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ESTABLISHING EQUIVALENCE RELATIONS USING A RESPONDENT-TYPE TRAINING PROCEDURE III

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In this study, 12 5-year-old normal functioning children were exposed to a respondent-type training procedure and tested for emergent conditional discriminations. During respondent-type training, arbitrary stimuli were presented in pairs, one at a time, using a table-top procedure. On a given trial, for example, the arbitrary stimulus A1 was presented on an observation card for 1 s, followed by the arbitrary stimulus B1 presented on another observation card for 1 s (represented as A1→B1). Emergent conditional discriminations were tested using a standard matching-to-sample procedure. On one test trial, for example, B1 was presented as a sample, with A1 and A2 as comparisons. Choosing A1 (rather than A2) was defined as the correct choice (represented as B1-A1), based on the previous respondent-type training (A1→B1). In Experiment 1 (linear condition), subjects were trained and tested in the following sequence: train A1→B1, A2→B2, test B1-A1, B2-A2; train B1→C1, B2→C2, test C1-B1, C2-B2, C1-A1, C2-A2; train C1→D1, C2→D2, test D1-B1, D2-B2, D1-A1, D2-A2. In Experiment 2 (one-to-many condition), subjects were trained and tested in the following sequence: train B1→A1, B2→A2, test A1-B1, A2-B2; train B1→C1, B2→C2, test C1-B1, C2-B2, C1-A1, C2-A2; train B1→D1, B2→D2, test D1-C1, D2-C2, D1-A1, D2-A2. In Experiment 3 (many-to-one condition), subjects were trained and tested in the following sequence: train A1→B1, A2→B2, test B1-A1, B2-A2; train C1→B1, C2→B2, test B1-C1, B2-C2, C1-A1, C2-A2; train D1→B1, D2→B2, test D1-C1, D2-C2, D1-A1, D2-A2. The study demonstrated that respondent-type training is an effective means of generating equivalence classes with young children. Results also showed that it is possible to extend an equivalence class using the respondent procedure without testing for the "mediating" symmetry relations. The training protocols (linear, one-to-many, and many-to-one) were found to be equally effective, although a possible ceiling effect needs to be taken into account.

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In one recent study a respondent-type[1] training procedure was used to produce equivalence responding instead of the typical matching-to-sample preparation (Leader, Barnes, & Smeets, 1996). During the training, nine nonsense syllables were presented to the subject in the form of six stimulus pairs. The first stimulus of each pair simply appeared on the screen for 1 s (e.g., A1). The screen subsequently cleared for 0.5 s (within-pair-delay) before the second stimulus of the pair (i.e., B1) appeared for 1 s. A 3-s interval (between-pair-delay) then occurred before the next stimulus pair was presented in the same fashion. All six stimulus pairs (A1→B1, A2→B2, A3→B3, B1→C1, B2→C2, B3→C3) were presented in this way in a quasi-random order for 90 trials, the only constraint being that each stimulus pair was presented once in each successive block of nine trials. When all stimulus pairs were presented subjects were tested for the emergence of symmetry and equivalence relations using a standard matching-to-sample test. The vast majority of subjects successfully passed the equivalence test (85.7%). This represents an interesting finding in that the subjects (a) had no experimental history of matching-to-sample training and testing, (b) received minimal instructions, and (c) were not provided with explicit feedback for "correct" responding.

In another study, Smeets, Leader, and Barnes (1997) investigated whether the respondent procedure (e.g., A→B, B→C) would produce symmetry responding and equivalence class formation in 5-year-old, normal functioning children. In Experiments 3 and 4 of this study, when a simple-to-complex training and testing protocol was employed, 87.5% of subjects matched all directly paired stimuli (B-A and C-B) and 76.2% of subjects matched all indirectly paired stimuli (C-A).

One possible criticism of the Smeets et al. study, however, was that stimulus pairs (e.g., A→B, B→C) were presented on opposite sides of the *same* observation card. The authors argued that this use of spatial contiguity may have facilitated the emergence of equivalence relations, and thus it cannot be determined to what extent the temporal relations among stimulus pairs, per se, were responsible for the formation of equivalence classes. To establish the relative effectiveness of the respondent procedure for young children, therefore, the confounding variable of spatial contiguity will have to be removed from the procedure. To address this issue in the current study, stimulus pairs were presented on separate observation cards.

