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A PRECURSOR TO THE RELATIONAL EVALUATION PROCEDURE: SEARCHING FOR THE CONTEXTUAL CUES THAT CONTROL EQUIVALENCE RESPONDING

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The precursor to the relational evaluation procedure (pREP) is a go/no-go successive discrimination procedure for examining stimulus equivalence. Previous research has shown that it does not readily produce equivalence responding unless some matching-to-sample (MTS) procedures are incorporated into the experimental sequence. Two experiments attempted to identify contextual cues that would generate equivalence responding on the pREP. Experiment 1 examined the effects of using abstract symbols or various verbal labels as response options on the pREP. Only the words *same* and *different,* when used as response options, reliably produced equivalence responding across 4 subjects. Experiment 2 examined different pretraining preparations designed to attach the functions of the words *same* and *different* to abstract symbols that could then be used as response options on the pREP. The most effective pretraining procedure involved multiple-exemplar training during which subjects were trained to respond to abstract symbols in the presence of pairs of stimuli that were either formally the same or different. The abstract symbols were subsequently used as response options with the pREP, and all subjects reliably demonstrated equivalence responding. The findings suggest that the relations of *same* and *different* may be fundamental to equivalence responding. These findings are discussed in terms of what they suggest about the nature of the equivalence phenomenon specifically and derived relational responding more generally.

Key words: stimulus equivalence, go/no-go successive discrimination, matching to sample, response interval, adult humans

Most of the research on the phenomenon of stimulus equivalence has used a matching-to-sample (MTS) procedure first to train a series of conditional discriminations and then to test for a number of untrained derived relations (e.g., Cullinan, Barnes, Hampson, & Lyddy, 1994; Devaney, Hayes, & Nelson, 1986; Dymond & Barnes, 1994; see Sidman, 1994, for a review). For example, reinforcement is provided for choosing Stimulus B from an array of comparisons when presented with Stimulus A as a sample, and for choosing Stimulus C from an array of comparisons when presented with B as a sample (A-B and B-C conditional discriminations). Without further training, subjects then may choose A from an array of comparisons when presented with B as a sample, and choose B when presented with C as a sample (B-A and C-B symmetry relations). Subjects may also choose A in the presence of C (combined symmetry and transitivity, i.e., equivalence), again in the absence of explicit reinforcement.

One recent trend in the study of stimulus equivalence is the search for alternatives to the matching-to-sample (MTS) procedure as a means of training and testing the relations involved. For example, Leader, Barnes, and Smeets (1996) used a respondent training procedure, in which pairs of stimuli were simply presented, one after the other, on a computer screen. When subjects were asked to observe the screen, and were subsequently presented with a standard MTS test, symmetry and equivalence relations often emerged (e.g., if A-B and B-C stimulus pairs had been presented during the training procedure, subjects then related the C and A stimuli to-

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gether). Leader et al. also reported that when control conditions were excluded from the analysis, 84% of subjects demonstrated both symmetry and equivalence responding.

Another alternative procedure, described by Fields, Reeve, Varelas, Rosen, and Belanich (1997), was a stimulus-pairing/yes-no procedure. Pairs of stimuli were presented successively on a computer screen and subjects were required to respond by pressing either of two keys labeled *yes* and *no*. Subjects pressed a key marked *yes* after presentation of positive stimulus pairs (e.g., A1-B1) and a key marked *no* after presentation of negative stimulus pairs (e.g., A1-B2). This procedure was used both to establish the baseline conditional discriminations and to test for the derived relations of symmetry, transitivity, and combined symmetry and transitivity. Fields et al. found that 56% of subjects demonstrated symmetry, transitivity, and equivalence using this procedure.

Three specific aspects of the Fields et al. (1997) procedure could have provided contextual cues for equivalence responding in verbally sophisticated subjects. First, a pretraining keyboard-familiarization task required subjects to respond to semantically related words using the experimental procedure; second, the instructions included the phrase ''discover whether the words go together''; and third, the response keys were labeled *yes* and *no*. Because of the potential role of these features as contextual cues for equivalence responding, it is unclear to what extent the reinforcement contingencies per se or some combination of one or more contextual cues were responsible for the emergent performances (see Barnes, 1994). Some progress towards addressing this issue of contextual control has been made, however, in two recent studies (Cullinan, Barnes, & Smeets, 1998; Cullinan, Barnes-Holmes, & Smeets, 2000).

