Reversal of equivalence relations.

Print

Author: *Smeets, Paul M.; Akpinar, Demet; Barnes-Holmes, Yvonne; Barnes-Holmes, Dermot*
Date: *Jan 1, 2003*
Words: *11830*
Publication: *The Psychological Record*
ISSN: *0033-2933*

Numerous studies have shown that after being trained on multiple arbitrary match-to-sample tasks, most verbal humans relate, without further training, all directly and indirectly linked stimuli conditionally with one another. For example, after being trained to select B1 (not B2) or C1 (not C2) when given A1, and to select B2 (not B1) or C2 (not C1) when given A2 (A1-B1, A2-B2; A1-C1, A2-C2), most humans readily match all same-class stimuli: (a) A1-A1, A2-A2; B1-B1, B2-B2; and C1-C1, C2-C2 (reflexivity), (b) B1-A1, B2-A2 and C1-A1, C2-A2 (symmetry), and (c) B1-C1, B2-C2 and C1-B1, C2-B2 (symmetric transitivity). When these matching performances occur, equivalence classes are said to be formed (A1-B1-C1, A2-B2-C2) because each member of a class is treated equivalently (e.g., Barnes, 1994; Saunders & Green, 1992; Sidman & Tailby, 1982; Wilson & Hayes, 1996).

Several studies examined whether equivalence relations can be reversed by reversing the trained relations. Equivalence reversal is important because the trained relations are held to be the basis for equivalence-class performances. At least two types of reversal training can be distinguished, complete reversal and partial reversal. In complete reversal, all initially trained relations are reversed. These reversals reliably produce equivalence reversal (Spradlin, Cotter, & Baxley, 1973; Wilson & Hayes, 1996). For example, in Experiments 1 and 2 of the Spradlin et al. study (1973), persons with mental retardation were trained on three sets of match-to-sample tasks: A-C, B-C, and A-D. This training led to the emergence of class-consistent B-D performances. Subsequent reversal training on all baseline tasks produced reversed B-D performances in all 6 subjects.

In partial reversal, only some pairs of trained relations are reversed. Partial reversal is the most frequently used procedure but often with negative results. During the period in which the current study was carrried out (1993-2000), equivalence reversal was reported only in studies involving class-specific reinforcers (Dube & McIlvane, 1995; Dube, McIlvane, Mackay, & Stoddard, 1987; Dube, McIlvane, Maquire, Mackay, & Stoddard, 1989), but not in others (Pilgrim, Chambers, & Galizio, 1995; Pilgrim & Galizio, 1990, 1995; Roche, Barnes, & Smeets, 1997; Saunders, Saunders, Kirby, & Spradlin, 1988; Spradlin et al., 1973, Experiment 3). In general, these latter studies showed that the reversed baseline relations frequently produce reversed symmetry relations while they do not affect, or partially disrupt, the symmetric transitivity performances. These findings suggest that the performances on the trained and symmetry tasks are more sensitive to contingency reversals than those on the symmetric transitivity tasks o r, as some authors formulated, that the symmetric transitivity relations become independent from the trained relations from which they emerged (Pilgrim & Galizio, 1996; Roche et al., 1997; Saunders et al., 1988; Spradlin, Saunders, & Saunders, 1992).

The present study sought to determine if these inconsistent equivalence reversals could be related to particular features of the partial reversal training. The study consists of two parts, each comprising multiple experiments, and all involving Dutch children and adults.

Part I examined if the failures to establish equivalence reversal resulted from the fact that the partial reversal training requires subjects to make novel discriminations on only some rather than on all training tasks (as in complete reversal training). If so, the equivalence performances should be easier to reverse when using a partial reversal training procedure that requires the subjects to make novel discriminations on all training tasks.

Consider the following reversal experiment (for a schematic overview, see Figure 1). At first, the subjects are trained on two 2-choice matching tasks, A-B (A1-B1, A2-B2) and A-C (A1-C1, A2-C2), and tested for symmetry (B-A, C-A) and symmetric transitivity (B-C, C-B). Then an A-B reversal is initiated.

In standard reversal training, the subjects receive the same A-B and A-C training tasks but with reversed contingencies for the A-B tasks. Thus, the subjects learn to make different B choices (A1-B2, A2-B1) while making the same C choices (A1-C1, A2-C2) before symmetry (B1-A2, B2-A1; C1-A1, C2-A2) and symmetric transitivity is assessed (B1-C2, B2-C1; C1-B2, C2-B1).

In nonstandard reversal training, the subjects must choose between two same-class comparisons: between B1 and C1, or between B2 and C2. During reversal training, the subjects receive positive feedback for selecting C1 (not B1) or B2 (not C2) when given A1, and for selecting B1 (not C1) or C2 (not B2) when given A2. This training protocol is similar to the standard reversal training in that only the A-B relations are changed. It is also similar to the effective complete reversal procedure in that it requires different choices on all training tasks. Therefore, we expected the nonstandard procedure to produce equivalence reversal more reliably than the standard procedure.

The data obtained from Experiment 1 of the current study, however, indicated that both types of reversal training were equally effective. We then carried out three more experiments to determine if these findings could be attributed to various sources of extraneous control. Again, almost all subjects demonstrated equivalence reversal. These findings raised the question whether or not the equivalence reversals were related to specific features of our training and testing program which were not in operation in previous studies.

In Part II, therefore, we modified our procedures to resemble more closely those used by Pilgrim and Galizio (1990) and Pilgrim et al. (1995). Collectively, the findings from the latter experiments were highly consistent with those obtained in Part I. Again, most subjects evidenced equivalence reversal when the probes were introduced after the reversal training had been completed. When the probes were presented before the reversal training had been completed, standard reversal produced equivalence reversal in most subjects, whereas nonstandard reversal training did not.

PART I

This part of the study examined equivalence reversal as a function of two partial-reversal training procedures, standard and nonstandard (Experiment 1), and various extraneous variables that might have contributed to the obtained findings (Experiments 2-4).

Experiment 1

This experiment compared the efficacy of standard and nonstandard reversal training in generating equivalence reversals with preschool children.

Subjects

Two groups of eight 5-year-old normally capable children were used. The age and sex of each subject are listed in Table 1. Subjects 1-8 constituted Group 1, and Subjects 9-16 Group 2.

Sessions and Setting

Sessions were conducted in a quiet room in the school building and were scheduled once a day, 5 days per week. Individual sessions lasted from 3 to 13 min (M = 9). The experiment required 13 to 18 sessions (per subject) over a time span of 22 to 24 days.

The procedures were carried out by an adult female, hereafter referred to as Experimenter 1. Three other adults served as observers, one at a time. The experimenter and subject sat at the same table facing one another. The experimenter had received extensive training in the prevention of subtle cues that could influence the subject's responses (Saunders & Williams, 1998). The reliability observer was present in the same room and was located such that she could clearly observe the subject's responses, but not the experimenter's data sheet.

Stimulus Materials

The stimuli consisted of two color patches, red (Al) and green (A2), and four black forms resembling a theta ([theta], B1), a delta ([DELTA], B2), a gamma ([GAMMA], C1), and an equal sign (=, C2). All stimuli (3.0 x 3.0 cm) were shown on white cards (6.0 x 6.0 cm). The cards were placed in windows of a display board (14.0 x 25.0 cm) (see Figure 2). The display board had two windows, each of which could hold several stacked cards. Additional materials were a tray with beads and a standing glass tube showing a mark. Filling the tube to the mark required 50 beads.

Trials, Responses, and Contingencies

A training trial started with the experimenter placing (a) the comparison cards in the windows and (b) the sample card in front of the subject. Then the experimenter waited for the subject to place the sample in one of the two windows (no time limit). A response was scored correct if the subject placed the sample card in the window with the designated correct comparison card. All other placement responses were scored incorrect. Correct responses were followed by positive feedback (e.g., "Very good," "excellent," "right") and the delivery of a bead. Incorrect responses were followed by negative feedback (i.e., "Wrong, no bead"). After each trial (training and testing), the experimenter removed all cards from the board. If on any training trial the accumulated beads reached the tube's mark (50 beads), the experimenter interrupted the session, permitted the child to exchange the beads for a picture or sticker (e.g., animal, cartoon character, soccer player), and resumed the the training. Test trials were the sam e but without scheduled consequences.

Design

All subjects received the same baseline condition. First, they were trained on four arbitrary color-form matching tasks: Al-B1 , A2-B2 and Al-C1, A2-C2. Then they received tests measuring symmetry (B-A, C-A) and symmetric transitivity (B-C, C-B). Subjects who demonstrated criterion performance on all tasks (see below) received the reversal condition: Group 1 nonstandard reversal and Group 2 standard reversal.

