All subjects completed the experiment in one session. Experimental sessions lasted no more than 2 hr, including signing of informed consent, subject instruction, and debriefing.

Apparatus and Stimulus Materials

Sessions were conducted in a small room, with the subject seated at a desk that held a color computer monitor and a keyboard. Twelve arbitrarily configured visual figures (4 cm by 5 cm) served as stimuli (see Figure 1). A sample stimulus appeared at the top of the

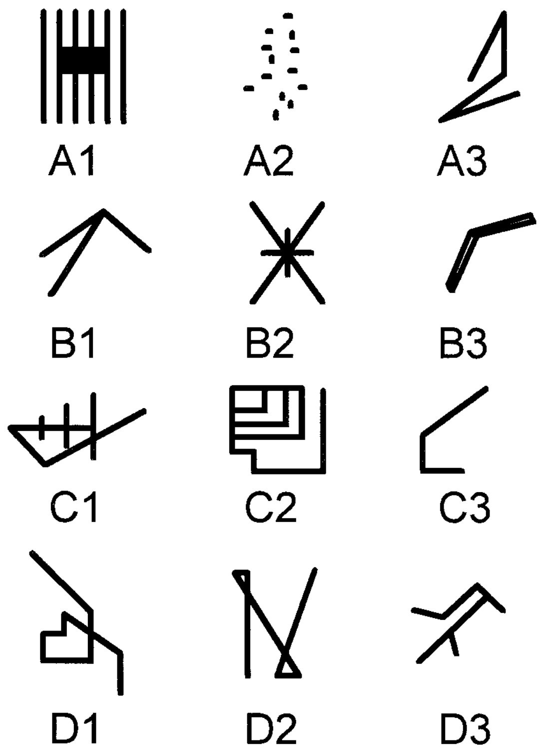

Fig. 1. Visual stimuli used in the experiment.

screen, with three comparison stimuli spaced evenly across the bottom of the screen. The sample and comparison stimuli were surrounded by red rectangles (approximately 6 by 7 cm). The red rectangle flashed rapidly and the computer emitted a staccato tone when the subject selected a comparison stimulus. The subject registered his or her selection by pressing the enter key while the rectangle flashed. The sample stimulus remained on the screen until the selection was registered.

Procedure

Each subject was first asked to sign a consent form that contained the following description of the experimental procedure:

> During the experiment, you will see a figure appear at the top of the computer screen. Then, you will see three other figures appear at the bottom of the screen. You will be asked to select which of the bottom three figures goes with the one at the top of the screen. To select the figure on the left side of the screen, press 1. To select the figure in the center, press 5. To select the figure on the right side of the screen, press 9. After you have pressed the number you think is right, the corresponding figure will be surrounded by a flashing box. While the box is flashing, press Enter. If you press a number and then change your mind, wait a few seconds and the box will stop flashing. Then, you may make another selection. Sometimes during the experiment you will get feedback telling you if have made the correct selection. At the end of the experiment, the computer will tell you that the experiment is over, and you will be asked to go get the experimenter, who will be in the adjacent room. This experiment is not timed, and we will not be testing you on your ability to memorize these instructions. You may take this form in with you while you are in the experiment to remind you of the procedure. We ask that you do not write anything down during the experiment.

The subject was then seated at the desk in front of the computer monitor. Instructions that appeared on the monitor were as follows:

> In this part of the experiment your task is to note the symbol at the top and then to choose a symbol from the bottom. Do this by striking one of three keys (on the top row): the number 1 for left, the number 5 for the middle, the number 9 for the right. While the box is blinking, you may confirm your choice by hitting the enter key. You may change your choice by not hitting the enter key, and when the box stops blinking, making a new choice.

To insure that subjects understood the instructions, a brief program displayed the matching-to-sample layout and instructed the subject to make and confirm a selection. During this instructional program, no stimuli were used that were used in the actual experiment. If the subject performed appropriately, the screen displayed the message: "Good. See how it works? Remember, your task is to note the symbol at the top and then choose a symbol from the bottom. Attend carefully."

The experiment consisted of 13 phases. (See Table 1 for summaries of trial types and number of trials in each phase.) In all phases, the comparison stimuli were randomly assigned trial by trial to either the left, middle, or right position. In Phases 1 through 4 and Phases 6 through 9, feedback about whether the choice was correct or incorrect was provided on all trials. Phases 5, 10, 11, and 13 were carried out in extinction. Only feedback about incorrect choices was provided during

Table 1

Trial composition for each phase.