Cullinan et al. (1998) employed a type of go/no-go procedure (see D'Amato & Colombo, 1985) that they called the precursor to the relational evaluation procedure (pREP). This procedure was developed as part of a broader research program concerned with expanding the range of available methodologies for analyzing human language and cognition within the framework of relational frame theory (see Barnes-Holmes, Healy, & Hayes, 2000; Hayes, Barnes-Holmes, & Roche, 2001). A typical pREP trial consisted of the presentation of one sample stimulus followed by either a positive or a negative comparison stimulus. Subjects pressed the space bar of a computer keyboard when presented with positive sample–comparison pairs (e.g., A1-B1) and did not press the space bar when presented with negative sample–comparison pairs (e.g., A1-B2). In this way a series of conditional discriminations were trained, with positive and negative sample–comparison relations presented on separate trials. The pREP was also used to test for the emergent relations of symmetry and equivalence. Twenty subjects were trained using either the pREP or an MTS procedure and then were tested using both pREP and MTS. Although subjects readily produced symmetrical responding using the pREP, only 1 subject out of 5 (Experiment 1) demonstrated equivalence responding. Cullinan et al. (1998) also suggested, however, that prior exposure to MTS training or testing may increase rates of equivalence responding on subsequent pREP tests. A follow-up study by Cullinan et al. (2000) found support for this suggestion. When subjects demonstrated equivalence using MTS and then were exposed to pREP training and testing using the same stimuli and relations among stimuli, all subjects subsequently demonstrated equivalence using pREP training and testing with novel stimuli.

Cullinan et al. (2000) demonstrated that the pREP, which itself has a weak equivalence-generating effect, can produce reliable equivalence responding if an MTS procedure is incorporated into the training and testing protocol. One strategy for future research, therefore, might involve systematically modifying the pREP to incorporate the appropriate discriminative or contextual properties that are most likely responsible for generating equivalence class formation (see Barnes, 1994). This was the strategy adopted in the current study.

EXPERIMENT 1

In previous versions of the pREP (Cullinan et al., 1998, 2000), the response requirement involved pressing the space bar (when presented with positive stimulus pairs; e.g., A1-B1) or not pressing the space bar (when pre-

sented with negative stimulus pairs; e.g., A1-B2) during a 5-s response interval. This was identified by Cullinan et al. as a possible weakness in the procedure because a no-press response could be recorded on trials in which the response latency simply exceeded 5 s. Experiment 1 was designed to address this issue. The pREP was modified so that on each trial two response options were presented on the computer screen, and these remained visible until a subject responded by choosing one of them. The term *response option* is used to denote the stimulus that a subject selected to identify a particular sample–comparison pair as correct or incorrect. Prior to the experimental sessions, one of these response options was designated as positive and the other as negative. That is, subjects were trained to choose the positive response option when presented with positive sample–comparison pairs (e.g., A2 → B2) and to choose the negative response option when presented with negative sample–comparison pairs (e.g., A1 → B2). The first condition of this experiment used abstract symbols (e.g., !!!!!, *****) as response options to examine whether simply modifying the response requirement would result in higher levels of equivalence responding than earlier versions of the pREP.

As well as allowing the subject to control the duration of the response interval, this modification to the pREP allowed us to introduce potential contextual cues for equivalence responding into the procedure by using various verbal labels as response options. As indicated above, Fields et al. (1997) used the words *yes* and *no* as response options in their stimulus-pairing procedure, and it has been argued that using these words may have functioned as contextual cues for equivalence responding. In Condition 2 of Experiment 1, therefore, we replicated Condition 1, but replaced the abstract stimuli used as response options with the words *yes* and *no*. Would this modification facilitate the emergence of equivalence responding with the pREP?