Baseline

Six steps were used. All subjects received training on four match-to-sample tasks: two A-B tasks in Step 1, two A-C tasks in Step 2, and a mixed A-B and A-C training in Step 3. Three additional steps were conducted without scheduled consequences: A test for maintenance of the A-B and A-C performances (Step 4), a test for symmetry (B-A, C-A; Step 5), and a test for symmetric transitivity (B-C, C-B; Step 6). Each step consisted of 12 to 40 trials. For each step, criterion on each type of task was set at the total number of trials minus one.

Step 1: Training A-B. Immediately before the presentation of the first trial, the experimenter placed cards B1 and B2 in the windows and sample cards Al and A2 on the table. The experimenter then said, "I am going to give you one of these cards, sometimes this one (experimenter pointed to Al), sometimes that one (experimenter pointed to A2). You have to place these cards on one of these two pictures, this one (experimenter pointed to B1) or this one (experimenter pointed to B2). You have to guess which one is right." From that point on the experimenter started each trial without instructions.

The revised blocked trial procedure (Smeets & Striefel, 1994) was used to help the children learn these tasks with a minimum of errors. Four substeps were used, each consisting of 12 trials (Steps 1 a, 1 b) or 16 trials (Steps 1c, 1d).

In Step 1a, the locations of the B stimuli were fixed. B1 was always located left. B2 was always located right. The samples (Al and A2) varied quasirandomly across trials. In Steps 1b-1d no introductory comments were made. In Step 1b, the locations of the B stimuli were reversed (B1 always right, B2 always left). In Step 1c, the locations of the B stimuli alternated after every 4th trial (4 trials B1 left and B2 right, 4 trials B2 left and B1 right, etc). In Step 1d, the locations of the B stimuli alternated quasirandomly across trials. The mastery criterion was set at 11/12 trials correct in Steps la and 1b, and at 15/16 trials correct in Steps 1c and 1d. Following the completion of Step 1d, the experimenter started Step 2.

Step 2: Training A-C. This step was the same as Step 1 except that no instructions were used.

Step 3: Mixed A-B and A-C training. Blocks of 16 trials were used: 8 A-B trials quasirandomly mixed with 8 A-C trials. Training continued until, in two consecutive blocks, the subjects responded correctly on 15/16 AB trials and on 15/16 A-C trials. Then the subjects advanced to Step 4.

Step 4: Testing A-B and A-C. This step assessed whether the trained performances remained intact without programmed consequences. Two blocks of 20 trials were used. In each block, the first 12 trials, which provided the data, were conducted without feedback: 6 A-B trials mixed quasirandomly with 6 A-C trials. Immediately before these trials began, the experimenter removed the bead containers from the table and informed the subjects that she would not tell whether responses were right or wrong and that no beads would be given. Once the 12 no-feedback trials were completed, the experimenter placed the bead containers on the table, saying "Now you can earn beads again," or simply, "Beads again." An 8-trial training review, 4 A-B trials mixed quasirandomly with 4 A-C trials, was then conducted with feedback. Thereafter, the entire process was repeated, yielding a total of 24 test trials and 16 training-review trials. Subjects who responded correctly on 11/12 A-B test trials, 11/12 A-C test trials, and on 15/16 tr aining-review trials, proceeded to Step 5.

Step 5: Testing B-A and C-A symmetry The procedures were the same as in Step 4, except that the test trials in each 12-trial block consisted of 3 B-A and 3 C-A trials quasirandomly mixed with 3 A-B and 3 A-C trials. Subjects who responded correctly on 5/6 B-A, 5/6 C-A, and 11/12 A-B and A-C test trials (no feedback), and on 15/16 training review trials (feedback) proceeded to Step 6. Those who did not received Step 5 once more. Then, they proceeded to Step 6 irrespective of their test performance.

Step 6: Testing B-C and C-B symmetric transitivity. Two blocks of 24 trials were used. In each block, the first 16 trials were conducted without feedback: 4 B-C and 4 C-B trials mixed with 4 A-B and 4 A-C trials. The remaining 8 trials, conducted with feedback, were a review training: 4 A-B trials mixed with 4 A-C trials. Step 6 was presented twice, with an interval of at least 24 hr between the first and second presentations. Criterion was reached when a subject responded correctly on 7/8 B-C and 7/8 C-B test trials, on 15/16 A-B and A-C test trials, and on 15/16 training-review trials during the second presentation. Subjects who demonstrated criterion performance in Step 6 without having done so in Step 5, were returned to Step 5. Subjects who demonstrated criterion performance in Steps 5 and 6 proceeded, without any introduction, to the reversal program.

Reversal

Nonstandard reversal. The procedures were the same as in baseline except that, during all trials with A stimuli as samples, the subjects were to choose between a B and a C comparison: B1 and C1, or B2 and C2 (see Table 2). Subjects 1-4 received A-C reversal training. These subjects were trained to place Al on B1 and not on C1, and A2 on C1 and not on B1 (Step 1); and to place Al on C2 and not on B2, and A2 on B2 and not on C2 (Step 2). Subjects 5-8 received A-B reversal training. These subjects were trained to place Al on C1 and not on B1, and A2 on B1 and not on C1 (Step 1); and to place Al on B2 and not on C2, and A2 on C2 and not on B2 (Step 2). Following mixed training and testing of these tasks (Steps 3 and 4), all 8 subjects received the same symmetry probes (Step 5) and symmetric transitivity probes (Step 6) as in baseline.

Standard reversal. The procedures were the same as in baseline except that the contingencies for the A-C performances (Subjects 9-12) or A-B performances (Subjects 13-16) were reversed.

Reliability

The observers monitored 2232 training trials (31%) and 1072 test trials (29%). The observers and experimenter agreed on all but 1 training trial and on all test trials.

Results and Discussion

Table 3 shows the required numbers of trials for completing the training and testing of the A-B and A-C tasks in Steps 1-4, and the percentages of correct responses during the symmetry and symmetric transitivity probes in Steps 5 and 6 during baseline and reversal.

Baseline

All 16 subjects completed the A-B and A-C training and testing (Steps 1-4) in a near errorless fashion and continued to respond accurately on these trials when presented in Steps 5 and 6. All subjects immediately demonstrated criterion performance on the symmetry probes (Step 5) and on the symmetric transitivity probes (Step 6).

Reversal

All 16 subjects progressed through the training in near errorless fashion, continued to respond accurately on these tasks under testing conditions (i.e., no resurgence), and demonstrated symmetry performances consistent with the newly trained relations. Fourteen subjects, 7 in each group, demonstrated reversed symmetric transitivity, most during the first presentation.

These findings indicated that, regardless of which reversal protocol was used, the reversed contingencies controlled the training and test performances much better than would be expected on the basis of the literature available at that time (Michael & Bernstein, 1991; Pilgrim & Galizio, 1990; Saunders et al., 1988; Spradlin et al., 1973, Experiment 3). Could these findings be related to extraneous variables such as the duration of the experiment, the response topography (i.e., placing samples on comparisons rather than pointing to comparisons), or facial cues from the experimenter? These questions were addressed in Experiments 2-4.

Experiment 2

This experiment examined if the reversed equivalence measures, notably symmetric transitivity, could be related to the length of the experiment. The interval between the last presentation of the baseline symmetric transitivity test and the first presentation of the reversed symmetric transitivity test varied from 13 to 17 days (M = 16). Although studies with persons with retardation have shown that equivalence relations can be maintained over periods much longer than 16 days (e.g., Spradlin et al., 1992), these intervals might have been long enough to cause some deterioration or "forgetting" of derived relations in these young children. Could the results of Experiment 1 be replicated with adults capable of completing the experiment in one session and surely not forgetting the initially derived relations?

Method

Eight 17- to 21-year-old students from a local high school and a teachers' college participated (see Table 1). The subjects were recruited through notice board announcements and personal contacts and were paid for their participation. The experimental sessions were conducted in a quiet room of the school or college building, or in one of the lab rooms of the university. The experimenter and setting (experimenter facing subject), stimuli and procedures were the same as in Experiment 1 except that (a) Steps 1c (A-B training) and 2c (A-C training) were omitted, and (b) responses on training trials were followed by verbal feedback only (no beads were used). Four subjects received nonstandard reversal training, 2 with A-C (17, 18) and 2 with A-B (19, 20). The other 4 subjects received standard reversal training, 2 with A-C (21, 22) and 2 with A-B (23, 24). All subjects completed the experiment in one session (72-94 min; M = 85).

Two new adults served as observers, one at a time. The observers monitored 576 training trials (19%) and 336 test trials (19%). The experimenter and observers disagreed on 3 training trials.

Results and Discussion

All subjects completed the experiment with very few if any errors (see Table 4). This finding suggested that the reversal data of Experiment 1 probably were not related to the time interval between equivalence tests.

