*EMERGENT SIMPLE DISCRIMINATION ESTABLISHED BY
INDIRECT RELATION TO DIFFERENTIAL
CONSEQUENCES*

JULIO C. DE ROSE, WILLIAM J. McILVANE, WILLIAM V. DUBE,
VIRGINIA C. GALPIN, AND LAWRENCE T. STODDARD

UNIVERSIDADE FEDERAL DE SAO CARLOS, BRAZIL, E. K. SHRIVER CENTER, AND
NORTHEASTERN UNIVERSITY

Three experiments examined a discrimination training sequence that led to emergent simple discrimination in human subjects. The experiments differed primarily in their subject populations. Normally capable adults served in the first experiment, preschool children in the second, and mentally retarded adults in the third. In all experiments, subjects learned a simple simultaneous discrimination: When visual stimuli A1 and A2 were displayed together, reinforcers followed selections of A1, the S+, but not A2, the S-. The subjects also learned a conditional discrimination taught with an arbitrary visual-visual matching-to-sample procedure. Comparisons were two additional visual stimuli, B1 and B2, and samples were A1 and A2. Reinforcers followed selections of B1 in the presence of A1 and of B2 in the presence of A2. After the simple-discrimination and conditional-discrimination baselines had been acquired, B1 and B2 were displayed alone (without a sample) on probe trials. Subjects had never been taught explicitly how to respond to such displays. Nonetheless, they almost always selected B1, which was involved in a conditional relation with A1, the stimulus that served as S+ on the simple-discrimination trials. This outcome suggested the formation of stimulus classes during conditional-discrimination training. Through class formation, B1 and B2 had apparently acquired stimulus functions similar to those shown by A1 and A2 on simple-discrimination trials, thereby leading to emergent selections of B1 on the probes.

Key words: Simple and conditional discrimination, stimulus classes, emergent behavior, button pressing, pointing, normally capable and mentally retarded humans

An important problem facing the experimental analysis of behavior is to account for apparently novel behavior that (a) occurs without an explicit reinforcement history and (b) cannot be explained by primary stimulus generalization. Considerable progress toward an explanation of such behavior has been made in some research areas. Studies of stimulus

equivalence and its logical prerequisites, for example, have done much to account for the emergence of novel behavior in the context of the conditional-discrimination procedure known as matching to sample (Catania, 1984; Sidman, 1986; Spradlin & Saunders, 1984; Stoddard & McIlvane, 1986).

In a typical matching-to-sample procedure, two comparison stimuli, B1 and B2, are displayed simultaneously, and the subject can produce a reinforcer by touching one of them. The comparison stimulus to be touched changes from trial to trial conditionally upon a third stimulus, the sample. When sample A1 is present, reinforcers follow selections of B1 and not B2; when A2 is present, reinforcers follow selections of B2 and not B1. Through continued exposure to these contingencies, the subject may reliably select B1 conditionally upon A1 and B2 conditionally upon A2.

A rapidly increasing number of studies has documented the fact that when human subjects learn conditional discriminations, they are capable not only of the behavior taught directly but also of new behavior that emerges apparently without explicit training (e.g., Lazar, 1977; Sidman, Kirk, & Willson-Morris, 1985;

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Sidman & Tailby, 1982; Silverman, Anderson, Marshall, & Baer, 1986; Spradlin & Saunders, 1986). For example, transitivity of conditional relations can be demonstrated when additional baseline conditional discriminations are established. If subjects learn to select (a) B1 and B2 conditionally upon A1 and A2, respectively, and (b) C1 and C2 conditionally upon B1 and B2, respectively, then they may prove immediately capable of selecting C1 and C2 conditionally upon A1 and A2, respectively. The new conditional discriminations emerge although A1 and A2 have never been simultaneously present with C1 and C2. Symmetry of conditional relations is shown when subjects prove immediately capable of selecting former samples, displayed as comparison stimuli, conditionally upon former comparison stimuli displayed as samples. Moreover, with appropriate test procedures, one may document the formation of two classes of equivalent stimuli, with A1, B1, and C1 comprising one class and A2, B2, and C2 the other (Sidman & Tailby, 1982); all stimuli in each class acquire the matching-to-sample functions of the other members.