One explanation for the facilitative effect of MTS on equivalence responding is that the format itself provides contextual cues for responding to stimuli as ''going together'' (e.g., Barnes, 1994; Hayes, Gifford, & Wilson, 1996). Based on this interpretation, Condition 3 attempted to introduce a ''goes with'' function into the pREP by using the phrases *goes with* and *does not go with* as response options. We also recognized, however, that although the phrase *goes with* specifies that two or more events go together in a relation, it fails to specify the exact nature of that relation (e.g., do the events go together because they are the same, or different, or opposite, etc.?). Based on this line of reasoning, for Condition 4 we inserted more specific relational terms into the pREP. The two terms we chose were *same* and *different,* because these relations, it has been argued, are involved in equivalence responding (e.g., Barnes, 1994; Hayes, 1991). Therefore, the words *same* and *different* were used as response options in Condition 4.

Method

Subjects

Sixteen subjects, 11 females and 5 males, participated. Some were college students attending University College Cork, and others were second-level students attending a local school. The age range was from 16 to 30 years, and none of the subjects had any prior experience with stimulus equivalence research. They were recruited through noticeboard advertisements and personal contacts, and were randomly assigned to one of the four conditions (i.e., 4 subjects in each condition).

Apparatus and Setting

All subjects were trained and tested individually in a quiet room free of distractions. Stimuli were presented on an Apple Macintosh® computer, and subjects responded by pressing one of two marked keys on the keyboard. The computer was programmed in BBC BASIC to control the presentation of sample and comparison stimuli and response options, and to record responses. The stimuli used in all four conditions were nonsense syllables (e.g., *cug, zid*). For simplicity, the nonsense syllables are indicated here by alphanumerics (e.g., A1, B1, C1, A2, B2, C2, etc.) but subjects never saw these labels. The response options used in each condition were as follows: Condition 1: abstract symbols (e.g., !!!!!, *****); Condition 2: the words *yes* and *no*; Condition 3: the phrases *goes with* and *does not go with*; and Condition 4: the words *same* and *different*.

Procedure

Each trial of the pREP entailed the presentation of a sample stimulus in the center of the computer screen for 1 s, after which the screen cleared for 1 s, and then one comparison stimulus was presented for 1 s. The screen then cleared again for 1 s, after which two response options were presented across the bottom of the screen (their positions were counterbalanced across trials, and when symbols were used the designation of attributes—i.e., positive or negative—was counterbalanced across subjects). The response options remained on the screen until the subject pressed one of two marked keys as a means of choosing one of them. During training phases a correct response resulted in positive feedback (see programmed consequences) on the screen, and an incorrect response resulted in negative feedback. The screen then cleared for a 1-s intertrial interval, after which the next trial was presented. During testing phases no feedback was presented; the intertrial interval began immediately after selection of a response option and was followed by presentation of the next trial. Training and testing procedures were presented in blocks of trials. At the end of each block of trials the experimenter checked the results during which time the subject could take a short break. After the break the subject was presented with further training or testing trials. There was wide variability in the rate at which subjects progressed through the stages of the experiments; thus, it was necessary to adopt a flexible approach to the length of experimental sessions. These ranged from 20 min to 2 hr, and almost all subjects required more than one session to complete the experiment.

For each session, each subject was seated in front of the computer monitor and the instructions were read aloud. During training phases the instructions were as follows:

> One nonsense syllable will appear in the centre of the screen for one second, the screen will clear for one second, then another nonsense syllable will appear for one second. Then two symbols/words/phrases [the word used depended on the condition the subject was assigned to] will appear across the bottom of the screen. I want you to look at the nonsense syllables that appear on the screen and then choose one of the symbols/words/phrases that appear at the bottom. To choose the symbol/word/phrase on the left press this marked key on the left, to choose the symbol/word/phrase on the right choose this marked key on the right. A message will then appear on the screen saying either "GOOD" and adding a point on to a running total which you will see on the screen, or "BAD" and subtracting a point from the running total. Then two more nonsense syllables will appear and the whole sequence will be repeated a number of times. When the experiment is finished you will be paid a penny for each point you earn, so you should try to earn as many points as possible. When this session is finished a message will appear asking you to call the experimenter. I will be waiting outside. Do you have any questions?