Experiment 3

This experiment examined whether the findings of Experiments 1 and 2 could be related to the response topography (de Rose, 1996). In both of these experiments, the subjects were required to place the sample cards on the designated comparisons rather than, as in most equivalence studies, to point to the comparisons or make a key-press response. Although similar stimulus-displacement performances (i.e., lifting comparison stimuli) were also used in previous research (Pilgrim et al., 1995; Pilgrim & Galizio, 1990, 1995), placing samples on comparisons could have facilitated equivalence formation.

Method and Results

Four new high school students participated (see Table 1). The experimenter, setting and duration (one session), materials, and procedures were the same as in Experiment 2, except that the subjects were instructed to point to the comparisons. Subjects 25 and 26 received nonstandard reversal training, and Subjects 27 and 28 standard reversal training; Subjects 25 and 27 on the A-C relations, and Subjects 26 and 28 on the A-B relations. A new adult served as reliability observer. The observer monitored 608 training trials (40%) and 336 test trials (38%). The experimenter and observer disagreed on 1 training trial and 1 test trial.

Both reversal protocols induced reversed baseline, symmetry, and symmetric transitivity performances in all 4 subjects (see Table 4). These findings suggest that the reversed relations in Experiments 1 and 2 were not related to the response topography.

Experiment 4

This experiment examined whether the results of Experiments 1-3 could be restricted to subjects of normal if not superior intelligence and be related to the experimenter and setting. Because all these experiments were conducted by Experimenter 1, always sitting across the table and facing the subjects, the many near perfect probe performances could be inadvertently controlled by facial cues. Could the results of Experiments 1-3 be replicated with a new experimenter sitting next to the subject and with subjects of sub-average intelligence?

Method

Eight new children participated (see Table 1), four normally developing 5-year-olds (Subjects 29-32) and four 8-year-olds with JQs from 63 to 71 (WISC, Revised Amsterdam Child Intelligence Test [RAKIT]) (Subjects 33-36).

Four subjects received nonstandard reversal training, 2 on the A-C relations (29, 33) and 2 on the A-B relations (30, 34). Four other subjects received standard reversal training, 2 on the A-C relations (31, 35) and 2 on the A-B relations (32, 36). The procedures were the same as in Experiment 3 except that a new experimenter was used (Experimenter 2). The experimenter was seated next to the subject on the same side of the table (no facial contact except when addressing the subject).

Seven other adults served as reliability observers, one at a time. The observers monitored 1032 training trials (30%) and 864 test trials (46%). The observers and experimenter disagreed on 1 training trial and 2 test trials.

Results and Discussion

Except for Subject 35, all subjects demonstrated equivalence reversal. Subject 35 responded always correctly during the symmetry probes (B1-Al, B2-A2; Cl-A2, C2-Al) and always incorrectly during the symmetric transitivity probes (B1-Cl, B2-C2; Cl-B1, B2-02). The performances of the other 7 subjects were consistent with those obtained in Experiments 1-3. One of these children (33) responded inaccurately during the symmetry and trained tasks. After the A-B and A-C tasks were trained again (Steps 3 and 4), his symmetry and symmetric transitivity performances were consistent with the reversed trained relations (see Table 5). These findings suggested that the equivalence reversals in Experiments 1-3 were not based on any facial cues from Experimenter 1 and not restricted to subjects of normal intelligence.

Discussion of Part I

In summary, the results of Experiments 1-4 were much different from those reported in previous studies in which similar one-to-many protocols and same-size equivalence classes were used (e.g., Pilgrim et al., 1995; Pilgrim & Galizio, 1990; Spradlin et al., 1973, Experiment 3). Contrary to expectations, nonstandard and standard reversal training produced (near) immediate reversal of the trained (A-B, A-C) and symmetry relations (B-A, C-A) in all 36 (100%) subjects, and reversed symmetric transitivity relations in 33 (92%) subjects of Experiments 1-4 (for an overview, see Table 6).

PART II

The following three experiments examined if the equivalence reversal in Experiments 1-4 could be related to specific features of the program. Unlike all other equivalence reversal studies, the current training procedures were designed to establish the initial and reversed baseline tasks (A-B, A-C) with a minimum of errors and may have implied considerable overtraining.

Also the testing procedures differed in several ways from those used in previous research. One obvious difference is the onset of probing. Unlike in some other studies (Michael & Bernstein, 1991; Pilgrim & Galizio, 1990), the equivalence probes were not introduced until the reversal training was completed. In the adult study by Pilgrim and Galizio (1990), for example, the equivalence probes were presented well before the (intermittent) reversal training (Al-Bi, A2-B2; A1-C2, A2-C1) was completed. Hence, the control by the initially trained relations should be undiminished when the first probe trials were presented (Garotti, De Souza, De Rose, Molina, & Gil, 2000).

Also the proportions of equivalence probe trials were different. In Experiments 1-4 of the current study, half the trials of each probe block measured equivalence (B-A, C-A or B-C, C-B) and the other half the trained relations (A-B, A-C). In the studies by Pilgrim and Galizio, these proportions were 25% and 75%, respectively. Perhaps, these low proportions of equivalence trials affected the outcome negatively.

Our equivalence reversals could also be related to the sequential arrangement of the probes. Except for Subject 3 in Experiment 1, all subjects entered the symmetric transitivity probes only after symmetry had been demonstrated. In the studies by Pilgrim and Galizio, the symmetry probes were repeatedly alternated with symmetric transitivity probes. Thus, the class-inconsistent performances during a symmetric transitivity test could have affected the performance on the subsequent symmetry test, and Vice versa.

Finally, the contrasting results could be related to the number of probe presentations. In the studies by Pilgrim and Galizio, the reversal training was not initiated until a strict stability criterion had been met for all probe and baseline trials for at least eight consecutive sessions. This protracted probing may have encouraged the subjects to simply repeat what they had done in previous sessions thereby permitting the various relations to function independently from one another (i.e., A-B, B-A separate from A-C, C-A, separate from B-C, C-B). In Experiments 1-4 of the current study, the subjects received only one or two presentations of each probe. Thus, the probe performances may have been more sensitive to the trained relations.

The following experiments, therefore, incorporated a number of changes to make our procedures more similar to those used by Pilgrim and Galizio (Pilgrim et al., 1995; Pilgrim & Galizio, 1990). First, the A-B and A-C relations each were trained in a single step (no more fine-grained multiple-step training). Mastery criterion for any training step was set 14/16 responses correct (in Part I: N-1 responses correct). Second, in each test block, the proportions of equivalence trials and baseline trials were 25% and 75%, respectively. The proportions of reinforced and non-reinforced trials were 33% and 67%, respectively (half of the training trials were reinforced). Third, each symmetry probe was followed by an equivalence probe. This cycle was repeated at least three more times. Fourth, all adults participated in at least four sessions, spread over 3 to 6 days with a minimum of at least 3 hours between sessions (in Part I, all adults completed experiments in one session; in the study by Pilgrim and Galizio [1990], the adults required eight or more sessions). Individual sessions were restricted to six or seven blocks (i.e., 96 to 112 trials) or 50 mm. Fifth, the intertrial interval was set at 12 s (in Part I these intervals lasted 5-6 s; Pilgrim and Galizio [1990] used 15-s intervals). Following the completion of each response, the experimenter pressed a button of a timing device and waited for an auditory signal before starting the next trial. Finally, only A-C relations were reversed (in Part I, A-C or A-B relations were reversed).

In Experiment 5, the probes were presented after the reversal training had been completed (see Pilgrim et al., 1995). In Experiment 6, the probes were introduced at the onset of the (intermittent) reversal training (see Pilgrim & Galizio, 1990). Experiment 7 examined whether the (non)reversed equivalence performances in Experiment 6 were related to the discriminated probability of feedback in training and probe trials.

General Method

Subjects

Eight 5-year-old children and 22 adults participated. None of the subjects had participated in any course on equivalence or had participated in equivalence research before. The recruitment procedures were the same as in Part I.

Experimenter, Stimuli, Tasks, and Setting

All three experiments were conducted by a new experimenter (Experimenter 3). The stimuli, tasks, response topography (placing samples on comparisons), setting (experimenter facing the subject), instructions, and contingencies were the same as in Experiment 1 (Part I).

Training and Testing Sequence

The training and testing sequence was the same as in the studies by Pilgrim and Galizio. The full program consisted of 13 steps (see Table 7).