A second issue that arose from the Smeets et al. (1997) study was that the majority of subjects passed the equivalence test only when a

[1]Consistent with our previous publications in this area, we have included the suffix "type" to indicate that the respondent training procedure described in this article differs considerably from traditional respondent conditioning experiments. In our procedure, for example, no unconditional stimuli are presented, and we do not measure responses that are closely related to the activity of the autonomic nervous system. We should also stress, that using the term respondent-type training does not imply that the main behavioral *process* produced by this procedure is best characterized as respondent behavior (we shall return to this important issue in the General Discussion).

simple-to-complex training protocol was employed. For example, in one condition in Experiment 3 subjects were trained A→B and tested A-B, B-A, trained B→C and tested B-C, C-B and tested A-C, C-A; and in one condition in Experiment 4, subjects were trained A→B and tested B-A, trained B→C and tested C-B and C-A. When a simultaneous protocol was used, however, the vast majority of subjects failed the equivalence test. In one condition in Experiment 2, for example, subjects were trained A→B, B→C and were then tested for B-A, C-B, A-C, and C-A in a single test block. One question that arises from this finding is whether some form of procedural modification would allow the respondent procedure to generate equivalence relations without *first* testing for symmetry. Previous research has shown that once an equivalence class has been established, additional members may be added to the class with less training and testing than was needed to establish the initial class (Saunders, Saunders, Kirby, & Spradlin, 1988). Perhaps, therefore, it may be possible to establish equivalence relations using the respondent procedure and young children, without first testing for symmetry, if an initial class was first established and then an additional member was added to that class. To test this suggestion in the current study, we trained two three-member equivalence classes using a simple-to-complex protocol (as in Experiment 4 of Smeets et al., 1997), and then added another stimulus to each of the existing classes (i.e., train C→D). We then determined whether equivalence would emerge (i.e., test D-B and D-A), without testing for symmetry (i.e., D-C).

Finally, we examined variables that have been found either to suppress or facilitate equivalence responding in human subjects. Studies by Spradlin and Saunders (1986), for example, found that multiple sample, single comparison, conditional relational training (many-to-one) appears to facilitate equivalence responding more readily than single-sample multiple comparison training (one-to-many). Furthermore, recent studies have also found that many-to-one training (relative to one-to-many) facilitates derived performances in nonhuman subjects such as pigeons (see Urcuioli & Zentall, 1993, and Zentall & Urcuioli, 1993). The data obtained in Condition 1 of Smeets et al. (1997) together with Condition 2 (linear) of Leader et al. (1996) provided tentative evidence that many-to-one was superior to one-to-many, which was in turn superior to the linear protocol with an adult population. However, with a population of normal functioning 5-year-old children in the Smeets et al. (1997) study, a superiority effect was not found in favor of any of the three protocols. The current study was designed to examine this issue once again. In Experiment 1, subjects were exposed to the respondent procedure using a linear preparation, in Experiment 2 using a one-to-many preparation, and in Experiment 3 using a many-to-one preparation.

General Method

Subjects

Twelve normal functioning 5-year-old Dutch preschool children served as subjects. The children were randomly assigned to one of three experimental conditions. Age (years and months) and sex of subjects are shown in Tables 1, 2, and 3.

Apparatus

The stimuli (3.0 x 3.0 cm) consisted of 12 black symbols (see Figure 1). The stimuli are indicated by alphanumerical codes (e.g., X1, A1); subjects never saw these codes. The stimuli were presented on white cards (14.5 x 20.0 cm) covered with plastic to prevent staining. Observation cards displayed one stimulus (e.g., B2) positioned at the center of the card. Matching cards displayed three stimuli, two horizontally aligned (e.g., B1 and B2) 9 cm apart, and one centered 3 cm below (e.g., A2). Additional materials were a tray with beads and a standing transparent glass tube which displayed a mark. Filling the tube to the mark required 50 beads.

Sessions and Settings

Sessions were conducted in a quiet room in the school building, once a day, 5 days a week, typically for a duration of 10 to 15 min. Three adults participated in the study, an experimenter and two reliability observers. The experimenter and subject were seated at a table facing each other. The reliability observer (one at a time) was present in the same room, but situated so that she could clearly observe the stimuli and the subject's response but not the experimenter's data sheet.