During testing phases the instructions were as follows:

> In this part of the experiment one nonsense syllable will appear in the centre of the screen for one second, the screen will clear for one second, then another nonsense syllable will appear for one second, and then the two symbols/words/phrases will appear across the bottom as before. I want you to look at the two nonsense syllables and then choose one of the symbols/words/phrases as before. However this time you will not get a message saying good or bad, so just do whatever you think is right. Do you have any questions?

Any questions were answered by repeating the relevant section of the instructions, and then the experimenter left the room.

The pREP was used to train the two conditional discriminations A1 → B1/A2 → B2 and B1 → C1/B2 → C2. Eight pREP tasks were used to establish these conditional discriminations (i.e., four trial types per discrimination). On one trial, for example, A1 appeared before B1 followed by positive (P) and negative (N) response options (i.e., A1 → B1–*P*/N). In this case, choosing P was reinforced, whereas choosing N was punished (the reinforced option is italicized). The remaining tasks may be summarized as follows: A1 → B2–P/*N*, A2 → B1–P/*N*, A2 → B2–*P*/N, B1 → C1–*P*/N, B1 → C2–P/*N*, B2 → C1–P/*N*, B2 → C2–*P*/N. The eight tasks were presented five times each in a quasirandom order (40 trials in each training block). Once the training criterion of 90% correct (36 trials correct in any one block of 40) was reached, the subjects were presented with a test block consisting of 12 tasks. These may

be represented as follows, with the italicized response option indicating the correct response based on symmetry and equivalence relations: symmetry: B1 → A1–*P*/N, B1 → A2–P/*N*, B2 → A1–P/*N*, B2 → A2–*P*/N, C1 → B1–*P*/N, C1 → B2–P/*N*, C2 → B1–P/*N*, C2 → B2–*P*/N; and equivalence: C1 → A1–*P*/N, C1 → A2–P/*N*, C2 → A1–P/*N*, C2 → A2–*P*/N. Each of these tasks was presented 10 times in a quasirandom order (120 test trials in each test block). If a subject reached the training criterion but was unable to undertake the testing procedures at the time, the subject was retrained to criterion at the beginning of the next session before being presented with a test block. The criterion for passing a test was 8 of 10 correct responses on each testing task in any one block of testing trials (80% or more correct in total). If subjects did not reach this test criterion, they were retrained to criterion and retested repeatedly until they either passed the test or demonstrated a stable incorrect performance. The criterion for a stable incorrect performance required that the difference between scores on each individual test task, across two blocks of test trials, be no more than 2 (out of a possible total of 10).

Programmed consequences. During training stages, positive feedback consisted of an auditory tone and "GOOD: POINTS = XX" appearing on the screen, displaying the total points earned during that training block, incremented by 1. Negative feedback consisted of an auditory tone and "BAD: POINTS = XX" appearing on the screen, displaying the total points earned during that training block decremented by 1. That is, subjects were awarded 1 point for each correct response, and 1 point was deducted for each incorrect response. During testing phases there were no programmed consequences.

Results and Discussion

Table 1 shows individual-subject data for Experiment 1. Across the four conditions all subjects demonstrated symmetrical responding. However, in Condition 1, when abstract symbols were used as response options, only 1 of the 4 subjects (S3) demonstrated equivalence responding. In Condition 2, when the words *yes* and *no* were used as response options, none of the 4 subjects showed equivalence. In Condition 3, when the phrases *goes with* and *does not go with* were used, only 1 subject (S9) showed equivalence. Only in Condition 4, when the words *same* and *different* were used, did all 4 subjects (S13, S14, S15, and S16) reliably demonstrate equivalence responding.

Table 1

Number of training trials, number of test exposures, and results for symmetry and equivalence probes on the final exposure to the test in Experiment 1.