Early training			
Conditional discrimination training: Each trial type was presented five times.			
Phase 1: A-B relations (15 trials):	**A1:** B1 B2 B3	**A2:** B2 B1 B3	**A3:** B2 B1 B3
Phase 2: A-C relations (15 trials):	**A1:** C1 C2 C3	**A2:** C2 C1 C3	**A3:** C3 C1 C2
Phase 3: A-D relations (15 trials):	**A1:** D1 D2 D3	**A2:** D2 D1 D3	**A3:** D3 D1 D2
Phase 4: Mixed A-B, A-C, A-D relations (27 trials): Each of the above nine trial types was presented three times.			
Test for equivalence and symmetry			
Phase 5 (27 trials): Each trial type was presented once.			
B-A relations:	**B1:** A1 A2 A3	**B2:** A2 A1 A3	**B3:** A3 A1 A2
C-A relations:	**C1:** A1 A2 A3	**C2:** A2 A1 A3	**C3:** A3 A1 A2
D-A relations:	**D1:** A1 A2 A3	**D2:** A2 A1 A3	**D3:** A3 A1 A2
B-C relations:	**B1:** C1 C2 C3	**B2:** C2 C1 C3	**B3:** C3 C1 C2
C-B relations:	**C1:** B1 B2 B3	**C2:** B2 B1 B3	**C3:** B3 B1 B2
B-D relations:	**B1:** D1 D2 D3	**B2:** D2 D1 D3	**B3:** D3 D1 D2
D-B relations:	**D1:** B1 B2 B3	**D2:** B2 B1 B3	**D3:** B3 B1 B2
C-D relations:	**C1:** D1 D2 D3	**C2:** D2 D1 D3	**C3:** D3 D1 D2
D-C relations:	**D1:** C1 C2 C3	**D2:** C2 C1 C3	**D3:** C3 C1 C2
Late training			
Conditional discrimination training: Each trial type was presented five times.			
Phase 6: A-B relations (15 trials):	**A1:** B3 B1 B2	**A2:** B1 B2 B3	**A3:** B2 B1 B3
Phase 7: A-C relations (15 trials):	**A1:** C2 C1 C2	**A2:** C3 C1 C2	**A3:** C1 C2 C3
Phase 8: A-D relations (15 trials):	**A1:** D3 D1 D2	**A2:** D2 D1 D3	**A3:** D1 D2 D3
Phase 9: Mixed A-B, A-C, A-D relations (27 trials): Each of the above nine trial types was presented three times.			
Resurgence test			
Phase 10 (16 trials): Each included trial type was presented once.			
B-A relations:	**B1:** A2 A1 A3	**B2:** A3 A1 A2	**B3:** A1 A2 A3
C-A relations:	**C1:** A3 A1 A2	**C2:** A1 A2 A3	**C3:** A2 A1 A3
D-A relations:	**D1:** A3 A1 A2	**D2:** excluded	**D3:** A1 A2 A3
B-C relations:	**B1:** C3 C1 C2	**B2:** C1 C2 C3	**B3:** C2 C1 C3
B-D relations:	**D1:** excluded	**D2:** excluded	**D3:** excluded
D-B relations:	**B1:** excluded	**B2:** excluded	**B3:** excluded
C-B relations:	**C1:** B2 B1 B3	**C2:** B3 B1 B2	**C3:** B1 B2 B3
C-D relations:	**C1:** excluded	**C2:** D3 D1 D2	**C3:** excluded
D-C relations:	**D1:** excluded	**D2:** excluded	**D3:** C2 C1 C3
Phase 11 (16 trials): Each included trial type was presented twice.			
A-B relations:	**A1:** B3 B1 B2	**A2:** B1 B2 B3	**A3:** B2 B1 B3
A-C relations:	**A1:** C2 C1 C3	**A2:** C3 C1 C2	**A3:** C1 C2 C3
A-D relations:	**A1:** D3 D1 D2	**A2:** excluded	**A3:** D1 D2 D3
Phase 12 (80 trials): Each trial type included in Phase 10 was presented five times.			
Phase 13 (16 trials): Each of the trial types included in Phase 11 was presented twice.			

Note. In all the trial types, the sample is in boldface and the correct response is the first stimulus to appear after the sample.

Phase 12. To increase the subjects' motivation to finish the experiment, they were given a "countdown" as they progressed through the study. At the beginning of each phase the monitor displayed the phrase "Phase X." The first phase was numbered 10, and so on in sequence, with the last phase numbered 1. From the subject's perspective, Phases 10 through 13 constituted one long phase (labeled Phase 1 at its beginning).

In Phase 1, subjects were trained to select one of three comparison (B) stimuli in response to one of the three sample (A) stimuli ($A1 \rightarrow B1$, $A2 \rightarrow B2$, $A3 \rightarrow B3$). The phase consisted of 15 trials. The trials with A1, A2, and A3 as sample stimuli were presented in random order (five repetitions of each trial type per 15-trial block). If the subject made a correct choice, the words "CORRECT" and "EXCELLENT" appeared on the screen. If the subject made an incorrect choice, the word "WRONG" appeared on the screen.

The phases were repeated until the subject achieved 90% accuracy and then advanced to the next phase of the experiment.

Phase 2 was identical to Phase 1 except that the C stimuli were presented as the comparisons (A1 → C1; A2 → C2; A3 → C3). Phase 3 was again identical except that the D stimuli were presented as the comparisons (A1 → D1; A2 → D2; A3 → D3). Phase 4 consisted of 27 trials in which A → B, A → C, and A → D conditional discrimination trials were mixed. These mixed trials were presented in random order. Each of the nine trial types occurred three times during the phase. Phase 4 was repeated until the subject achieved 90% accuracy.

In Phase 5, 27 trials were presented that assessed the emergence of symmetrical and equivalence relations (nine derived relations were tested: B → A, C → A, D → A, B → C, C → B, C → D, D → C, B → D, and D → B). These symmetry and equivalence trials were carried out in extinction. The 27 possible trial types were presented in random order. If the subject made class-consistent selections on 90% of the trials, he or she advanced to Phase 6. If the subject failed to reach the 90% criterion, he or she was returned to Phase 4, which provided additional mixed A → B, A → C, A → D training. These two steps were repeated until the subject achieved the 90% criterion on the symmetry and equivalence trials. This training regimen provided the basis for three four-member classes consisting of the sets A1/B1/C1/D1, A2/B2/C2/D2, and A3/B3/C3/D3 (see Figure 2). From this point forward, Phases 1 through 4 will be referred to as "early" training.