A comprehensive account of emergent behavior also must address stimulus functions that develop outside the context of matching to sample. A study by Lazar (1977) provides an important illustration. Normally capable adults first learned to point sequentially to each member of several pairs of visual stimuli. If X1 and X2 were displayed, for example, subjects were to point to X1 first and to X2 second. If Y1 and Y2 were displayed, subjects were to point to Y1 first and Y2 second, and so on. Subsequent tests suggested the formation of two classes of stimuli, those to which subjects pointed first and those to which they pointed second. Then, in a matching-to-sample format, new stimuli were presented as comparison stimuli to be selected conditionally upon samples from either the "first" or the "second" class. When the new stimuli were then displayed for sequential responding, subjects pointed to them in a sequence consistent with the class membership of the samples to which they were related. For example, if new stimuli N1 and N2 were comparisons that had been conditionally related to samples from the "first" and "second" classes, respectively, subjects pointed to N1 first and to N2 second although

they had not been taught explicitly to do so. Through the matching-to-sample training, the new stimuli apparently acquired the functions that defined the "first" and "second" classes.

Our study concerned a somewhat different type of emergent behavior and emergent stimulus functions—relations between discriminative stimuli and consequences as established in simple simultaneous discrimination procedures. In a typical procedure, for example, two stimuli, A1 and A2, are displayed simultaneously. One stimulus, A1, is designated S+, and selections of it are followed by reinforcers. The other stimulus, A2, is designated S−, and no reinforcers follow its selection. Through exposure to these contingencies, the subject comes to select A1 with increasing frequency and to select A2 rarely or not at all.

Our study asked whether S+ and S− stimulus functions could be developed without directly exposing subjects to differential reinforcement contingencies. The basic method is shown in the upper part of Figure 1. The first display illustrates a simple-discrimination procedure. Simultaneously displayed forms A1 and A2 serve as S+ and S−, respectively. The second display shows a matching-to-sample procedure. Two other forms, B1 and B2, are comparison stimuli to be selected conditionally upon samples A1 and A2, respectively. Across trials, B1 and B2 are correct equally often. The third display shows a trial that displays only B1 and B2. This probe task resembles the original simple-discrimination task in that there is no sample to serve as a basis for conditional discrimination. How will subjects respond to this novel display?

Considering only the reinforcement histories for selecting B1 and B2, there is no basis for selecting one stimulus over the other. When the subject masters the conditional discrimination, selections of B1 and B2 are followed equally often by reinforcers. The subject could have a basis for selecting B1 and rejecting B2, however, if one considers the reinforcement histories of A1 and A2, the forms to which B1 and B2 were respectively related. If, during conditional-discrimination training, B1 and B2 acquired the simple-discrimination functions of A1 and A2, then B1 would function as S+ and B2 as S− on the probes. Moreover, B1 and B2 would acquire those functions without explicit differential reinforcement.

Experimental Design

The present study consisted of three systematic replications of the procedures illustrated in the upper part of Figure 1. Normally capable adults served as subjects in the first experiment, preschool children in the second, and mentally retarded adults in the third. In each experiment, subjects first learned to perform simple- and conditional-discrimination tasks like those shown in the upper portion of Figure 1. The simple and conditional discriminations will be termed the A1/A2 and the AB tasks, respectively. Then, A1/A2 and AB trials were intermixed in a mixed baseline. Finally, B1 and B2 were displayed in the simple-discrimination format (see Figure 1, Probes). The B-probes were interspersed among mixed-baseline trials. Probe selections were never reinforced. Specifics of procedures will be described in the individual experiments.

EXPERIMENT 1

Normally capable adults were studied initially, primarily because we expected that these subjects would acquire the necessary baselines rapidly.

METHOD

Subjects

Eleven normally capable adults were recruited through personal contacts. Their ages ranged from 18 to 50 years. Eight subjects (SW, EK, DR, MC, CF, JH, JJ, and OH) were females, and 3 (NS, RV, and LA) were males. None of the subjects had served in prior research on discrimination learning. The first language of 4 subjects was Portuguese.

Apparatus

The apparatus was an Apple® 512k Macintosh microcomputer. The subject used the machine's standard input device, called a mouse, in responding to stimuli drawn on the Macintosh screen. Stimulus presentations and data recording were controlled automatically by computer programs written in MacPascal (THINK Technologies, Inc.).