Condition	Subject	Train to criterion	No. of tests	pREP test	
				Symmetry	Equivalence
1	1	240	3	Pass	Fail
	2	600	4	Pass	Fail
	3	160	2	Pass	Pass
	4	320	3	Pass	Fail
2	5	160	3	Pass	Fail
	6	520	2	Pass	Fail
	7	400	3	Pass	Fail
	8	240	2	Pass	Fail
3	9	80	1	Pass	Pass
	10	160	3	Pass	Fail
	11	40	2	Pass	Fail
	12	240	2	Pass	Fail
4	13	120	2	Pass	Pass
	14	80	1	Pass	Pass
	15	40	1	Pass	Pass
	16	80	1	Pass	Pass

The data for symmetry testing (not presented) were relatively consistent across all subjects and conditions (i.e., symmetry was demonstrated early in the experimental sequence and was maintained throughout). The data for equivalence tests, however, revealed some error patterns that may contribute to the interpretation of the data (see Table 2). Two error patterns emerged: Subjects either reversed the expected derived relations (i.e., they chose the negative response option on trials involving positive pairs of stimuli, and chose the positive response option on trials involving negative stimulus pairs) or they chose the same response option on all equivalence trials. The data in Table 2 show that these two patterns of responding were common across Conditions 1, 2, and 3. The fact that some subjects reversed the expected derived relations may suggest that they were engaging in generalized conditional responding, and thus perhaps even subjects who passed the equivalence tests also may have been engaging in this performance

Table 2

Number of test trials on which each subject responded in accordance with equivalence and nonequivalence in Experiment 1.

Condition	Subject	Equivalence		Nonequivalence	
		C1-A1	C2-A2	C1-A2	C2-A1
1	1	10	10	0	0
	2	0	0	0	0
	3	10	10	10	10
	4	0	0	0	0
2	5	5	2	10	0
	6	0	0	10	10
	7	1	0	0	0
	8	10	10	0	0
3	9	10	10	10	10
	10	9	0	10	10
	11	0	0	10	10
	12	0	0	10	9
4	13	10	9	10	10
	14	9	10	10	10
	15	10	10	10	10
	16	8	10	10	10

(i.e., a false-positive result). However, in Condition 4, all 4 subjects reliably chose the correct comparison on both equivalence and nonequivalence trials; thus, this seems less likely to be a case of generalized conditional control.

The procedures employed in Experiment 1 helped us to separate those features that seem to facilitate equivalence responding on the pREP from those that do not. For example, Cullinan et al. (1998, 2000) predicted that allowing subjects to control the duration of the response interval would result in higher levels of equivalence. Condition 1 in the present study demonstrated, however, that this modification to the pREP did not on its own have the predicted effect. In Conditions 2 and 3 we employed the words *yes* and *no* or the phrases *goes with* and *does not go with* as response options in the expectation that they would provide contextual cues for equivalence responding. The procedures used, however, were not effective in achieving this goal. The use of the words *yes* and *no* was based on their use by other researchers (e.g., Fields et al., 1997) and on the assumption that subjects would have a history of using these words in the presence of objects or events that were related in some way. However, the words *yes* and *no* are not clearly relational terms (on their own they do not specify a relation between objects or events). Condition 4 demonstrated that the use of the more precise relational terms *same* and *different* yielded better results.

EXPERIMENT 2

The procedure used in Condition 4 of Experiment 1 produced equivalence responding, but only by using verbal labels that had a very specific preexperimentally established relational function. Although we have identified a pREP that reliably produces equivalence responding, the critical history involved in generating this performance remains outside of the control of the experimenter. In the Fields et al. (1997) study, the words *yes* and *no* were used as response options, but, unlike Condition 2 in Experiment 1, the Fields et al. subjects also were provided with a history of using these words as response options in the presence of semantically related words (i.e., in the preexperimental keyboard-familiarization task). Perhaps this history facilitated the equivalence-generating effect of the experimental procedure. In Experiment 2, therefore, we examined the potential history effects involved in generating reliable equivalence responding.