Trials, Response Recordings, and Contingencies

Three types of trials were used: Respondent training trials, matching-to-sample training trials, and matching-to-sample test trials. During a respondent training trial, the experimenter showed the child an observation card (e.g., A1) for 1 s (the experimenter silently counted "21") followed 0.5 s later by another observation card (e.g., B1) for 1 s. The experimenter then recorded whether the subject had looked at both observation cards, and without delivering any programmed consequences initiated the next training trial (i.e., there was a 3-s delay between the presentation of one stimulus pair and the next). If after every fifth training trial the subject had observed all stimulus presentations, the experimenter praised the subject (i.e., "Good girl/boy, you are doing well, take a bead.").

Two types of matching-to-sample training trials were used: demonstration and no-help trials. A demonstration trial began with the experimenter presenting a matching card and pointing to the sample and designated correct comparison saying, "If you see this, point to that." The experimenter then asked the subject to point to the sample and correct comparison. During the matching-to-sample no-help trials, the subject did not receive instruction or modeling (i.e., the experimenter silently presented the matching card).

X1	X2	Y1	Y2
@	#	%	£

A1	A2	B1	B2	C1	C2
&	◊	¢	¶	!	∞

D1	D2
Ω	∑

Figure 1. Symbols used as stimuli.

Responses on the matching-to-sample training trials were scored as correct, incorrect, or invalid. Correct or incorrect responses were defined as pointing to the correct or incorrect comparison, respectively. Invalid responses were recorded when the subject pointed, for example, to the sample, to both comparisons, or when the subject pointed to the comparison without looking at the sample. Correct responses were followed by verbal praise and the delivery of a token ("Good, take a bead"). Incorrect responses were followed by verbal disapproval ("Wrong, no bead"), and invalid responses were followed by corrective feedback (e.g., "look at the pictures when pointing").

The matching-to-sample test trials were the same as the no-help trials (silent presentation of matching cards) except that (a) responses consistent with the respondent and matching-to-sample training were recorded, and (b) no programmed consequences were used. In addition to the nonverbal responses (looking at cards, pointing), the experimenter also recorded the subjects verbal comments during the respondent training trials and on matching-to-sample test trials involving stimuli that were used in respondent training.

Experiment 1

Procedure

A linear preparation was used during respondent training (see Figure 2, upper panel, for a schematic representation of the trained and tested relations). In Steps 1 and 2 of this experiment, two matching-to-sample tasks (unrelated to the tasks used in the experiment proper) were pretrained so that any failure in the matching-to-sample test could not be attributed to a lack of familiarity with the matching-to-sample task per se.

Step 1A: Pretraining X-Y. One block of 18 matching-to-sample training trials was used. The step began with two demonstration trials in which X1 and X2 served as samples and Y1 and Y2 as comparisons. This was followed by 16 no-help trials. In this step, the Y1 and Y2 comparisons were always placed in the same position (i.e., Y1 to the left and Y2 to the right). A stability criterion of 15 out of 16 correct responses on the no-help trials was required. If the subject failed to reach this criterion, then he or she was reexposed to this step. If the subject was not successful at this point he or she was dropped from the study (one subject was excluded on this basis, but no other subjects were dropped from this or the other two experiments).

Step 1B: This step consisted of 16 no-help trials. The step was identical to Step 1A except that no demonstration trials were used and the position of the comparison stimuli was reversed (i.e., Y2 to the left and Y1 to the right). The stability criterion from Step 1A was employed (i.e., 15 out of 16 correct responses).

Step 1C: In this step 16 no-help trials were used. The position of the comparison stimuli was randomized (i.e., eight trials with Y1 to the left and Y2 to the right quasi-randomly mixed with eight trials with Y2 to the left and Y1 to the right). The stability criterion from the previous two steps was employed again.

Step 2: Testing X-Y and Y-X. This step examined whether the subjects continued the X-Y performance accurately: (a) without programmed consequences and (b) when the sample-comparison functions of the X and Y stimuli were reversed. The step consisted of two blocks of test trials (Blocks 1 & 3) and two blocks of training trials (Blocks 2 & 4). Each training block consisted of six X-Y training trials and each test block consisted of eight X-Y test trials, quasi-randomly mixed with eight Y-X test trials.