In Phases 6 through 9, subjects received conditional discrimination training similar to that of Phases 1 through 4. The only difference between these phases and the earlier phases was that in Phases 6 through 9, the stimuli were reorganized such that correct responding provided the basis for three four-member classes consisting of the sets A1/B3/C2/D3, A2/B1/C3/D2, and A3/B2/C1/D1, rather than the original classes (see Figure 2). The reinforced choices on the conditional discrimination trials were A1 → B3, A2 → B1, A3 → B2 in Phase 6; A1 → C2, A2 → C3, A3 → C1 in Phase 7; and A1 → D3, A2 → D2, A3 → D1 in Phase 8. These nine trial types were mixed in Phase 9. In all other respects these trials were identical to those in Phases 1 through 4. From this point forward, Phases 6 through 9 will be referred to as "late" training.

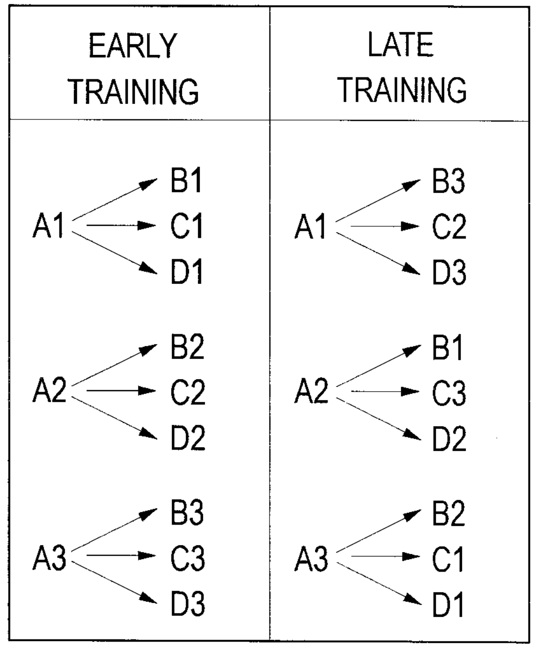

Fig. 2. Trained relations for early and late discrimination training. Arrows depict reinforced conditional discriminations, where the A stimuli are always the sample and the B, C, or D stimuli constitute the array.

Phase 10 consisted of 16 symmetry and equivalence trials. Subjects were not required to show any particular pattern of responding in this or any subsequent phase. These trials were carried out in extinction. All symmetry and equivalence trials that could yield the same response on the basis of early and late training were excluded. For example, a trial that consisted of B3 as a sample stimulus with D1, D2, and D3 as the comparison stimuli was excluded because D3 would be the expected choice whether the selection was based on the early or the late training. Six additional equivalence trials were excluded, leaving an equal number of symmetry and equivalence trials in the phase (eight symmetry and eight equivalence trials; see Table 1). The equal number of symmetry and equivalence trials in this phase permitted a balanced comparison of the differential effects of the altered baseline discriminations on these two types of tri-

Table 2

Number of early and late training trials (total number of trials/repetitions of phase (P).

	Early training						Late training				
Subject	P1 A-B	P2 A-C	P3 A-D	P4 mixed	Early total	P5 test	P6 A-B	P7 A-C	P8 A-D	P9 mixed	Late total
S0	45/3	15/1	15/1	54/2	144	54/2	30/2	30/2	30/2	216/8	322
S1	30/2	15/1	15/1	54/2	114	54/2	60/4	15/1	30/2	81/3	202
S2	15/1	45/3	45/3	108/4	213	54/2	30/2	30/2	45/3	162/6	283
S3	30/2	30/2	30/2	135/5	225	54/2	30/2	15/1	15/1	54/2	130
S4	30/2	30/2	30/2	216/8	306	81/3	30/2	30/2	30/2	162/6	—
S5	105/7	15/1	15/1	297/11	447	162/6	30/2	30/2	—	—	—
S7	60/4	30/2	30/2	162/6	282	81/3	30/2	15/1	30/2	54/2	145
S8	45/3	30/2	30/2	27/1	117	27/1	30/2	30/2	30/2	27/1	133
S9	45/3	30/2	30/2	135/5	240	81/3	30/2	75/5	30/2	189/7	340
S10	30/2	30/2	30/2	27/1	117	27/1	60/4	15/1	15/1	27/1	133
S11	150/10	15/1	15/1	135/5	345	54/2	30/2	30/2	30/2	81/3	187
S12	45/3	30/2	30/2	54/2	144	54/2	30/2	30/2	30/2	27/1	133
S13	30/2	30/2	30/2	108/4	183	54/2	45/3	30/2	30/2	189/7	310
S15	60/4	15/1	15/1	108/4	198	81/3	45/3	30/2	30/2	81/3	202
S16	45/3	30/2	30/2	27/1	132	27/1	30/2	45/3	30/2	54/2	175
S17	15/1	45/3	45/3	81/3	156	27/1	30/2	15/1	15/1	27/1	103
S18	75/5	45/3	45/3	108/4	258	54/2	30/2	30/2	30/2	162/6	268
S19	30/2	30/2	30/2	54/2	144	54/2	30/2	30/2	60/4	108/4	244
S20	60/4	30/2	30/2	54/2	174	54/2	60/4	30/2	45/3	54/2	205
S21	30/2	30/2	30/2	81/3	171	54/2	30/2	30/2	30/2	216/8	322
S22	15/1	30/2	30/2	54/2	129	54/2	30/2	30/2	30/2	54/2	160
S24	45/3	30/2	30/2	27/1	132	27/1	45/3	30/2	30/2	81/3	202
S25	45/3	60/4	60/4	108/4	243	27/1	45/3	30/2	30/2	216/8	337
S26	45/3	15/1	15/1	54/2	144	54/2	45/3	30/2	30/2	81/3	202
S28	15/1	45/3	45/3	27/1	102	27/1	45/3	30/2	30/2	27/1	148

als. The trial types were presented in random order.

Phase 11 consisted of 16 mixed A → B, A → C, and A → D trials. This block was similar in appearance to the training trials in Phases 1 through 4 and 6 through 9, with two exceptions. First, the trials were carried out in extinction. Second, the A2 → D2 trial type was excluded because the early and late training choice would be the same. Each of the remaining eight trials was presented twice during the phase in random order.