One way to examine this history effect would be to replace the use of verbal labels as response options with pretraining procedures designed to attach the required relational functions to abstract symbols. Other researchers have employed effective forms of pretraining as a means of establishing a variety of relational response patterns. For example, pretraining with nonarbitrary relations has been used in conjunction with MTS procedures in studies of equivalence and other derived relations (e.g., Dymond & Barnes, 1994, 1995; Roche & Barnes, 1996; Steele & Hayes, 1991). Perhaps, adapting such procedures for use with the pREP would also yield better results. In Experiment B, therefore, we examined various pretraining preparations that employed nonarbitrarily related symbols as stimuli (i.e., pairs of stimuli were either formally the same or different), and either symbols or words as response options. Once subjects completed the pretraining, they were exposed to pREP training and testing using the pretrained symbols as response options.

In Condition 1, subjects were exposed to pretraining using two abstract computer-generated symbols as response options to assess whether simple pretraining of this kind would be sufficient to establish the response options as contextual cues for responding in accordance with relations of same and different. In Condition 2, subjects were first pretrained using the words *same* and *different* as response options, followed by pretraining using abstract symbols. The final condition employed multiple-exemplar pretraining (i.e., three types of pretraining each using a different set of nonarbitrarily related stimuli, but all using the same abstract symbols as response options) (see Dymond & Barnes, 1994, 1995, 1996; Steele & Hayes, 1991). It was predicted that the multiple-exemplar pretraining would provide a sufficient history to attach the functions of *same* and *different* to the abstract symbols used as response options.

Method

Subjects

Twelve subjects, 9 females and 3 males, participated. All were college students attending University College Cork, their age range was from 18 to 30 years, and none of them had any prior experience with stimulus equivalence research. They were recruited through notice-board advertisements and personal contacts, and were randomly assigned to one of the three conditions (i.e., 4 subjects in each condition).

Apparatus and Setting

These were identical to those used in Experiment 1.

Procedure

The pREP used in this experiment was the same as that used in Experiment 1, except that the response options used were abstract symbols that had functioned as response options during pretraining.

Pretraining. A pREP-type procedure was used to present pairs of abstract stimuli that were either the same or different, followed by positive (P) and negative (N) response options. For example, a trial involving *same* stimuli could be &&&& → &&&&–P/N, and a trial involving *different* stimuli could be &&&& → $$$$–P/N. The response options were also abstract computer-generated symbols (e.g., !!!!!, *****) except for the first stage of pretraining in Condition 2, which used the words *same* and *different*. Pretraining instructions were the same as those used for the pREP, except that instead of being told that nonsense syllables would appear on the screen, subjects were informed that symbols would be presented. Pretraining trials were presented in blocks of 40, with the position of response options counterbalanced across trials. The criterion for passing the pretraining was 90% correct responding (i.e., 36 correct in any one block of pretraining trials). In Condition 1, subjects had to pass only one block of pretraining trials. In Condition 2, subjects had to pass two blocks of pretraining trials (one block using the response options *yes* and *no* and one block using a single set of nonarbitrarily related stimuli). In Condition 3, subjects had to pass three blocks of pretraining trials (each block employed a novel set of nonarbitrarily related stimuli).

After completing the pretraining, subjects were trained and tested using the pREP, as described in Experiment 1, but using the pretrained response options (e.g., !!!!!, *****). If subjects did not pass the test they were reexposed to the pretraining and the pREP training before being exposed to pREP testing again. This continued until they either passed a test or demonstrated a stable incorrect performance (as described in Experiment 1).

Results and Discussion

The data for individual subjects obtained during the pretraining and pREP training and testing are presented in Table 3, and detailed results of final exposures to equivalence tests are presented in Table 4. The subjects mastered the pretraining procedures across the three conditions. In Condition 1, S19 and S20 demonstrated both symmetry and equivalence on pREP tests. S17, however, demonstrated symmetry but not equivalence, and S18 failed to demonstrate either symmetry or equivalence over two exposures to the pREP tests. This suggests that the nonarbitrary pretraining procedure was successful in establishing the arbitrary response options as contextual cues for equivalence responding for 2 of the 4 subjects.

In Condition 2, all 4 subjects demonstrated both symmetry and equivalence on either

Table 3

Number of exposures to pretraining sessions, number of pREP training trials, number of exposure to tests, and results for symmetry and equivalence tests on the final test exposure in Experiment 2.