Baseline: Steps 1-7. The A-B and A-C relations each were trained in a single step, A-B in Step 1, and A-C in Step 2. Each step consisted of blocks of 16 trials, 8 trials of one relation (e.g., Al-B1) and 8 trials of the other relation (A2-B2). Criterion performance on each of two consecutive blocks was required to proceed to the next step. Step 3 was the same except that (a) each block consisted of 8 A-B trials quasirandomly mixed with 8 A-C trials, and (b) criterion performance on one block was sufficient to proceed to the next step. Steps 4 and 5 were the same as Step 3, except that the reinforcement density was reduced to 75% in Step 4 (6/8 A-B trials and 6/8 A-C trials were reinforced) and to 50% in Step 5 (4/8 A-B trials and 4/8 A-C trials were reinforced). Prior to the introduction of the first trial in Step 4, the experimenter said, "From now on, I will not always tell you whether you were right or wrong."

Symmetry (B-A, C-A) was tested in Step 6, and symmetric transitivity (B-C, C-B) in Step 7. Each step consisted of 10 test trials (no feedback): 4 probe trials (2 B-A and 2 C-A, or 2 B-C and 2 C-B trials) and 6 baseline trials (3 A-B and 3 A-C trials). These test trials were quasirandomly mixed with six training (3 A-B and 3 A-C) trials (100% reinforcement). Steps 6 and 7 each were presented at least four times, one after another (6, 7, 6, 7, 6, 7, 6, 7). Subjects who, during the last four presentations, responded correctly on at least 11/12 baseline trials in each presentation, and on at least 7/8 symmetry trials and 7/8 symmetric transitivity trials, proceeded, without any form of introduction, to the reversal training (same as in Part I).

Standard A-C reversal: Steps 8-13. Except for the reversed contingencies, the procedures for Steps 8-13 were the same as for Steps 2-7: A-C training in Step 8 (100% reinforcement), mixed A-C and A-B training in Steps 9 (100% reinforcement), 10 (75% reinforcement), and 11 (50% reinforcement), symmetry testing in Step 12, and symmetric transitivity testing in Step 13. Steps 12 and 13 each were presented at least four times, one after another (12, 13, 12, 13, 12, 13, 12, 13), provided that, during each of the last four presentations, 11/12 A-B and A-C trials were scored correct.

Nonstandard A-C reversal: Steps 8-13 The procedures were the same for standard reversal except that the subjects were trained to relate (a) A1 to B1 and not to Cl, and A2 to Cl and not to B1 (Al-B1, A2-C1), and (b) Al to C2 and not to B2, and A2 to B2 and not to C2 (Al-C2, A2-B2). Two relations (Al-B1 and A2-C1) were trained in Step 8, and all four relations (Al-B1, A2-B2, A1-C2, A2-C1) were trained in Step 9 (see Table 7).

Experiment 5

This experiment was a modified replication of the Pilgrim et al. study (1995). Although their study dealt only with children, we used adults as well. After demonstrating class-consistent B-A, C-A, B-C, and C-B relations as a result of A-B and A-C training, the subjects received A-C reversal training, first in isolation, then together with the unchanged A-B tasks. After reducing the reinforcement density from 100% to 50%, the symmetry probes and symmetric transitivity probes were introduced.

Eight 5-year-old children and six adults participated (see Table 1). After demonstrating the designated baseline performances in Steps 1-7, reversal Steps 8-13 were introduced. Half the subjects of each population (Subjects 37-40, 45-47) received standard reversal training, the other half nonstandard reversal training (Subjects 41-44, 48-50).

The observers monitored 1006 training trials (26%) and 1077 probe trials (40%). The experimenter and observers disagreed on 1 training trial.

Results and Discussion

Prior to the introduction of the reversal training, 6 subjects were replaced 3, (all children) because they failed to learn the A-B and A-C tasks, and 3 (2 children and 1 adult) because of equivalence-inconsistent probe performances. The remaining children required 13 to 25 sessions (M = 16) to complete the experiment. The sessions lasted 8-30 min (M = 15) and were spread over 12 to 30 days. The adults completed the experiment in four sessions spread over 3 to 6 days. Tables 8 and 9 show the percentages of correct responses on the prereversal and postreversal probe trials and on the intermittently reinforced training trials for the subjects who completed the experiment. In these and all following tables, group data (mean percentages of correct responses) are reported. Data on individual subjects are reported only for those with atypical performances.

All subjects learned the A-B and A-C tasks in Steps 1-5 with little or no difficulties (Children: M = 156 trials, Range: 112-288; Adults: M = 117 trials, Range: 112-192), and immediately or quickly demonstrated stable class-consistent performances during the symmetry and symmetric transitivity probes (Steps 6 and 7). They learned the reversed training tasks (Steps 8-11) in close to the minimum number of trials (Children: M = 90, Range: 80-112; Adults: M= 83 trials, Range: 80-96) and, except for Subjects 40 (standard reversal) and 50 (nonstandard reversal), evidenced probe performances that were consistent with the retrained A-B and A-C relations (Steps 12 and 13).

In spite of procedures being similar to those used by Pilgrim et al. (1995), present findings are highly consistent with those obtained in Part I. Of the 14 participants, 13 (93%) showed symmetry performances that were consistent with the unchanged A-B and the reversed A-C relations. Of these 13 subjects, 12 (92%) also showed symmetric transitivity. The new training procedure, however, was far less effective in teaching young children the initial baseline tasks (A-B and A-C) and generating equivalence relations (B-C, C-B) than the errorless training procedure (Smeets & Striefel, 1994) that was used in Experiments 1-4.

Experiment 6

This experiment was a modified replication of the Pilgrim and Galizio study (1990) with adults. After obtaining class-consistent B-A, C-A, B-C and C-B probe performances as a result of A-B and A-C training, the subjects continued to receive the equivalence probes while receiving intermittent reversal training (A1-B1, A2-B2; A1-C2, A2-C1). Unlike in Experiments 1-5, the probes were presented before the reversal training was completed.

Method

Eight adults participated (see Table 1). After demonstrating the designated baseline performances in Steps 1-7 (see Table 7), all subjects immediately proceeded to Steps 12 and 13 (reversal). Subjects 51-54 received standard reversal and Subjects 55-58 nonstandard reversal. Following the completion of the last trial, all subjects were given some more symmetry and symmetric transitivity trials and were asked to explain the selections.

The observers monitored 510 training trials (31%) and 387 test trials (27%). The experimenter and observers disagreed on 1 test trial.

Results and Discussion

The results are shown in Table 10. All subjects quickly learned the baseline training tasks in Steps 1-5 (M = 118 trials, Range: 112-128), responded class consistently during the probes (Steps 6 and 7), and needed no more than three trial blocks to adapt their A-B and A-C performances in accordance with the changed contingencies (Steps 12 and 13). The probe performances, however, differed markedly between conditions.

Standard reversal training produced symmetry reversal in all 4 subjects (51-54) and symmetric transitivity reversal in 3 of them (52-54).

All 4 subjects explained their probe performances on the basis of the trained relations. So did Subject 51 who did not reverse his performance during the symmetric transitivity test. He explained his symmetry performances (B-A, C-A) by saying that these selections were (sometimes) followed by feedback while those during the symmetric transitivity tests (B-C, C-B) were not. Therefore, he responded during the symmetric transitivity test as before. This explanation suggested a contingency discrimination problem that led to inadequate partitioning (training and symmetry vs. symmetric transitivity) (see also Pilgrim & Galizio, 1996). Therefore, we asked all following subjects whether their performances on the baseline (A-B, A-C) and equivalence probes, B-A, C-A, B-C, C-B) were sometimes or never followed by feedback. AU 3 other subjects (52-54), who demonstrated symmetry and symmetric transitivity indicated that baseline trials were sometimes and the probe trials never followed by feedback.

Nonstandard reversal produced no symmetry and no symmetric transitivity reversal in any of the 4 subjects (55-58). All these subjects explained their probe performances in terms of the initially trained A-B and A-C relations (e.g., "Because in the beginning, I learned that ..."). All 4 subjects stated that responding on all trials was (sometimes) followed by feedback or could not recall whether feedback was given or not.

In conclusion, the concurrent intermittent reversal training and probing generated performances much different from those reported by Pilgrim and Galizio (1990). With one exception (Subject 51), standard and nonstandard reversal training generated symmetry and symmetric transitivity performances that were consistent with one another. These findings do not support the view that transitivity relations are less sensitive to contingency reversal than symmetry relations (Pilgrim & Galizio, 1996).

Experiment 7

This experiment examined how the discrimination of reinforcement probability and equivalence reversals were related to one another. The results of Experiment 6 could indicate that this discrimination is a necessary or facilitative condition for equivalence reversal to occur. If so, training the subjects to reliably predict the probability of feedback across different types of trials should produce more equivalence reversals. Alternatively, this discrimination could have been a concurrent phenomenon of equivalence reversal or a product of the standard reversal protocol. If so, training the subjects to discriminate the probability of feedback should have no effect.