Prior to the commencement of a test block the experimenter removed the tray of beads and glass tube and said, "Now we are going to play the game without me telling you whether you are right or wrong. You won't get

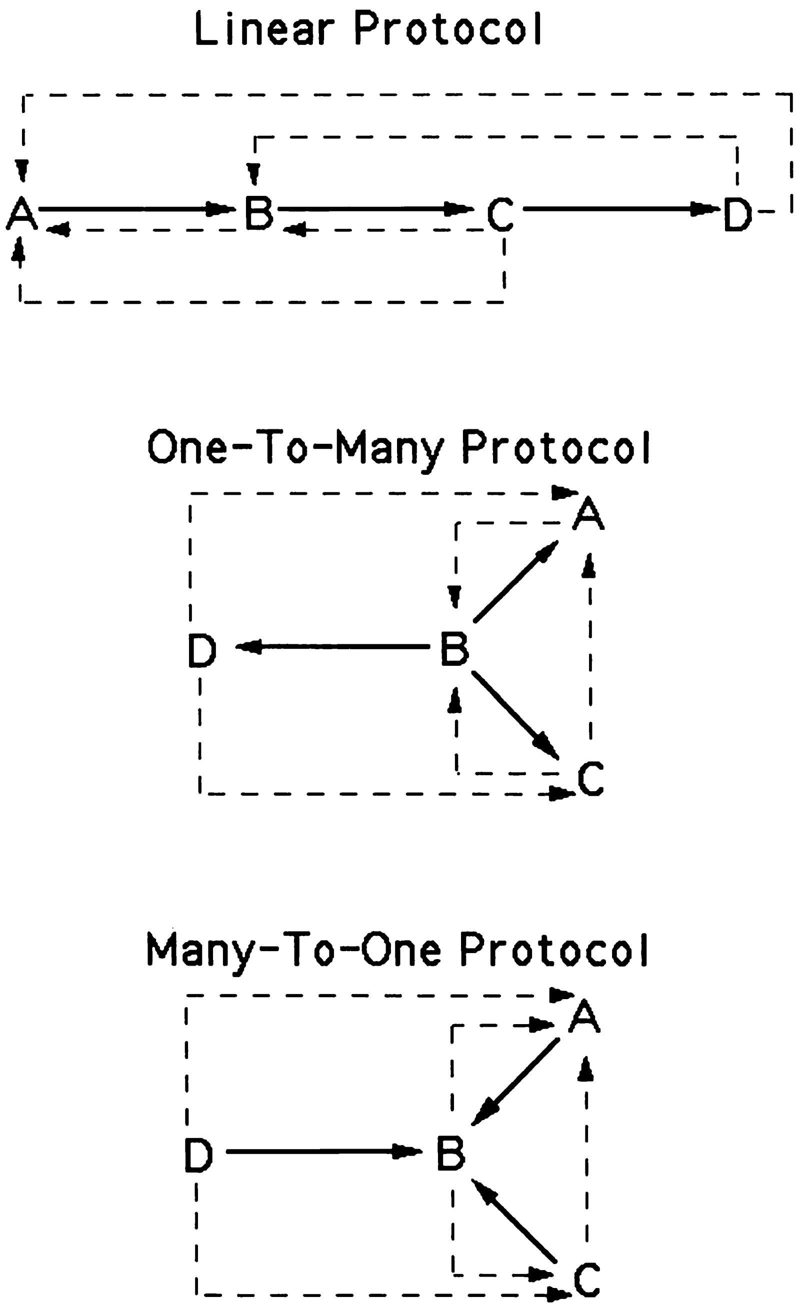

Figure 2. Schematic representation of the trained and tested relations in Experiments 1, 2, and 3. Solid arrows indicate trained relations and dashed arrows indicate tested relations.

any beads. Later on we will play the game with beads. Do your best." The experimenter then proceeded with the test trial and refrained from any communication with the subject. Prior to the commencement of a training block, the experimenter placed the tray of beads and the glass tube on the table and said, "Now you can earn beads again." When the subject succeeded in filling the glass tube to the mark (50 beads) during this step, or any other step of the experiment, the subject was allowed to exchange the beads for a preselected card (cartoon character, soccer player, animal). A stability criterion of (a) 7/8 correct responses on the X-Y test trials, (b) 7/8 correct responses on the Y-X test trials, and (c) 5/6 correct responses on the X-Y training trials was required to proceed to Step 3. If a subject did not reach the criterion he or she was reexposed to Step 2, and if at this point the subject was not successful his or her participation in the study was terminated (no subjects were dropped at this point in this experiment or in either of the other two).