Condition	Subject	Pretraining to criterion			Train to criterion	No. of tests	pREP test	
		1	2	3			Symmetry	Equivalence
1	17	80			120	2	Pass	Fail
	18	40			160	2	Fail	Fail
	19	80			120	2	Pass	Pass
	20	40			40	1	Pass	Pass
2	21	40	40		40	1	Pass	Pass
	22	40	40		120	2	Pass	Pass
	23	40	40		240	2	Pass	Pass
	24	40	40		120	2	Pass	Pass
3	25	40	40	40	40	1	Pass	Pass
	26	40	40	40	40	1	Pass	Pass
	27	40	40	40	40	1	Pass	Pass
	28	40	40	40	40	2	Pass	Pass

their first or second exposure to the pREP tests. These data illustrate that the pREP can reliably produce equivalence responding when the pretraining procedures incorporate the verbal functions of the words *same* and *different*. However, as in Condition 4 of Experiment 1, the use of these words means that a critical part of the history involved in generating the data remains outside of the control of the experimenter (i.e., the ''meanings'' or behavioral functions of these words were generated before the subjects participated in the experiment). The multiple-exemplar pretraining employed in Condition 3, however, succeeded in establishing the abstract response options as cues for the relations of *same* and different, and all 4 subjects demonstrated both symmetry and equivalence on their first (S25, S26, and S27) or second (S28) exposure to pREP tests.

Table 4

Number of test trials on which each subject responded in accordance with equivalence and nonequivalence in Experiment 2.

Condition	Subject	Equivalence		Nonequivalence	
		C1-A1	C2-A2	C1-A2	C2-A1
1	17	0	0	10	10
	18	0	0	10	0
	19	10	10	10	10
	20	10	10	10	10
2	21	10	10	10	10
	22	10	10	10	10
	23	10	10	9	10
	24	10	10	10	10
3	25	9	9	10	10
	26	10	10	10	10
	27	10	10	10	10
	28	10	10	10	10

GENERAL DISCUSSION

One of the goals of the present study was to identify procedures that could increase the equivalence-generating properties of the pREP and simultaneously to gain important information about the nature of the equivalence phenomenon. Some variables that we thought might be important in fact did not prove to be so (at least in the context of this study). In fact, the results reported in the first three conditions of Experiment 1 were remarkably similar to earlier work (e.g., Cullinan et al., 1998, 2000) in that the pREP had a strong symmetry-generating effect but a weak equivalence-generating effect. In Condition 4 of Experiment 1, introducing the words *same* and *different* into the pREP procedure reliably produced equivalence as well as symmetry responding in 4 subjects. This effect was examined further in Experiment 2, and was found to be a robust finding. That is, when the words *same* and *different* were replaced with multiple-exemplar pretraining with nonarbitrarily related stimuli, all subjects reliably produced equivalence as well as symmetry responding.

In our previous studies (Cullinan et al., 1998, 2000), the MTS format appeared to produce equivalence responding more readily than the pREP. The findings of the present study suggest that perhaps the MTS format itself contains features that may have been established preexperimentally (e.g., in preschool education exercises) as discriminative for responding in accordance with the relations of sameness and difference. When learning to read, for example, young children are often presented with MTS-type tasks in which they learn that a picture of an object is ''the same as'' the written word describing that object, or that the written word is ''the same as'' the actual object (and ''different from'' another object). A number of researchers have suggested that these arbitrary relations, frequently established during the course of natural interactions within the verbal community, may be fundamental to equivalence responding (Hayes, 1991; see also Barnes, 1994; Barnes & Holmes, 1991; Barnes & Roche, 1996; Barnes-Holmes & Barnes-Holmes, 2000).