Method

Participants were 8 adults, 2 male and 6 female (see Subjects 59-66, Table 1). Subjects 59-62 received standard reversal training, and Subjects 63-66 nonstandard reversal training. The procedure was the same as in Experiment 6 except the subjects were trained to accurately predict the probability of feedback on each training and test trial. Some subjects received this training during Baseline Steps 6 and 7 (Standard Reversal Subjects 59 and 60, and Nonstandard Reversal Subjects 63 and 64), others during Reversal Steps 12 and 13 (Standard Reversal Subjects 61 and 62, and Nonstandard Reversal Subjects 65 and 66).

This was done as follows: After presenting the stimuli and before giving the subject the opportunity to respond, the experimenter asked, "Look at the cards. After you have made your choice, will I tell you whether you are right or wrong? Please respond by saying 'Perhaps' or 'Certainly not'." Al I predictions were recorded. A prediction was recorded correct when a subject responded in accordance with the programmed contingencies: "Perhaps" when given any A-B or A-C trial, and "Certainly not" when given any B-A, C-A, B-C, or C-B trial. All other predictions and verbalizations (e.g., "Don't know") were recorded incorrect. Correct predictions were followed by positive feedback ("Good"). Incorrect predictions were followed by the experimenter stating the correct prediction, "Perhaps" or "Certainly not." Subjects were thus always informed about the probability of reinforcement prior to each comparison selection.

The experiment consisted of 1592 training trials and 1416 test trials. Contingency predictions were made on 508 training trials and on 384 probe trials. The observers monitored 856 selection responses on training trials (54%), 788 selection responses on test trials (56%), 408 contingency predictions on training trials (80%), and 308 contingency predictions on probe trials (80%). The observers and experimenter agreed on all selection responses and on all but 3 prediction responses (all on test trials).

Results and Discussion

All subjects learned the baseline training tasks in Steps 1-5 (M = 112.0 trials, no range), responded class consistently during the baseline probes (Steps 6 and 7), and needed 1 to 4 blocks to adapt their A-B and A-C performances in accordance with the changed contingencies (see Table 11). The accuracy of the contingency predictions ranged from 96.9-99.0% (M = 98.2) for the training trials and from 96.9-100% (M = 99.2) for the test trials.

The probe performances were basically the same as in Experiment 6. Standard reversal training produced equivalence reversal in all 4 subjects whereas nonstandard reversal training failed to do so in 3 of 4 subjects. All subjects who evidenced equivalence reversal later explained their performances in terms of the initially trained A-B and AC relations in combination with the reversed contingencies for the A-C tasks. The reversed contingencies were also mentioned by the subjects who did not show equivalence reversal. Yet this did not affect their probe performances because these trials were never reinforced. These findings suggest that (a) the discrimination of contingencies does not contribute to equivalence reversal and (b) in Experiment 6, the discriminated contingencies were a correlate of equivalence reversal.

Discussion of Part II

In conclusion, the changed procedures produced data much different from those reported by Pilgrim and Galizio. Standard reversal training produced symmetry reversal in all 15 subjects. Of these subjects, 13 also showed symmetric transitivity reversal, 6/7 when the probes were introduced after the training had been completed (Experiment 5), and 7/8 when the probes were introduced before (Experiments 6 and 7). Nonstandard reversal training also produced reversed symmetry and symmetric transitivity in most (6/7) subjects when the probes were introduced after the training had been completed (Experiment 5), but only in 1/8 subjects when the probes were introduced before (Experiments 6 and 7). Standard reversal training was thus more effective than nonstandard reversal training in establishing symmetry and symmetric transitivity that were consistent with the reversed baseline relations.

Equally important, the effects of the reversal training were almost always consistent within individuals. That is, symmetry and symmetric transitivity performances either reversed together (standard and nonstandard reversal training) or both failed to reverse (nonstandard reversal training). Unlike what has been reported elsewhere (Pilgrim et al., 1995; Pilgrim & Galizio, 1990; Roche et al., 1997), the symmetry and symmetric transitivity performances were equally sensitive or insensitive to the retrained relations.

Some of these data could be seen as biased or as incomplete. As a result of eliminating the fine-grained training procedure (Smeets & Striefel, 1994), in Experiment 5, 5 children had to be replaced by other children because they failed to learn the training tasks or failed to respond class consistently during the equivalence probes in baseline. This number was disproportionally high compared to the number of children replaced (1/24) in Part I. It may be argued, therefore, that the children who completed Experiment 5 were more advanced. This problem could have been avoided by exposing these five "failing" children to the fine-grained training program that was used in Part I. This approach, however, would have contaminated our purpose to replicate the training procedures that were used with 4 of the 8 children (DI, KI, DR, LA) in the Pilgrim et al. study (1995). These 4 children completed the baseline phase successfully, but showed no equivalence reversal.

Because the results of Experiments 6 and 7 were, at least in part, different from those in Experiments 1-5, the absence of child data could be seen as an omission. The reason to restrict these experiments to adults was based on previous pilot work indicating that most preschoolers do not benefit from intermittent reversal training.

GENERAL DISCUSSION

The present study set out to identify variables that prevented equivalence reversal in several studies that were available at the time this research was initiated (Michael & Bernstein, 1991; Pilgrim & Galizio, 1990; Saunders et al., 1988; Spradlin et al., 1973, 1992). Experiment 1 investigated whether these nonreversals could be related to the fact that the standard reversal procedure requires the subjects to make different selections on only some training tasks. If correct, this problem should not occur when subjects are required to make novel discriminations on all training tasks (nonstandard protocol). The data proved this assumption to be incorrect. Both types of reversal training (standard, nonstandard) produced equivalence reversal in most subjects. Experiments 2-7 examined whether this finding could be related to the subject's age and mental ability, the response topography, the identity and location of the experimenter, specific features of the training and testing design that were different from thos e used in previous research (Pilgrim & Galizio, 1990; Pilgrim et al., 1995) or to discriminating the probability of feedback during training and test trials. Again, both training protocols almost always produced equivalence reversal unless the probes had been already introduced at the onset of the nonstandard reversal training. Contrary to many earlier studies (Pilgrim et al., 1995; Pilgrim & Galizio, 1990, 1995, 1996; Roche et al., 1997), (a) equivalence reversal was a very reliable and robust phenomenon, (b) symmetry and symmetric transitivity were equally sensitive to the reversed contingencies, and (c) children responded as consistently to the changed contingencies as adults.

The question remains how these contrasting findings can be accounted for. Previous commentaries already identified several processes and variables that could have prevented equivalence reversal in the studies by Pilgrim and Galizio. Some suggested that the reversed contingencies could have induced a switch from Type S relations to Type R relations (Carrigan & Sidman, 1992; Garotti et al., 2000). Others related the negative findings to the baseline history, nodal distance, the early introduction of the probes, control by contextual cues or the absence thereof, and the use of atypical (3-dimensional) stimuli, response topography (lifting of objects), and apparatus (WGTA) (Garotti et al., 2000; Spradlin et al., 1992). The present study, notably Experiments 5-7, included several of the aforementioned features, yet they did not interfere with equivalence reversal. Clearly, the negative findings reported by Pilgrim and Galizio (Pilgrim et al., 1995; Pilgrim & Galizio, 1990) require alternative explanations. Perhaps their failures to generate reversed equivalence resulted from the fact that, in both of their studies, all subjects had already participated in (unspecified) conditional discrimination training and equivalence class testing before they entered the experiments. In the current study, none of the subjects had any experience with equivalence-related tasks.

Alternatively, our positive findings could be seen as a spurious product of the often criticized table-top arrangement (Saunders & Williams, 1998). Perhaps, our search for extraneous sources of stimulus control had not been thorough enough. Our findings, however, do not stand alone. The results of Experiments 1-5 are entirely consistent with those reported in two computer controlled studies that came to our attention just before and after the data collection in the current study had been completed (Garotti et al., 2000; Saunders, Drake, & Spradlin, 1999). Both these studies, one with adults (Garotti et al., 2000) and one with children (Saunders et al., 1999), used the same sequence (i.e., probing after reversal training) and both reported that most subjects demonstrated reversed equivalence. These findings are consistent with Sidman's formulations (Sidman, 1986, 1992, 1994; Sidman & Tailby, 1982); hence, they do not need further explanation. What remains to be explained, however, are the different outcomes of the standard and nonstandard training protocols in Experiment 6 and 7.

In both these experiments, the first probe trials were presented only after a few intermittently reinforced training trials had been completed.