Step 3: Respondent training A→B. In this step, subjects received respondent training during which they observed the stimuli A1→B1 and A2→B2 in a fixed temporal order. This was followed directly by the conditional discrimination probes, B1-A1 and B2-A2. The step consisted of six blocks. In the first block, subjects received 10 respondent training trials. Block 2 consisted of one X-Y and one Y-X matching-to-sample test trial followed by eight B-A conditional discrimination probes. Block 3 consisted of six X-Y training trials. Blocks 4, 5, and 6 were identical to Blocks 1, 2, and 3, respectively. Subjects reached the criterion if they observed the A→B stimulus presentation 18/20 times during the respondent training trials (Blocks 1 & 4), produced 14/16 correct responses on the B-A test trials, 3/4 correct responses on the X-Y and Y-X test trials (Blocks 2 & 5) and 11/12 correct responses on the X-Y training trials (Blocks 3 & 6). Two exposures to the step were allowed.

Step 4: Step 4 was identical to Step 3 except that (a) each respondent training block (1 & 4) consisted of 10 B→C respondent training trials, and (b) Blocks 2 and 5 consisted of one X-Y, one Y-X, eight C-B, and two B-A test trials (Blocks 3 and 6 were identical to the same block numbers in Step 3—they each consisted of six X-Y training trials).

Step 5: This step examined whether subjects matched both directly and indirectly paired stimuli. This step consisted of six blocks. Block 1 consisted of one X-Y, one Y-X, and four B-A test trials, quasi-randomly mixed with four C-B test trials. Block 2 consisted of eight C-A test trials. Block 3 consisted of six X-Y training trials. Blocks 4, 5, and 6 were identical to Blocks 1, 2, and 3, respectively. Subjects were allowed to proceed to Step 6 if they (a) produced 3/4 correct responses on the X-Y and Y-X test probes, 7/8 correct responses on the B-A test probes, and 7/8 correct responses on the C-B test probes (Blocks 1 and 4) and (b) produced 14/16 correct responses on the C-A test trials (Blocks 2 & 4) and 11/12 correct responses on the X-Y training (Blocks 3 & 6). Two exposures to the experimental sequence were allowed.

Step 6: There were eight blocks in this stage. Block 1 consisted of two

B-A, two C-B, and two C-A test trials. Block 2 consisted of 10 C→D respondent training trials. Block 3 consisted of eight D-B test trials, and Block 4 consisted of six X-Y training trials. Blocks 5, 6, 7, and 8 were identical to Blocks 1, 2, 3, and 4, respectively. Subjects were allowed to proceed to Step 7 if they (a) produced 10/12 correct responses on Blocks 1 and 4, (b) observed both stimuli 18/20 times in Blocks 2 and 5, (c) produced 14/16 correct responses in Blocks 3 and 7, and (d) produced 10/12 correct responses in Blocks 4 and 8. Two exposures to the experimental sequence were allowed.

Step 7: Step 7 consisted of six blocks. Block 1 consisted of two B-A, two C-B, two C-A, and two D-B test trials. Block 2 consisted of eight D-A test trials, and Block 3 consisted of six X→Y training trials. Blocks 4, 5, and 6 were identical to Blocks 1, 2, and 3, respectively. Subjects reached the criterion if they (a) produced 14/16 correct responses in Blocks 1 and 4, (b) produced 14/16 correct responses in Blocks 2 and 5, and (c) produced 11/12 correct responses in Blocks 3 and 6. Subjects were allowed two exposures.

Reliability

Reliability checks were made across 30% of all respondent training and matching-to-sample training and test trials. Experimenter and reliability observer always agreed.

Results and Discussion

Correct responses on symmetry and equivalence tests are presented in Table 1. All 5 subjects in Experiment 1 required one block of training trials in Steps 1A, 1B, and 1C to establish the pretrained X-Y conditional relations, and they maintained this performance throughout the experiment. In Step 2, all subjects reached criterion performance after one block of X-Y and Y-X test trials. All 5 subjects observed all stimulus pairs during respondent training, and they did not make any task related comments during the training (or throughout the entire experiment). Subjects 1, 2, 3, and 5 produced 16/16 correct responses on the first exposure to the B-A test probes, and Subject 4 produced 14/16 correct responses on the first exposure. In Step 4, Subjects 2 and 3 produced 15/16 correct responses on the C-B test probes, and Subjects 1, 4, and 5 produced 16/16 correct responses. In Step 5, all subjects were successful on the C-A equivalence test after one exposure and proceeded to Step 6. In this step, all subjects were successful on the D-B equivalence test probes, with Subjects 1, 2, 4, and 5 producing 16/16 correct responses, and Subject 3 producing 15/16 correct responses. In Step 7, 3 subjects (1, 2, & 5) were successful on the D-A equivalence test with Subjects 3 and 4 scoring 12/16 correct responses on the second exposure. None of the subjects provided the experimenter with any helpful verbal reports when questioned about their performance (e.g., "Just because," "don't know," shrugged shoulders). This experiment clearly showed that respondent training is an effective means of producing conditional relations and stimulus classes in a population of 5-year-old children. Furthermore, when stimulus classes have been established with this population, it is possible to extend the classes via respondent-type training.