Phase 12 consisted of 80 symmetry and equivalence trials (with the same trial types excluded as in Phase 10; see Table 1). During this phase, if a response was consistent with late training, the word "WRONG" appeared on the screen. If the subject selected a comparison consistent with early training, or if they selected the third comparison, no feedback was given, and the next trial appeared. The trial types were presented in random order.

Phase 13 consisted of 16 A → B, A → C, and A → D trials. These trials were carried out in extinction and excluded the same trial as was excluded in Phase 11. As in Phase 11, each trial type appeared twice during the phase. The trial types were presented in random order.

In summary, Phases 10 through 13 consisted of a test of both derived (Phase 10) and trained (Phase 11) relations carried out under extinction conditions, using only trial types that would occasion different responses based on early versus late training. The late derived relations then received negative feedback (Phase 12), and the trained relations were retested under extinction conditions (Phase 13).

RESULTS

Early and Late Discrimination Training in Phases 1 through 9

Early training: Phases 1 through 5. Table 2 shows the number of trials completed and the number of repetitions of Phases 1 through 9 for each subject. All 25 subjects who started

Table 3

Modal response type for individual subjects in Phases 10 through 13.

Subject	Phase 10 sym-equiv extinction	Phase 11 mixed extinction	Phase 12 sym-equiv punishment	Phase 13 mixed extinction
S0	E	E	E	E
S1	L	L	E	E
S2	L	L	N/L	E
S3	L	L	E	E/L
S4	—	—	—	—
S5	—	—	—	—
S7	L	L	E	E
S8	E/L	L	E	E
S9	L	L	L	E
S10	L	L	E	E
S11	L	L	N	L
S12	L	L	E	E
S13	L	L	E	E
S15	L	L	E	E
S16	L	L	L	L
S17	L	L	E	L
S18	L	L	N	E
S19	L	L	E	E
S20	E	E	E	E
S21	L	L	N	E/N
S22	L	L	N	N
S24	E	E/L	E	L
S25	L	E	E	E
S26	L	L	E	L
S28	L	L	E	E

Note. Sym-equiv indicates tests for symmetry and equivalence. E = early, L = late, N = novel.

Table 4

Number of subjects showing early, late, novel, or two modal response patterns across Phases 10 through 13.

Modal response pattern	Phase 10 equivalence and symmetry trials (extinction)	Phase 11 mixed A-B, A-C, A-D trials (extinction)	Phase 12 equivalence and symmetry trials (late-consistent punished)	Phase 13 mixed A-B, A-C, A-D trials (extinction)
Early consistent	3	3	16	15
Late consistent	19	19	2	5
Novel	0	0	4	1
Two modal responses	1	1	1	2

the experiment finished the first five phases. The first phase required the most repetitions to reach criteria, with an average of 3.04 repetitions required. Subject 11 required 10 repetitions to complete Phase 1; however, most subjects required far fewer. Nineteen of the 25 subjects completed the phase with three or fewer repetitions. All subjects went on to complete Phases 2 and 3 with three or fewer repetitions. Mixed A-B, A-C, A-D training in Phase 4 required more exposure for some subjects. Again, however, the majority of subjects (14 of 25) completed the phase with three or fewer repetitions. Phase 5 was completed by all but 1 subject with three or fewer repetitions.

Late training: Phases 6 through 9. In Phase 6, most subjects' responding quickly came under the control of the altered baseline contingencies (see Table 2). The number of subjects who completed Phases 6, 7, and 8 in three or fewer repetitions was 22, 24, and 23, respectively. As in the early training, there was more variability and more repetitions were required to complete the mixed training in Phase 9. Still, the majority of subjects (15) completed the phase in three or fewer repetitions. Two subjects decided to stop the experimental session during the late training. Subject 5 quit after meeting the 90% criterion on the second attempt at Phase 7, and Subject 4 quit after failing to meet the 90% criterion on the sixth attempt at Phase 9.

Test Phases 10 through 13

Table 3 shows the modal response patterns for individual subjects in Phases 10 through 13. Modal response patterns have been labeled as either "early," "late," or "novel." "Novel" indicates that subjects showed a majority of responses to the third alternative, rather than to either early or late consistent alternatives. Table 4 shows the aggregated modal response patterns for Phases 10 through 13. Figures 3, 4, and 5 show cumulative records of each response type (early, late, and novel) for each subject for Phases 10 through 13. Subject placement in Figures 3, 4, and 5 is organized with respect to modal response pattern in Phase 12 (the primary resurgence test). The letters a through w have been added to the subject numbers in the order of their placement in these figures. In discussions of the results for Phases 10 through 13, subjects will be referred to using their numerical and alphabetic labels in order to make them easy to locate on both the tables and in the figures.