Thus, the control by the original relations (trained with continuous reinforcement) should supersede, or at least interfere with, the control by the changed relations (trained with intermittent reinforcement) (Dube & McIlvane, 1996; Garotti et al., 2000). This is exactly what occurred in nonstandard reversal but not in standard reversal, typically from the first probe trials onwards. This finding may indicate that the reversed and nonreversed equivalence performances were, at least in part, controlled by contextual cues (e.g., Bush, Sidman, & De Rose, 1989; Lynch & Green, 1991; Meehan & Fields, 1995).

The standard reversal protocol was the same as in baseline except that the contingencies for the A-C tasks were changed. As a result, the subjects may have learned to make opposite selections when given C stimuli (C-A, B-C, C-B) and to respond as before when given no C stimuli (A-B, B-A) (for similar accounts, see Lynch & Green, 1992; Saunders et al., 1999). The nonstandard reversal protocol involved not only different contingencies but also different format stimulus configurations. These configurations required the subjects to choose between two previously correct or two previously incorrect comparisons (B1 vs. C1 or B2 vs. C2), thereby making it impossible to make same or opposite selections on any task. Even if they did, the subjects may have done so only when the comparison pairs were different (e.g., B1 vs. C1) from those in baseline (B1 vs. B2). If so, it should come as no surprise that during the symmetry and symmetric transitivity probes (same pairs of comparisons as in baseline), the subjects respond ed as before. Unless the probes were presented after the reversal training had been completed (Experiments 1-5), the probe performances continued to be directly controlled by the initially trained stimulus relations. In any case, the seven experiments reported here clearly demonstrate that the fracturing of symmetry from symmetric transitivity following reversal training is not a robust phenomenon.

Table 1

Sex (F/M) and Age of Each Subject

PART I PART II

Exp 1 Exp 2 Exp 3 Exp 4 Exp 5 Exp 6

1 F 5;5 17 F 17 25 F 18 29 F 5;3 37 F 5;4 51 M 24
2 M 5;3 18 M 19 26 M 18 30 M 5;3 38 F 5;5 52 M 23
3 F 5;4 19 F 19 27 M 17 31 F 5;3 39 F 5;6 53 F 23
4 M 5;1 20 F 18 28 F 17 32 M 5;4 40 F 5;6 54 F 22
5 F 5;3 21 M 17 33 M 8;4 IQ 67 41 F 5;5 55 M 22
6 F 5;4 22 F 17 34 F 8;3 IQ 65 42 F 5;2 56 M 22
7 F 5;2 23 M 21 35 M 8;10 IQ 71 43 F 5;3 57 F 20
8 M 5;0 24 F 17 36 M 8;4 IQ 63 44 F 5;9 58 F 24
9 M 5;5 45 F 21
10 M 5;3 46 F 19
11 F 5;3 47 F 23
12 M 5;2 48 F 22
13 F 5;6 49 M 22
14 F 5;0 50 F 19
15 M 5;5
16 F 5;1

PART II

Exp 1 Exp 7

1 F 5;5 59 F 23
2 M 5;3 60 F 32
3 F 5;4 61 M 19
4 M 5;1 62 F 22
5 F 5;3 63 M 23
6 F 5;4 64 F 21
7 F 5;2 65 F 22
8 M 5;0 66 F 24
9 M 5;5
10 M 5;3
11 F 5;3
12 M 5;2
13 F 5;6
14 F 5;0
15 M 5;5
16 F 5;1

Note: Ages of adults are expressed in years. Ages of children are expressed in years and months.

Table 2

Trial Compositions in Experiments 1-4

Nonstandard Reversal Standard
Reversal
Baseline A-C Rev A-B Rev A-C Rev

Train & Test
A1: B1/B2 A1: B1/C1 A1: C1/B1 A1: B1/B2
A2: B2/B1 A2: C1/B1 A2: B1/C1 A2: B2/B1
A1: C1/C2 A1: C2/B2 A1: B2/C2 A1: C2/C1
A2: C2/C1 A2: B2/C2 A2: C2/B2 A2: C1/C2
Symmetry Test
B1: A1/A2 B1: A1/A2 B1: A2/A1 B1: A1/A2
B2: A2/A1 B2: A2/A1 B2: A1/A2 B2: A2/A1
C1: A1/A2 C1: A2/A1 C1: A1/A2 C1: A2/A1
C2: A2/A1 C2: A1/A2 C2: A2/A1 C2: A1/A2
Symmetric Transitivity Test
B1: C1/C2 B1: C2/C1 B1: C2/C1 B1: C2/C1
B2: C2/C1 B2: C1/C2 B2: C1/C2 B2: C1/C2
C1: B1/B2 C1: B2/B1 C1: B2/B1 C1: B2/B1
C2: B2/B1 C2: B1/B2 C2: B1/B2 C2: B1/B2

Standard
Reversal
Baseline A-B Rev

Train & Test
Al: B1/B2 A1: B2/B1
A2: B2/B1 A2: B1/B2
Al: Cl/C2 A1: C1/C2
A2: C2/C1 A2: C2/C1
Symmetry Test
Bl: Al/A2 B1: A2/A1
B2: A2/A1 B2: A1/A2
Cl: A1/A2 C1: A1/A2
C2: A2/A1 C2: A2/A1
Symmetric Transitivity Test
Bl: Cl/C2 B1: C2/C1
B2: C2/Cl B2: C1/C2
Cl: Bl/B2 C1: B2/B1
C2: B2/Bl C2: B1/B2

Note. In all trial types, the sample is left and the correct comparison right of the colon (:).

Table 3

Numbers of Required Training Trials (Steps 1-4) and Percentages of Test Trials Correct (Steps 5-6) in Experiment 1 (Normal Children)

Subjects Group 1
Steps Relations 1 2 3 4

BASELINE
1-4 A-B, A-C 200 244 200 200
5 B-A, C-A 100 100 100 100
6 B-C, C-B 100 100 100 100
100 100 100 100

Subjects Group 1 Subjects Group 2
Steps 5 6 7 8 9 10

BASELINE
1-4 200 200 200 212 200 244
5 100 100 100 100 100 100
6 100 100 100 100 100 88
100 100 100 94 100 100

Subjects Group 2
Steps 11 12 13 14 15

BASELINE
1-4 200 200 200 200 200
5 100 92 100 100 100
6 94 100 100 94 100
94 100 94 100 100

Subjects
Group 2
Steps 16

BASELINE
1-4 212
5 100
6 100
100

REVERSAL NONSTANDARD
A-C

1-4 A-B, A-C 200 200 200 200
5 B-A, C-A 100 100 75 100
83
6 B-C, C-B 81 100 81 100
100 100 100 100

5 B-A, C-A 100

NONSTANDARD
A-B A-C

1-4 200 200 200 200 200 200
5 100 92 100 67 92 92
92
6 100 75 0 88 88 100
100 100 44 94 100 100
5

STANDARD
A-C A-B

1-4 212 200 200 200 200 200
5 100 100 100 100 100 100

6 94 88 50 100 94 44
100 100 94 100 100 31
5

Table 4

Numbers of Required Training Trials (Steps 1-4) and Percentages of Test Trials Correct (Steps 5 - 6) in Experiments 2 and 3 (Adults)

Subjects Exp 2
Steps Relations 17 18 19 20

BASELINE
1-4 A-B, A-C 184 168 168 168
5 B-A, C-A 100 100 100 100
6 B-C, C-B 100 100 69 100
100 100 100 100

Subjects Exp 2 Subjects Exp 3
Steps 21 22 23 24 25

BASELINE
1-4 168 168 168 168 184
5 100 100 100 100 100
6 100 100 88 100 100
100 100 100 100 100

Subjects Exp 3
Steps 26 27 28

BASELINE
1-4 168 168 168
5 100 100 100
6 100 100 100
100 100 100

RIVERSAL NONSTANDARD
A-C A-B

1-4 A-B, A-C 168 168 168 168
5 B-A, C-A 92 92 100 100
6 B-C, C-B 100 94 100 100
100 100 100 100

RIVERSAL STANDARD NONSTAND STANDARD
A-C A-B A-C A-B

1-4 168 168 168 168 168 168
5 100 100 100 100 92 100
6 100 100 100 100 100 100
100 100 100 100 100 100

RIVERSAL NONSTAND STANDARD
A-C A-B

1-4 168 168
5 100 100
6 100 100
100 100

Table 5

Numbers of Required Training Trials (Steps 1-4) and of Test Trials
Correct (Steps 5-6) in Experiment 4 (Children)