This study, as did Smeets et al. (1997), employed a linear protocol. Smeets et al. (1997) also investigated the effectiveness of a one-to-many and a many-to-one protocol. No clear differences were found among the three training procedures. However, as stated in the introduction, stimulus pairs were presented on the same observation card (e.g., A1 on the front and B1 on the back). In the present study, stimulus pairs were presented on separate observation cards. Furthermore, Smeets et al. (1997) examined three-member classes, whereas in this study three-member classes were extended to four members. Experiments 2 and 3 of the current study were designed to determine whether there would be any differences among the three protocols under these conditions.

Table 1

Sex, Age (in years and months), and Number of Correct Conditional Discrimination Responses for Each Subject During Steps 3-7 of Experiment 1

Subject Sex Age	Step 3 B-A	Step 4 C-B	Step 5 C-A	Step 6 D-B	Step 7 D-A
S1 F 5;0	16	16	16	16	16
S2 F 5;2	16	15	14	16	16
S3 M 5;7	16	15	14	15	10 12
S4 M 5;4	14	16	16	16	10 12
S5 M 5;3	16	16	16	16	16

Note. Additional conditional discrimination probes in Steps 4, 5, 6, and 7 are not reported here. Subjects were successful on all these test probes.

Experiment 2

Procedure

This experiment was identical to Experiment 1, except that during respondent training a one-to-many preparation was used rather than a linear preparation (i.e., B→A respondent training in Step 3, B→C training in Step 4, and B→D training in Step 6) (see Figure 2, center panel). Reliability checks were made on 40% of all respondent training and matching-to-sample training and test trials. The experimenter and reliability observer always agreed.

Results and Discussion

Correct responses on symmetry and equivalence test probes are presented in Table 2. Subjects 6-10 reached the stability criterion on Steps 1A, 1B, and 1C after one block of training, and they maintained this performance throughout the experiment. In Step 2, all subjects were successful on the X-Y and Y-X test probes. Subjects remained silent and observed all stimulus pairs during respondent training (and did not make any task-related comments throughout the experiment). In Step 3, Subjects 6, 8, and 9 produced 16/16 correct responses on the A-B test probes on their second exposures to the step. Subjects 7 and 10 were successful after their first exposures. Subjects 6 and 8 reached criterion on the C-B and A-B test probes of Step 4 on their second exposures, and Subjects 7, 9, and 10 were successful on their first exposures. In Step 5, all subjects passed the C-A equivalence test. Subjects 8 and 9 scored 14/16 correct responses on their first exposures, Subjects 7 and 10 scored 16/16 correct responses on their first exposures, and Subject 6 was successful on the second exposure. In Step 6 all subjects passed the D-C equivalence test and proceeded to Step 7. In the final step, Subjects 6, 7, 8 and 10 scored 16/16 correct responses on the D-A equivalence test, and Subject 9 scored 11/16 on the second exposure. As in Experiment 1, subjects did not provide the experimenter with any "insightful" reports to explain their performances. This study demonstrated that a one-to-many preparation can also be used effectively with the respondent-type training procedure to produce equivalence responding in young children.

Table 2

Sex, Age (in years and months), and Number of Correct Conditional Discrimination Responses for Each Subject During Steps 3-7 of Experiment 2

Subject Sex Age	Step 3 A-B	Step 4 C-B	Step 5 C-A	Step 6 D-C	Step 7 D-A
S6 M 5:6	12 16	12 16	11 16	16	16
S7 F 5;7	15	16	16	16	16
S8 M 5;8	10 16	11 16	14	8 14	16
S9 F 5;1	10 16	15	14	9 15	8 11
S10 F 5;0	16	16	16	16	16

Note. Additional conditional discrimination probes in Steps 4, 5, 6, and 7 are not reported here. Subjects were successful on all these test probes.