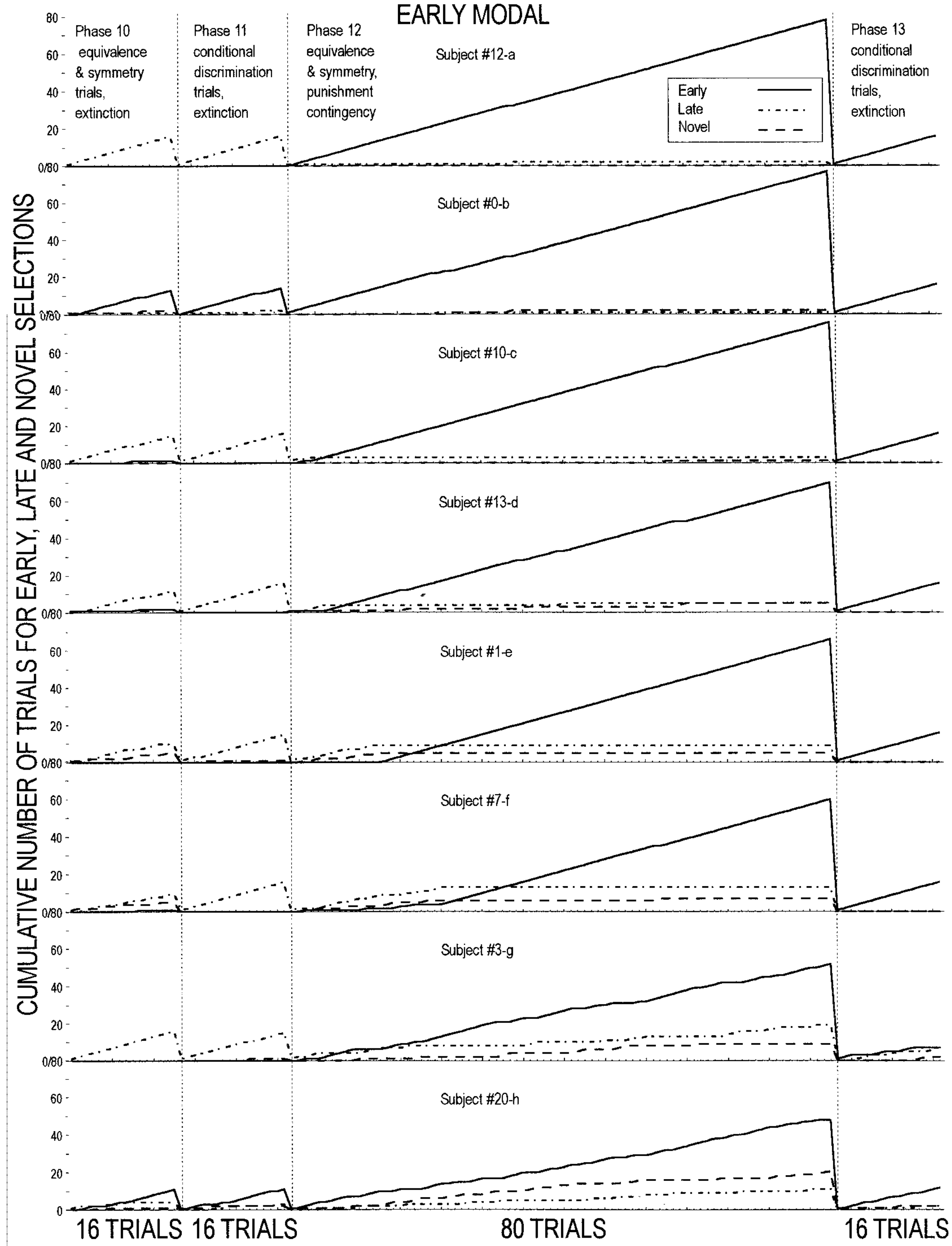

Fig. 3. Cumulative records for each response type (early, late, or novel) across Phases 10 through 13. All lines move to the right one tick on the *x* axis for each trial. The line corresponding to early, late, or novel response topographies moves up one tick if the response conforms to that topography. Response-category labels specify the modal pattern in Phase 12. Records are shown for 8 subjects.