Subjects
Normal Intelligence
Steps Relations 29 30 31 32

BASELINE
1-4 A-B, A-C 168 180 180 168
5 B-A, C-A 92 100 100 100
6 B-C, C-B 100 100 100 94
100 100 100 100

Mental Retardatin
Steps 33 34 35 36

BASELINE
1-4 168 180 180 168
5 92 100 100 92
6 94 94 100 100
94 100 100 100

REVERSAL NONSTAND STANDARD

A-C A-B A-C A-B

1-4 A-B, A-C 168 168 192 184
5 B-A, C-A 92 92 100 100
6 B-C, C-B 81 94 100 94
94 94 100 100
3-4 A-B, A-C
5 B-A, C-A
6 B-C, C-B

REVERSAL NONSTAND STANDARD

A-C A-B A-C A-B

1-4 232 180 288 168
5 75 92 100 100
6 -- 81 0 94
-- 88 0 00
3-4 104
5 100
6 94
100

Table 6

Basic Conditions and Results in Experiments 1-7

Position Training
Experi- Experi- Response Prediction
Exp menter menter Topogr Feedback Subjects

PART I

1 1 facing S placing no 8 normal children
no 8 normal children

2 1 facing S placing no 4 adults
no 4 adults

3 1 facing S pointing no 2 adults
no 2 adults

4 2 next to S pointing no 2 normal children
no 2 normal children
no 2 MR children
no 2 MR children

PART II
5 3 facing S placing no 4 normal children
no 4 normal children
no 3 adults
no 3 adults

6 3 facing S placing no 4 adults
no 4 adults

7 3 facing S placing yes 4 adults
yes 4 adults

Symm-
Reversal Symm Trans
Exp Protocol Rev Rev

PART I
1 nonst 8 7
stand 8 7

2 nonst 4 4
stand 4 4

3 nonst 2 2
stand 2 2

4 nonst 2 2
stand 2 2
nonst 2 2
stand 2 1

PART II
5 stand 4 3
nonst 4 4
stand 3 3
nonst 2 2

6 stand 4 3
nonst 0 0

7 stand 4 4
nonst 1 1

Table 7

Training and Test Sequence in Experiments 5-7

BASELINE STANDARD A-C REVERSAL

%
Steps Relations Trials Reinf Steps Relations

1 A1-B1, A2-B2 16 100 8 A1-C2, A2-C1
2 A1-C1, A2-C2 16 100 9 A1-B1, A2-B2
3 A1-B1, A2-B2 8 100 A1-C2, A2-C1

A1-C1, A2-C2 8 100 10 A1-B1, A2-B2
4 A1-B1, A2-B2 8 75 A1-C2, A2-C1
A2-C2, A2-C2 8 75 11 A1-B1, A2-B2
5 A1-B1, A2-B2 8 50 A1-C2, A2-C1
A1-C1, A2-C2 8 50 12 B1-A1, B2-A2
6 B1-A1, B2-A2 2 0 C1-A2, C2-A1
C1-A1, C2-A2 2 0 A1-B1, A2-B2
A1-B1, A2-B2 6 50 A1-C2, A2-C1
A1-C1, A2-C2 6 50 13 B1-C2, B2-C1
7 B1-C1, B2-C2 2 0 C1-B2, C2-B1
C1-B1, C2-B2 2 0 A1-B1, A2-B2
A1-B1, A2-B2 6 50 A1-C2, A2-C1
A1-C1, A2-C2 6 50

STANDARD A-C NONSTANDARD A-C REVERSAL
REVERSAL

%
Steps Trials Reinf Steps Relations Trials

1 16 100 8 A1-B1, A2-C1 16
2 8 100 9 A1-C2, A2-B2 8
3 8 100 A1-B1, A2-C1 8
8 75 10 A1-C2, A2-B2 8
4 8 75 A1-B1, A2-C1 8
8 50 11 A1-C2, A2-B2 8
5 8 50 A1-B1, A2-C1 8
2 0 12 B1-A1, B2-A2 2
6 2 0 C1-A2, C2-A1 2
6 50 A1-C2, A2-B2 6
6 50 A1-B1, A2-C1 6
2 0 13 B1-C2, B2-C1 2
7 2 0 C1-B2, C2-B1 2
6 50 A1-C2, A2-B2 6
6 50 A1-B1, A2-C1 6

NONSTANDAR
D A-C
REVERSAL

%
Steps Reinf

1 100
2 100
3 100
75
4 75
50
5 50
0
6 0
50
50
0
7 0
50
50

Note. Steps 8-11 were not used in Experiments 6 and 7.

Table 8

(Mean) Percentages of Responses Correct in Experiment 5 (Children)

BASELINE

Step A-B A-C B-A C-A B-C C-B

Ss 37-40
6 100 100 100 100
7 100 100 50 50
6 100 100 100 100
7 100 96 100 88
6 100 100 100 100
7 100 100 100 88
6 100 100 100 100
7 100 100 100 100
6 100 100 100 100
7 100 100 100 100
6 100 100 100 100
7 100 100 100 100
Ss 41-44
6 100 100 75 88
7 100 100 75 100
6 100 100 100 100
7 100 100 88 88
6 100 100 100 88
7 100 100 100 88
6 100 100 100 100
7 100 100 100 100
6 100 100 100 100
7 100 100 100 100
6 100 100 100 100
7 100 100 100 100

A-C REVERSAL

STANDARD

Ss 37-39
12 100 100 100 100
13 100 100 100 100
12 100 100 100 100
13 100 100 100 100
12 100 100 100 100
13 100 100 100 100
12 100 100 100 100
13 100 100 100 100
S 40
12 100 100 100 100
13 100 100 50 50
12 100 100 100 100
13 100 100 50 0
12 100 100 100 100
13 100 100 100 50
12 100 100 50 100
13 100 100 50 0

NONSTANDARD

Ss 41-44
12 96 96 100 88
13 100 96 88 100
12 100 100 88 63
13 100 100 88 100
12 100 100 100 100
13 100 100 100 100
12 100 100 100 100
13 100 100 100 100

Table 9

(Mean) Percentages of Responses Correct in Experiment 5 (Adults)

Step A-B A-C B-A C-A B-C C-B Step A-B A-C B-A

BASELINE
Ss 45 - 47 45-47 Ss 48 - 50
6 100 100 100 100 6 94 100 100
7 100 100 100 100 7 100 100
6 100 100 100 100 6 100 100 100
7 100 100 100 100 7 100 100
6 100 100 100 100 6 100 100 100
7 100 100 100 100 7 100 100
6 100 100 100 100 6 94 100 100
7 100 100 100 100 7 100 100

Step C-A B-C C-B

BASELINE
Ss 45 - 47
6 100
7 100 100
6 100
7 100 100
6 100
7 100 100
6 100
7 100 100

A-C REVERSAL
STANDARD NONSTANDARD

Ss 45-47 Ss 48 & 49
12 89 100 100 100 12 100 100 100
13 100 100 100 100 13 100 100
12 100 100 100 100 12 100 100 100
13 100 100 100 100 13 100 100
12 100 94 100 100 12 100 100 100
13 100 100 100 100 13 100 100
12 100 94 100 100 12 100 100 100
13 100 100 100 100 13 100 100

S 50
12 100 100 100
13 100 100
12 100 100 100
13 100 100
12 100 100 100
13 100 100
12 100 100 100
13 100 100

A-C REVERSAL
STANDARD

Ss 45-47
12 100
13 100 100
12 100
13 100 100
12 100
13 100 100
12 100
13 100 100

50
0 0
0
0 0

0
0 0
0
0 0

Table 10

(Mean) Percentages of Responses Correct in Experiment 6 (Adults)

BASELINE
Step A-B A-C B-A C-A B-C C-B

Ss 51 - 54
6 100 100 100 100
7 100 100 100 100
6 100 100 100 100
7 100 96 100 100
6 100 100 100 100
7 100 100 100 100
6 100 100 100 100
7 100 100 100 100

BASELINE
Step Step A-B A-C B-A C-A B-C

Ss 51 - 54 Ss 55 - 58
6 6 100 100 100 100
7 7 100 100 100
6 6 100 100 100 100
7 7 100 100 100
6 6 100 100 100 100
7 7 100 100 100
6 6 100 100 100 100
7 7 100 100 100

BASELINE
Step C-B

Ss 51 - 54
6
7 100
6
7 100
6
7 100
6
7 100

A-C REVERSAL
Step A-B A-C B-A C-A B-C C-B

STANDARD
S 51
12 83 50 50 50
13 100 100 0 0
12 100 100 100 100
13 100 100 0 0
12 100 100 100 100
13 100 100 0 0
100 100 100 100
100 100 0 0

sS 52 - 54
12 94 78 83 83

13 100 100 100 100
12 100 100 100 100
13 100 100 100 100
12 100 100 100 100
13 100 100 100 100
12 100 100 100 100
13 100 100 100 100