Experiment 3

Procedure

This experiment was identical to Experiments 1 and 2, except that a many-to-one preparation was used (i.e., A→B respondent training in Step 3, C→B training in Step 4, and D→B training in Step 6) (see Figure 2, lower panel). Reliability checks were made on 35% of all respondent training and matching-to-sample training and test trials. The experimenter and reliability observer always agreed.

Results and Discussion

Correct responses on symmetry and equivalence test probes are presented in Table 3. Subjects 11-15 learned the X-Y conditional discrimination of Step 1 in one training block, and they continued to respond accurately to it and its symmetrical form Y-X under the test conditions of Step 2. Subjects observed all stimuli and remained silent during respondent training (and did not make any task-related comments during the entire experiment). All subjects responded successfully to the B-A test probes of Step 3. In Step 4, all subjects reached the criterion after one test block. In Step 5, all subjects scored 16/16 correct responses to the C-A equivalence probes. All subjects were successful on the D-C test probes of Step 6, with Subjects 12 and 14 requiring two exposures. In Step 7, all subjects scored 16/16 correct responses on the D-A equivalence probes, with Subject 14 requiring two exposures. As in Experiments 1 and 2, none of the subjects provided the experimenter with any helpful verbal reports when questioned about their performances.

Table 3

Sex, Age (in years and months), and Number of Correct Conditional Discrimination Responses for Each Subject During Steps 3-7 of Experiment 3

Subject Sex Age	Step 3 A-B	Step 4 C-B	Step 5 C-A	Step 6 D-C	Step 7 D-A
S11 F 5;4	16	16	16	16	16
S12 F 5;7	16	16	16	13 16	16
S13 M 5;2	16	14	16	16	16
S14 M 5;1	16	16	16	13 16	12 16
S15 F 5;0	16	16	16	16	16

Note. Additional conditional discrimination probes in Steps 4, 5, 6, and 7 are not reported here. Subjects were successful on all these test probes.

General Discussion

This study clearly demonstrated that respondent-type training is an effective and powerful means of generating equivalence relations with young children. In Experiments 1, 2, and 3 all 15 subjects matched all directly paired stimuli with each other. This compares favorably with the 87.5% success rate obtained in Experiments 3 and 4 of the Smeets et al. (1997) study. In the present study, all subjects successfully matched the indirectly paired stimuli, C and A, with each other, and again this compares well with the 76.2% success rate reported by Smeets et al. (1997). The current success rates are particularly impressive, given the following point made by Smeets et al.: "The efficiency of respondent training with these youngsters is particularly noteworthy in view of the repeated negative attempts to establish conditional discriminations and stimulus classes with this age group through other nonmatch-to-sample tasks" (Smeets et al., 1997, p. 302).

An issue that arose from the Smeets et al. (1997) study was that subjects only succeeded in passing the equivalence test when a simple-to-complex training protocol was used (i.e., subjects were exposed to a symmetry test before being tested for transitive/equivalence relations). Perhaps, therefore, the respondent training procedure is only effective in producing equivalence classes if subjects are first tested for symmetry. To determine if this is always the case, we trained two three-member equivalence classes using a simple-to-complex protocol and then added another stimulus to each of the classes (C→D in Experiment 1, and B→D in Experiments 2 and 3). Equivalence relations were then tested without a prior symmetry test (D-B and D-A in Experiment 1, and D-C and D-A in Experiments 2 and 3). In Experiment 1, for which a linear training preparation was used, all 5 subjects were successful on the D-B equivalence test, and 3 of these subjects were successful on the D-A equivalence test. In Experiment 2, the one-to-many condition, all 5 subjects were successful on the D-C equivalence test, and 4 out of 5 subjects were successful on the D-A test. Finally, in Experiment 3, the many-to-one condition, all 5 subjects were successful on the D-C equivalence test, and all 5 subjects were successful on the D-A equivalence test. This supplements the findings of the Smeets et al. (1997) study, in that it demonstrates that it is possible to extend an equivalence class without testing for the "mediating" symmetry relations. It is worth noting that subjects were 100% successful on the second equivalence test (D-B in Experiment 1, D-C in Experiments 2 and 3), and it was only when the third equivalence test was introduced (D-A) that some negative results were obtained. With regard to the linear design (Experiment 1), these results are consistent with previous research that has found that success on a test for equivalence responding is a negative function of the number of nodes separating the stimuli within the test (e.g., a subject is more likely to pass a C-A test than a D-A test following A-B-C-D training). However, nodal distance cannot explain Subject 9's failure on the D-A test, with the one-to-many protocol, because both D and C were separated by only one node from A. Clearly, this issue will require further research.