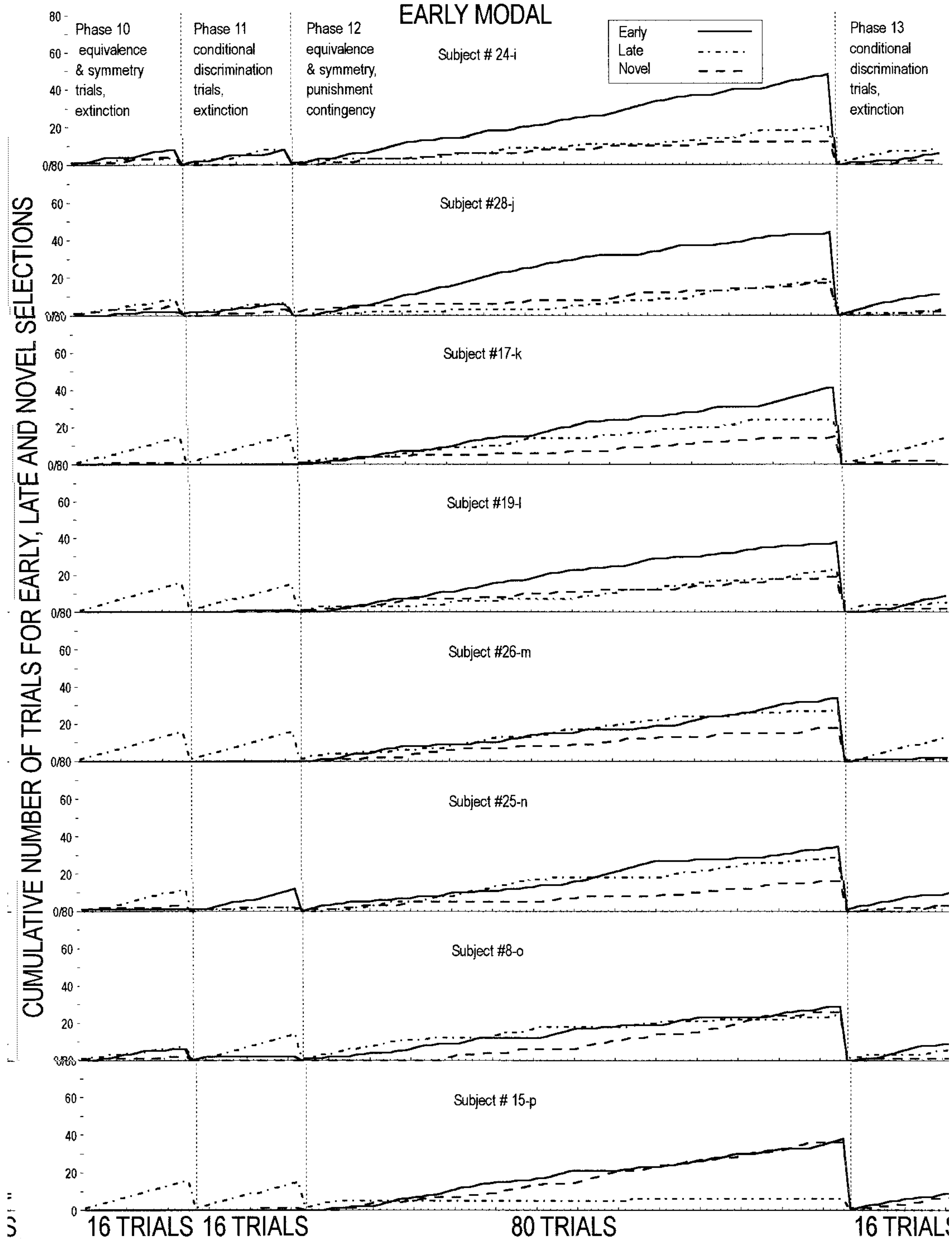

Fig. 4. Cumulative records for 8 subjects. See Figure 3 caption for details.

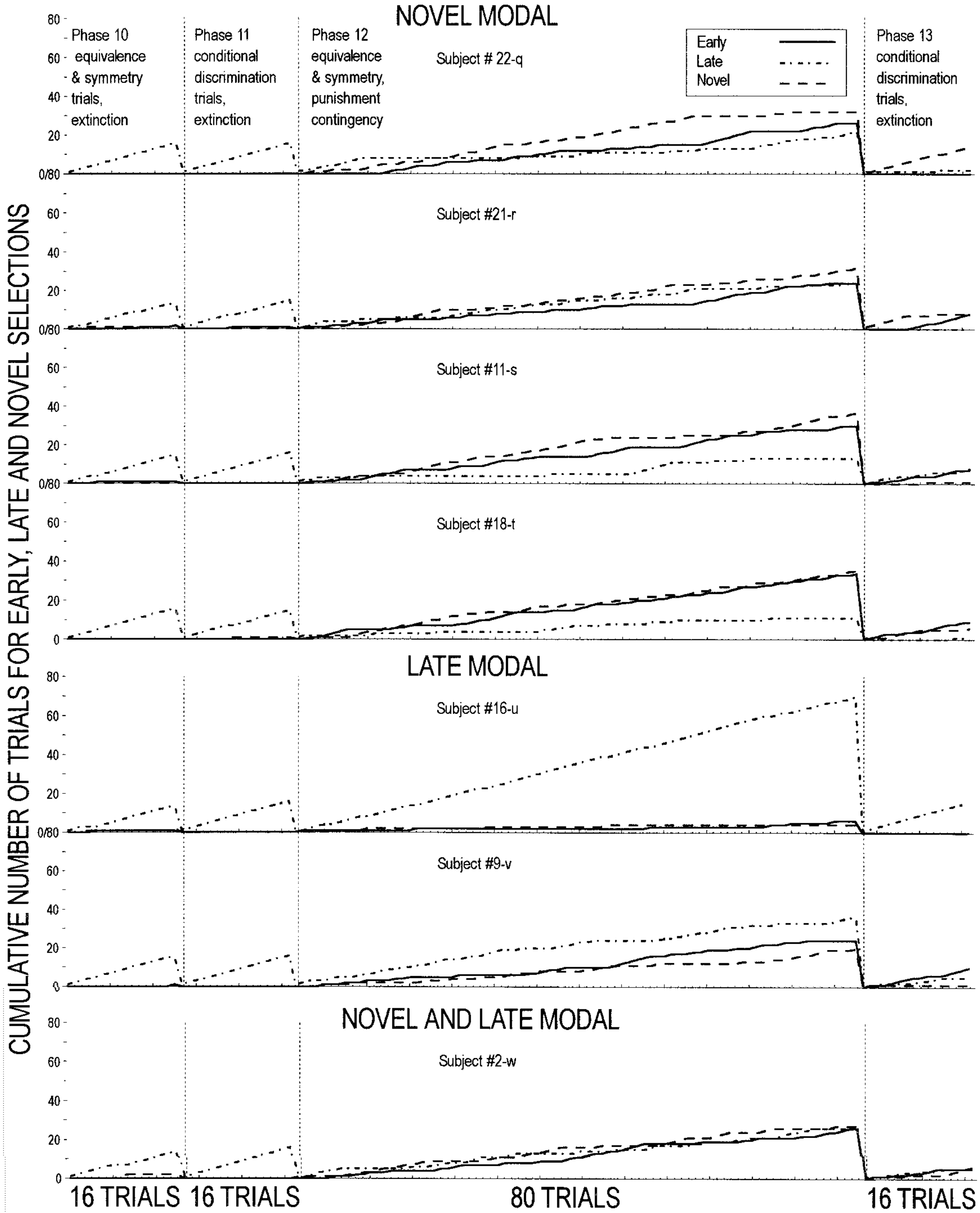

Fig. 5. Cumulative records for 7 subjects. See Figure 3 caption for details.