General Procedures

Stimuli. Figure 1 shows the forms displayed on discrimination trials and representative trial

Fig. 1. Illustrative stimulus displays presented in Experiment 1, along with training and probe procedures. Upper portion: Forms designated as A1 and A2 were S+ and S-, respectively, on simple-discrimination trials and were samples on conditional-discrimination trials. Forms designated as B1 and B2 were comparison stimuli on conditional-discrimination trials and also were displayed without a sample on probe trials. Displays did not include the letter/number combinations, plusses, or minuses. Lower portion: Reversed simple-discrimination contingencies in which A2 became S+ and A1 became S-. Conditional-discrimination and probe trial displays were the same as above.

types. For 10 subjects, A1, A2, B1, and B2 were the forms depicted in Figure 1. For 1 subject (SW), the comparison designated B2 in Figure 1 served as B1 and vice versa.

The forms, about 2 cm high, were centered within white rectangular keys on the computer's screen. Three keys were displayed; each measured 4.5 by 5.0 cm. The spatial arrangement differed somewhat from that shown in Figure 1. Two keys appeared in the upper left and right corners of the screen, separated by 7.5 cm. The third key was in the center of the screen, displaced 4 cm downward from the top border of the upper keys.

All three keys were drawn on every trial. When only two forms were displayed (on A1/A2 or B-probe trials), they always appeared on the upper keys; the lower was blank. When three were displayed (e.g., on AB trials), comparison stimuli were on the upper keys and the sample on the lower.

Response definition. Subjects used the mouse to position a cursor within the borders of one of the upper two keys. When the cursor was in position, the subject pressed a button on the mouse to make his or her selection; this button press was defined as the response. Any button presses that occurred while the cursor was not within the borders of an upper key were ignored by the computer program.

Programmed consequences. In some conditions of the experiment, every response was followed by differential consequences (continuous reinforcement). When the subject selected a stimulus defined as correct, a tone sounded and the word "Correct" appeared in the lower portion of the screen for 1.5 s. Then, the forms and "Correct" display disappeared, and all keys were blank for 0.5 s before the presentation of the next trial. If the subject selected a stimulus defined as incorrect, that response was followed by a buzz, all forms disappeared, and the 0.5-s intertrial interval began. After every reinforced response, the computer program incremented a counter. The counter value was not displayed during the session. Rather, instructions were given (see Appendix) that described the method of tallying correct responses. Each correct response earned 10 cents, and subjects typically accumulated about \$8 to \$10 in the course of their participation.

In some conditions, discrimination trials were conducted without differential conse-

quences. Following all responses, the forms simply disappeared and the intertrial interval began. Although this schedule resembles extinction, all correct selections continued to increment the counter that tallied monetary reinforcers. Before every block of trials conducted without differential consequences, the following written message (or its Portuguese translation) was presented on the computer screen: "In the next part of the experiment, you will not be told whether you are correct or wrong, but you will still earn dimes for correct responses."

Baseline Training

Each subject participated in a single session lasting about 15 to 20 min. Before the session, each subject received written English or Portuguese instructions that described the procedures (see Appendix), and was told that he or she would earn 10 cents for each correct response. Five subjects (SW, DR, LA, EK, and OH) received A1/A2 training first, and 6 (JH, CF, MC, NS, RV, and JJ) received AB training first.

On A1/A2 trials, stimuli A1 (the S+) and A2 (the S-) were displayed on the two upper keys. The S+ position varied unsystematically across trials. On AB trials, either A1 or A2 was presented as the sample on the lower key with B1 and B2 displayed simultaneously on the upper keys. Samples A1 and A2 were presented equally often; their order of presentation varied unsystematically, as did the positions of B1 and B2.

For each task, the learning criterion was 15 correct selections in a block of 16 trials. If a subject did not achieve this criterion within three 16-trial blocks, his or her participation ended at that point.

The mixed-baseline phase began after both A1/A2 and the AB tasks were learned. In 16-trial blocks, each trial type was presented equally often, and no more than three A1/A2 or AB trials occurred consecutively.

B-Probes

In this condition, six B-probe trials were interspersed among 18 mixed-baseline trials. This block of 24 trials immediately followed the criterion (15 of 16 correct) mixed-baseline block. None of the subjects' selections were followed by differential consequences.