In contrast to the cues for relational responding that may be inherent in the MTS procedure, we have suggested that the pREP may serve as a context for stimulus compounding (Cullinan et al., 2000). The results of earlier research appear to be consistent with this suggestion. In particular, Wulfert, Dougher, and Greenway (1991) demonstrated that when subjects indicated that they were responding to stimuli as compounds (using a think-aloud procedure and protocol analysis), symmetry responding reliably emerged but equivalence did not (note that we are not referring to separable compounds as specified by Stromer, McIlvane, & Serna, 1993). Wulfert et al. also reported that subjects tended to produce both symmetry and equivalence when the protocol analyses indicated that they were responding to the stimuli as relational elements rather than compounds. Insofar as the pREP provides a context for subjects to respond to pairs of stimuli as compounds, we might reasonably expect, therefore, that this procedure should produce symmetry but may often fail to produce equivalence responding. However, when appropriate relational elements (e.g., same) are introduced into the pREP, both symmetry and equivalence should emerge. Consequently, the current data may be seen as providing additional evidence to support the earlier work of Wulfert et al. on the importance of relational terms in establishing equivalence classes.

The general finding that the pREP readily produces symmetry but rarely produces equivalence responding also has wider conceptual implications. Early accounts of equivalence (e.g., Carrigan & Sidman, 1992; Sidman, 1990) conceptualized it as a single unitary phenomenon, but more recent research suggests that this conceptualization may be inadequate. For example, the work of Pilgrim and Galizio (1990, 1995) and Roche, Barnes, and Smeets (1997) indicates that symmetry and equivalence do not necessarily function as whole or complete behavioral units (but see Saunders, Drake, & Spradlin, 1999). The findings of the current program of research could be seen as supporting the argument that the relational responses illustrative of stimulus equivalence are flexible, separable units of behavior that may be under the control of specific environmental variables. Indeed, further work with the pREP, and perhaps other procedures, may help to identify the key variables involved in producing various patterns of derived relational responding, including those instances in which the component relational operants of symmetry and equivalence either separate or combine (cf. Hayes & Wilson, 1996).

An alternative account of the data presented here might suggest that the response option labels of the pREP functioned as members of established generalized equivalence classes to which the experimental stimuli were added. Of course, one could describe the data in this way. This description, however, fails to suggest in any way why the terms *same* and *different,* for example, came to participate in the experimenter-defined equivalence classes but the terms *yes* and *no*, for instance, did not. The relational frame theory definition of the response labels as contextual cues is consistent with previous research on derived stimulus relations (e.g., Steele & Hayes, 1991) and is also consistent with the relational frame theory view that *same* and *different* specify precisely the relations involved in equivalence and nonequivalence responding, whereas *yes* and *no*, and *goes with* and *does*

not go with, do not. Future research might explore this issue more fully.

A criticism that might be made of the current study is that equivalence testing was brief (10 exposures to each equivalence trial type within each test block), and thus perhaps the experimental manipulations affected the speed with which equivalence emerged, rather than the probability of emergence per se. This may be so, and equivalence may have emerged with the pREP for some of the subjects who failed, had they been exposed to a larger number of equivalence test trials. Nevertheless, data from our earlier studies (e.g., Cullinan et al., 1998) illustrate that even after up to seven exposures to pREP equivalence tests, some subjects still failed to respond in a manner suggesting equivalence. In addition, the stability criterion used in all the pREP experiments ensured that the minimum number of exposures to each equivalence trial type was 20 (i.e., a minimum of 80 equivalence test trials). This reduces the possibility of false-positive outcomes, which become increasingly likely as the number of test trials increases, especially if the researcher simply keeps training and testing until equivalence emerges.

In any case, the various forms of the pREP reported in the current study and in our previous research provide procedures for producing symmetry responding in the absence of combined symmetry and transitivity. The program of research also has identified ways of modifying the pREP so that the latter relational responses consistently emerge with this procedure. The data obtained thus far support the previous work of Wulfert et al. (1991), who showed that terms described as relational may be closely involved in the generation of equivalence responding.

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ERRATUM

Dinsmoor, J. A. (2001). Stimuli inevitably generated by behavior that avoids electric shock are inherently reinforcing. *Journal of the Experimental Analysis of Behavior, 75,* 311–333.

Page 318, line 3, reads, “To summarize the one-factor interpretation . . .” It should read, “To summarize the two-factor interpretation . . .”