Test for derived relations (Phase 10). Although all subjects had to complete Phases 6 through 9 with at least 90% accuracy, Phase 10 occurred in extinction and there was no 90% criterion. Three of the 23 subjects in Phase 10 (0-b, 20-h, and 24-i) showed more responses that were consistent with early training than either late consistent responses or novel responses. Subject 8-o divided her answers nearly equally among the three possible choices, responding with six early-training-consistent responses, six late-training-consistent responses, and four novel responses. The remaining 19 subjects showed more late-training-consistent responses than either of the other response types (see Figures 3, 4, and 5 and Tables 3 and 4).

Test of directly trained relations (Phase 11). Responding in Phase 11 was fairly consistent with responding seen in Phase 10 (see Figures 3, 4, and 5 and Tables 3 and 4). Subject 0-b and Subject 20-h, who showed a majority of early-training-consistent responses in Phase 10, also showed a majority of early-training-consistent responses in Phase 11. Subject 24-i produced mixed responding in Phase 10, with early-training-consistent responses slightly more frequent than the alternative responses. This subject's responses were similarly mixed in Phase 11, with eight early-consistent and eight late-consistent responses. Subject 8-o, who also had mixed responding in Phase 10, showed a majority of late-training-consistent responses in Phase 11. Of the 19 subjects who showed a majority of late-training-consistent responses in Phase 10, 18 showed a similar majority in Phase 11, although Subject 28-j had only one more of the late-training than early-training-consistent responses. Subject 25-n showed a clear shift from late-training-consistent responses in Phase 10 to early-training-consistent responses in Phase 11. In summary, 3 subjects showed a majority of early consistent responses, 19 showed a majority of late consistent responses, 1 showed a bimodal pattern (early and late), and none showed a majority of novel responses (see Figures 3, 4, and 5 and Table 4).

Resurgence findings for derived relations (Phase 12). A series of comparisons was made to assess whether punishing derived responses consistent with late training would result in a resurgence of early-training-consistent derived responses, as opposed to novel responses. Among the 23 subjects who completed the experiment, 16 showed a majority of early-training-consistent responses in Phase 12 (see Figures 3, 4, and 5), 4 showed a majority of novel responses, 2 showed a majority of late-training-consistent responses, and 1 split his responses nearly evenly, with 26 early consistent, 27 late consistent, and 27 novel responses. Both Subjects 16-u and 9-v, who persisted in late-training-consistent responding, produced slightly more early-training-consistent responses than novel responses when they did deviate from their modal response.

The main purpose of this phase was to examine whether or not early-training-consistent responses would be more frequent than novel responses. Considering only these two responses and leaving aside continuing late-training-consistent responses, 18 of the 23 subjects who completed the experiment showed the resurgence effect to at least some small degree (see Table 4). That is, they chose early-training-consistent responses over novel responses, many by a large margin.

Resurgence findings for directly trained relations (Phase 13). After the test for derived relations in Phase 10, subjects were exposed to 16 mixed $A \rightarrow B$, $A \rightarrow C$, $A \rightarrow D$ trials in Phase 11. As reported above, the majority of the subjects (i.e., 18 of 23) made the majority of their responses in Phase 11 consistent with late training. After Phase 12, during which late-training-consistent responses were punished, subjects were again exposed to 16 mixed baseline conditional discrimination trials ($A \rightarrow B$, $A \rightarrow C$, $A \rightarrow D$ trials) that were carried out in extinction. The purpose of this phase was to see if punishing derived responses consistent with late training would also occasion a resurgence of early-training-consistent responses on the directly trained relations. Among subjects who completed the experiment, 15 showed a majority of early-training-consistent responses, 6 showed a majority of late-training-consistent responses, Subject 22-q showed a majority of novel responses, and Subject 21-r divided her responses equally between early-training-consistent and novel responses (see Figures 3, 4, and 5 and Tables 3 and 4).

Differential impact on symmetry and equivalence. Some previous researchers who made

Table 5

Early versus late training consistent responses on symmetry and equivalence trials in Phase 10.

Subject	Early training consistent		Late training consistent	
	Symmetry	Equivalence	Symmetry	Equivalence
S0	7	6	1	2
S1	0	0	8	8
S2	0	0	8	8
S3	0	0	8	8
S7	0	1	8	7
S8	2	4	6	4
S9	0	1	8	7
S10	1	0	7	8
S11	1	0	7	8
S12	0	0	8	8
S13	0	2	8	6
S15	0	0	8	8
S16	0	1	8	7
S17	0	0	8	8
S18	0	0	8	8
S19	0	0	8	8
S20	6	5	2	3
S21	0	2	8	6
S22	0	0	8	8
S24	5	3	3	5
S25	0	1	8	7
S26	1	1	7	7
S28	1	1	7	7
Total	24	28	160	156

changes in a subset of baseline discriminations (e.g., Pilgrim & Galizio, 1990, 1995) found more resulting change in symmetry than in equivalence trials. Altering all baseline discriminations in this study showed no such differential effect. In Phase 10 subjects showed very few derived responses that were consistent with the original baseline discriminations. Of a total of 268 possible trials for all subjects combined in Phase 10, 52 were consistent with the early training. Twenty-four of the early-training-consistent responses were on symmetry trials, whereas 28 were on equivalence trials. Early-training-consistent responses were approximately equally probable on symmetry and equivalence trials, both for the group considered as a whole and for the individual subjects (data for individual subjects can be seen in Table 5).

DISCUSSION

Phase 10 showed effects similar to those seen in the study by Spradlin et al. (1973). Only 3 of the 23 subjects (0-b, 20-h, and 24-i) showed the sort of resilience of previous relations reported by Saunders, Saunders, Kirby, and Spradlin (1988), Spradlin et al. (1992), and Pilgrim and Galizio (1990, 1995). These findings suggest that alterations in a subset of the baseline conditional discriminations will have fairly local effects on relational responding, whereas changes in all baseline discriminations are likely to alter the composition of relational classes completely.