One criticism of the Smeets et al. (1997) study was that stimuli were presented on opposite sides of the same observation card (p. 303). Thus, it could not be determined whether the derived relations were a function of the temporal or spatial relations that occurred between the stimulus pairs. In the present study, stimulus pairs were presented on different observation cards and there was a marked improvement, in terms of success on the test probes, over that reported by Smeets et al. (1997). It appears, therefore, that removing the confounding variable of spatial contiguity from the current study facilitated derived relational responding. In effect, rather than aiding equivalence responding, spatial contiguity apparently "interfered" with equivalence formation in the Smeets et al. (1997) study. At the present time, this (perhaps) counterintuitive result remains unexplained, and further research will be needed to address this issue.

During the last decade a number of researchers have investigated the effects of training protocols on equivalence. Some of the data suggest that the many-to-one design may facilitate equivalence responding more readily than one-to-many in both human and nonhuman populations (e.g., Saunders et al., 1988; Spradlin & Saunders, 1986; Urcuioli & Zentall, 1993). Results obtained in Experiment 1 of Smeets et al. (1997), together with Condition 2 (linear) of Leader et al. (1996), provided tentative evidence that many-to-one is superior to one-to-many, which in turn is superior to the linear protocol when adults are used as subjects. However, in Experiments 2, 3, and 4 of the Smeets et al. (1997) study, 5-year-old children did not show clear performance biases across the three protocols. The present research is broadly consistent with this latter study. However, one of the problems with the current data is that subjects performed so well it is difficult to determine clearly the superiority of any one protocol over another. One solution to this problem might be to increase the number of stimuli within the equivalence classes; recent evidence suggests that clear differences across protocols can be demonstrated when seven-member classes are used, at least with adult subjects (Fields, personal communication).

In light of the current data, we can be reasonably confident that the respondent-type training procedure is capable of producing equivalence responding in both adults (Leader et al., 1996) and children as young as 5 years old. That is, when stimulus events are discriminated as correlated in space and/or time the formation of equivalence relations become likely. As argued by Leader et al. (1996, pp. 702-714), this effect can be interpreted from the relational frame view of equivalence responding (see also Barnes 1994; Barnes-Holmes, Hayes, Hegarty, & Dymond, in press; Barnes-Holmes, Healy, & Hayes, in press; Hayes & Barnes, 1997). The basic argument is that the verbal community very often reinforces the formation of equivalence classes among those events that are correlated in space and/or time (e.g., dark clouds and rain, thunder and lightning), and thus the respondent procedure is one that should readily produce equivalence responding, in verbally-able subjects. From the relational frame perspective, therefore, the respondent-type training procedure generates equivalence responding by tapping into a preexisting generalized *operant* repertoire of relational framing behavior (Barnes-Holmes & Barnes-Holmes, in press). At this point, therefore, we should emphasize that although our procedure is referred to as *respondent*-type training, we believe that the behavior it produces in verbally-able individuals is largely *operant* at the level of process.

One finding from the current study that might be seen to contradict the relational frame interpretation was the fact that the subjects failed to provide any coherent verbal reports concerning their performances on the equivalence tests. From the relational frame perspective, however, verbal functions are not defined in terms of the topography of speaking (e.g., for relational frame theory, listening is also verbal behavior; see Barnes & Holmes, 1991; Hayes & Hayes, 1989). From this point of view, therefore, there is no requirement that a subject need verbalize the relations involved in a successful test performance for that performance to be considered an example of relational framing. More specifically, there is no reason to expect that all of the functions that transform during the looking and pointing behavior that occurs during an equivalence test will also accompany the transformation of functions that are required for subjects to verbalize the tested relations in a postexperimental interview. The relational frame interpretation of the current data thus differs quite dramatically from that offered by Horne and Lowe (1996, 1997) who would require that the appropriate verbalizations should accompany (and give rise to) the successful test performances. That said, however, further research is clearly needed to test the relational frame view. For example, it would be interesting to attempt to replicate this study with even younger populations (e.g., 2-year-old children), as a way of focusing on the exact nature of the relationship between a subject's prior history of interaction with the verbal community and his or her performance on equivalence tests following respondent-type training.

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