A-C REVERSAL
Step Step A-B A-C B-A C-A

NONSTADARD
S 51 Ss 55 - 58
12 12 79 59 88 0
13 13 92 88
12 12 88 92 100 0
13 13 96 100
12 12 100 100 100 0
13 13 100 100
12 96 100 100 0
13 100 100
12 100 100 100 0
13 100 100
12 100 100 100 0
13 100 100
sS 52 - 54
12
13
12
13
12
13
12
13

A-C REVERSAL
Step B-C C-B

S 51
12
13 0 0
12
13 0 0
12
13 0 13

0 38

0 0

0 0
sS 52 - 54
12
13
12
13
12
13
12
13

Table 11

(Mean) Percentage of Responses Correct in Experiment 7 (Adults)

BASELINE

Step A-B A-C B-A C-A B-C C-B

Ss 59-62
6 96 100 100 100
7 100 96 88 100
6 100 100 100 100
7 100 100 100 100
6 100 100 100 100
7 100 100 100 100
6 100 100 100 100
7 100 100 100 100

BASELINE
Step Step A-B A-C B-A C-A B-C

Ss 59-62 Ss 63 - 66
6 6 100 100 88 100
7 7 100 100 88
6 6 100 100 88 100
7 7 100 100 100
6 6 100 100 100 100
7 7 100 100 100
6 6 100 100 100 100
7 7 100 100 100

BASELINE
Step C-B

Ss 59-62
6
7 88
6
7 100
6
7 100
6
7 100

A-C REVERSAL
Step A-B A-C B-A C-A B-C C-B
STANDARD

Ss 59 - 62
12 83 67 88 63
13 100 96 88 63
12 100 100 88 100
13 100 100 75 100
12 100 96 100 100
13 100 100 100 100
12 100 100 100 100
13 100 100 100 100

A-C REVERSAL
Step Step A-B A-V B-A C-A
NONSTANDARD

Ss 59 - 62 S 64

```
12 12 33 67 100 50
13 13 100 100
12 12 100 100 100 100
13 13 100 100
12 12 100 100 100 100
13 13 100 100
12 12 100 100 100 100
13 13 100 100

 Ss 63, 65, & 66 66
 12 67 77 100 17
 13 89 78
 12 94 100 100 17
 13 94 94
 12 100 72 100 0
 13 100 94
 12 100 100 100 0
 13 100 100
 12 100 100 100 0
 13 100 100

 A-C REVERSAL
Step B-C C-B


Ss 59 - 62
12
13 50 100
12
13 50 100
12
13 100 100
12
13 100 100



 17 17

 0 17

 0 0

 0 0

 0 0
```

References

BARNES, D. (1994). Stimulus equivalence and relational frame theory. The Psychological Record, 44, 91-124.

BUSH, K. M., SIDMAN, M., & DE ROSE, T. (1989). Contextual control of emergent equivalence relations. Journal of the Experimental Analysis of Behavior, 51, 29-45.

CARRIGAN, P. F., & SIDMAN, M. (1992). Conditional discrimination and equivalence relations: A theoretical analysis of control by negative stimuli. Journal of the Experimental Analysis of Behavior, 58, 183-204.

DE ROSE, J. C. (1996). Controlling factors in conditional discriminations and tests of equivalence. In T. R. Zentall & P. M. Smeets (Eds.), Stimulus class formation in humans and animals (pp. 173-195). Amsterdam: Elsevier.

DUBE, W. V., & MCILVANE, W. J. (1995). Stimulus-reinforcer relations and emergent matching to sample. The Psychological Record, 45, 591-612.

DUBE, W. W., & MCILVANE, W. J. (1996). Some implications of stimulus control for emergent behavior and stimulus classes. In T. R. Zentall & P. M. Smeets (Eds)., Stimulus class formation in humans and animals (pp. 197-217). Amsterdam: Elsevier.

DUBE, W. V., MCILVANE, W. J., MAGUIRE, R. W., MACKAY, H. A., & STODDARD, L. T. (1989). Stimulus class formation and stimulus-reinforcer relations. Journal of the Experimental Analysis of Behavior, 51, 65-76.

DUBE, W. V., MCILVANE, W. J., MACKAY, H. A., & STODDARD, L. T. (1987). Stimulus class membership established via stimulus-reinforcer relations. Journal of the Experimental Analysis of Behavior, 47, 159-175.

GAROTTI, M., DE SOUZA, D. G., DE ROSE, J. C., MOLINA, R. C., & GIL, M. A. (2000). Reorganization of equivalence classes after reversal of baseline relations. The Psychological Record, 50, 35-48.

LYNCH, D. C., & GREEN, G. (1991). Development of cross-modal transfer of contextual control of emergent stimulus relations. Journal of the Experimental Analysis of Behavior, 56, 139-145.

MEEHAN, F., & FIELDS, L. (1995). Contextual control of new equivalence classes. The Psychological Record, 45, 165-182.

MICHAEL, R. L., & BERNSTEIN, D. J. (1991). Transient effects of acquisition history on generalization in a matching-to-sample task. Journal of the Experimental Analysis of Behavior, 56, 155-156.

PILGRIM, C., CHAMBERS, L., & GALIZIO, M. (1995). Reversal of baseline relations and stimulus equivalence: II. Children. Journal of the Experimental Analysis of Behavior, 63, 239-254.

PILGRIM, C., & GALIZIO, M. (1990). Relations between baseline contingencies and equivalence probe performances. Journal of the Experimental Analysis of Behavior, 54, 213-224.

PILGRIM, C., & GALIZIO, M. (1995). Reversal of baseline relations and stimulus equivalence: I. Adults. Journal of the Experimental Analysis of Behavior, 63, 225-238.

PILGRIM, C., & GALIZIO, M. (1996). Stimulus equivalence: A class of correlations, or a correlation of classes. In T. R. Zentall & R M. Smeets (Eds.), Stimulus class formation in humans and animals (pp. 173-195). Amsterdam: Elsevier.

ROCHE, B., BARNES, D., & SMEETS, P. M. (1997). Incongruous stimulus pairing contingencies and conditional discrimination training: Effects on relational responding. Journal of the Experimental Analysis of Behavior, 68, 143-160.

SAUNDERS, R., DRAKE, K. M., & SPRADLIN, J. E. (1999). Equivalence class establishment in preschool children. Journal of the Experimental Analysis of Behavior, 71, 195-214.

SAUNDERS, R. R., & GREEN, G. (1992). The nonequivalence of behavioral and mathematical equivalence. Journal of the Experimental Analysis of Behavior, 57, 227-241.

SAUNDERS, R. R., SAUNDERS, K. J., KIRBY, K. C., & SPRADLIN, J. E. (1988). The merger and development of equivalence classes by unreinforced conditional selection of comparison stimuli. Journal of the Experimental Analysis of Behavior, 50, 145-162.

SAUNDERS, K. J., & WILLIAMS, D. C. (1998). Do parakeets exhibit derived stimulus control? Some thoughts on experimental control procedures. Journal of the Experimental Analysis of Behavior, 70, 321-324.

SIDMAN, M. (1986). Functional analysis of emergent verbal classes. In T. Thompson & M. D. Zeiler (Eds.), Analysis and integration of behavioral units (pp. 213-245). Hillsdale, NJ: Erlbaum.

SIDMAN, M. (1992). Equivalence relations: Some basic considerations. In S. C. Hayes & L. J. Hayes (Eds.), Understanding verbal relations (pp. 15-27). Reno, NV: Context Press.

SIDMAN, M. (1994). Equivalence relations and behavior: A research story. Boston, MA: Authors Cooperative.

SIDMAN, M., & TAILBY, W. (1982). Conditional discrimination vs. matching-to-sample: An extension of the testing paradigm. Journal of the Experimental Analysis of Behavior, 37, 5-22.

SMEETS, P. M., & STRIEFEL, S. (1994). A revised blocked-trial procedure for establishing arbitrary matching in children. The Quarterly Journal of Experimental Psychology, 47B, 241-261.

SPRADLIN, J. E., COTTER, V. W., & BAXLEY, N. (1973). Establishing a conditional discrimination without direct training: A study of transfer with retarded adolescents. American Journal of Mental Deficiency, 77, 556-566.

SPRADLIN, J. E., SAUNDERS, K. J., & SAUNDERS, R. R. (1992). The stability of equivalence classes. In S. C. Hayes & L. J. Hayes (Eds.), Understanding verbal relations (pp. 29-42). Reno, NV: Context Press.

WILSON, K. G., & HAYES, S. C. (1996). Resurgence of derived stimulus relations. Journal of the Experimental Analysis of Behavior, 66, 267-281.

Address correspondence to Paul M. Smeets, Behavior Analysis Unit, Department of Psychology, Leiden University, PO Box 9555, 2300 RB Leiden, The Netherlands.