Although in one sense the data from this study speak to the changeability of derived relations, they also speak to their stability. In Phase 12, in which late-training-consistent responses were punished, responses did not vary randomly across the two alternative selections. Although there was considerable variability, most subjects showed a preference for the previously learned relations.

It might be argued that the punishment contingency acted as a sort of contextual cue for control over the derived responses. The negative feedback might have served as a discriminative stimulus for switching to early-training-consistent responding. However, it might be as likely that the appearance of the punishment contingency would occasion "do something new," because that strategy had worked before in the transition from early to late training. In this sense, the data show the stability of early response patterns. Behavior varies under extinction conditions, but the range of the variability is constrained by the individual's reinforcement history. This sort of effect is seen in directly trained operant responses, and also seems to occur among responses based upon derived relations.

The resurgence effects seen in this study occurred in a highly constrained three-choice discrete-trial preparation (in which one choice was punished). We cannot say whether these same resurgence effects would be seen in a free-operant context. A larger range of choices might soften the resurgence effect and produce more response variability. Future studies might examine resurgence of derived relations under less restricted conditions in order to establish the generality of these findings.

Theoretical Implications

Theoretically, we do not know whether we ought to view equivalence classes as integrated units or as embodying more flexible relations (see discussions by Hayes, Gifford, & Wilson, in press; Pilgrim & Galizio, 1995, p. 237; Spradlin et al., 1992). Overall, most subjects behaved like the subjects in Spradlin et al.'s (1973) experiment. Thus, the present study replicates findings that if enough baseline discriminations are altered, previously established equivalence classes will be disrupted and new classes will emerge. The present study extends these findings, however, because it suggests that even when these classes are disrupted they are readily reestablished. As with other operant behavior, responding relationally has properties of both flexibility and stability—properties that would be expected if deriving stimulus relations is itself operant behavior, as has been argued by some theorists (i.e., Barnes, 1994; Boelens, 1994; Hayes, 1994; Hayes et al., in press; Hayes & Wilson, 1996). The fact that stimulus relations can be partly disassembled, as seen in studies by Pilgrim and Galizio (1990, 1995), Spradlin et al. (1992), and Saunders, Saunders, Kirby, and Spradlin (1988), or changed entirely, as seen in the present study and in that of Spradlin et al. (1973), seems to argue against viewing equivalence and other derived relational responding as necessarily unitary emergent phenomena.

Clinical Implications

The aim of most applied work is to stop or reduce some forms of behavior and establish other forms. Behavioral interventions are often based on an understanding of stimulus control relevant to the disorder. The area of substance abuse provides a good example. Ternes (1977) showed that monkeys that were repeatedly injected with morphine in the presence of a particular piece of tape-recorded music showed withdrawal symptoms in the presence of that music months after they had been detoxified from the morphine. Opiate-addicted humans report similar reemergence of drug cravings and withdrawal symptoms when returned to familiar drug-using environments after detoxification and treatment (e.g., Wickler, 1977). Others have examined discriminative stimuli that are involved in drug seeking and drug use, including both exteroceptive stimuli and the interoceptive discriminative-stimulus properties that result from drug ingestion (e.g., Bickel et al., 1987). If these stimuli can participate in equivalence relations, derived stimulus control and possibly resurgence of derived relations could be important factors in treatment.

There is a small amount of research emerging in this area. DeGrandpre, Bickel, and Higgins (1992) demonstrated transfer of discriminative control over drug consumption from drug-related to arbitrary visual stimuli via participation in equivalence classes. DeGrandpre and Bickel (1993) have also shown that interoceptive stimuli resulting from drug ingestion could participate in equivalence relations with arbitrary visual stimuli. Thus, it seems likely that various eliciting and discriminative stimuli could participate in equivalence relations in the natural environment of substance abusers.

Such derived stimulus control may be relevant, for example, to cue-exposure treatments for substance abuse (e.g., Drummond & Glautier, 1994). Cue exposure necessarily involves direct exposure and subsequent extinction of elicited responses to some, but not all, drug cues. It seems likely that some drug cues acquire their stimulus functions through derived processes such as participation in equivalence relations, not simply through direct training histories (e.g., DeGrandpre & Bickel, 1993; DeGrandpre et al., 1992). Studies such as that by Dougher et al. (1994) showing transfer of extinction functions through equivalence classes provide some hope that these procedures could be effective. However, findings such as those reported by Pilgrim and Galizio (1990, 1995) suggest that we may also see changes in stimulus control for some members of a class but not others. The present findings suggest that old classes (and potentially old stimulus functions) may reemerge under some conditions.

At this point, we simply do not have sufficient experimental analyses to know which outcome will prevail and under what conditions. The rich interactions among various public and private stimuli afforded by their participation in equivalence relations, combined with the possibility of derived resurgence effects, suggest a wealth of possible means of very indirectly acquired stimulus control. To date, there have only been a handful of studies that have examined the role of relational stimulus control in psychopathology. There is much work to be done.

A basic empirical analysis of derived relational responding seems to be critical to understanding complex human phenomena. Acquisition of derived stimulus relations is robust in humans and occurs in very young children (Devaney, Hayes, & Nelson, 1986; Lipkens, Hayes, & Hayes, 1993). At the same time, several authors have suggested that resurgence effects may play an important role in phenomena as diverse as clinical regression, symptom substitution, insight, and creativity (Epstein, 1985; Epstein, Kirshnit, Lanza, & Rubin, 1984; Mowrer, 1940; O'Kelly, 1940; see also Sajwah et al., 1972). If resurgence is a ubiquitous variable in derived relational responding, there should be many opportunities for empirical analyses of resurgence that are relevant to complex human behavior.

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Received March 17, 1996
Final acceptance July 27, 1996