Table 1

Performance of each subject on baseline trials in each condition in Experiment 1. See text for details of the experimental conditions. Numbers to the left and right of the semicolons give the number of (a) errors made by the subject in that condition and (b) 16-trial blocks presented in training and review conditions, respectively. Dots show that subjects made no errors on baseline trials in probe conditions. An "x" shows that the subject was not exposed to the indicated condition.

Subject	Condition								
	Initial training				Reversal				
	A1/A2	AB	Mixed	B-Probe	A1/A2	AB	Mixed	B-Probe	BA
SW	0; 1	4; 2	0; 1	•	1; 1	1; 1	0; 1	•	•
DR	5; 2	8; 2	8; 3	•	1; 1	1; 1	0; 1	•	•
LA	0; 1	0; 1	0; 1	•	1; 1	0; 1	0; 1	•	•
EK	0; 1	1; 1	0; 1	•	1; 1	0; 1	0; 1	•	•
JH	2; 2	1; 1	0; 1	•	x	x	x	x	•
CF	1; 1	3; 2	0; 1	•	x	x	x	x	•
MC	3; 2	0; 1	0; 1	•	x	x	x	x	•
NS	3; 2	2; 2	0; 1	•	x	x	x	x	•
RV	0; 1	0; 1	0; 1	•	x	x	x	x	•
OH	1; 1	33; 3	x	x	x	x	x	x	x
JJ	x	19; 3	x	x	x	x	x	x	x

Reversal Training and B-Probes Repeated

Four subjects (SW, DR, LA, and EK) were exposed to these conditions. The training and testing described above were repeated with one change: On all A1/A2 trials in which reinforcement occurred, each selection of A2 was followed by the tone and "Correct," and each selection of A1 was followed by the buzz, as shown in the lower portion of Figure 1. The order of training and testing was as follows: (a) reversed A1/A2 training, (b) review of the AB task, (c) mixed-baseline trials, and (d) the 24-trial B-probe testing block. The criterion to advance from one stage of training to the next (a-c above) remained at 15 correct responses in a 16-trial block.

Symmetry Probes

In this condition, A1 and A2 were displayed as comparisons on eight probe trials; B1 and B2 appeared as samples on four probe trials each. The symmetry probes were interspersed among 16 mixed-baseline trials. No differential consequences followed selections.

RESULTS

Baseline Training

Table 1 summarizes baseline performances in each experimental condition. All subjects acquired the A1/A2 task promptly. Only Subject DR made more than three errors. Nine

subjects acquired the AB task, and all but 1 of these subjects (DR) made four or fewer errors in doing so. Two subjects, OH and JJ, did not learn the AB task within the 48-trial (three-block) limit, and their participation ended. When A1/A2 and AB trials were intermixed, 8 of the 9 subjects made no errors. The remaining subject, DR, made a total of eight errors; seven were on A1/A2 trials. She met the criterion in the third mixed-baseline block.

B-Probes

All subjects selected B1 on all six B-probe trials. None made any errors on baseline trials during probe blocks.

Reversal Training

Each of the 4 subjects who participated in this phase selected A1 on the first trial of reversal training, thereby coming in contact with the reversed contingencies. All 4 subjects then displayed one-trial reversal learning by selecting A2 on the second and all subsequent A1/A2 trials. On the AB task review, 2 subjects made no errors, and 2 subjects made one error each. All subjects performed perfectly on the mixed-baseline block.

B-Probes Repeated and Symmetry Probes

B-probe results were consistent with the reversed A1/A2 contingencies. Subjects almost

always selected B2, the form conditionally related to A2 (now the S+ on A1/A2 trials). Three subjects did so on all six probe trials, and one (DR) did so on five of six probe trials; DR selected B1 on the fifth probe trial. Performance on all baseline trials was perfect.

On symmetry probe trials, all 9 subjects always selected A1 conditionally upon B1 and A2 conditionally upon B2.

DISCUSSION

Results from all subjects who mastered the necessary baseline performances showed that novel simple-discrimination performances could emerge without explicit training. On the B-probes, subjects almost always selected the form that was conditionally related to the form that served as S+ on A1/A2 trials. This outcome cannot be attributed to a direct history of reinforcement because selections of B1 and B2 were reinforced approximately equally often on AB trials. The B-probe data also cannot be explained by a simple stimulus preference, unrelated to the training history. All 4 subjects who were exposed to the reversed A1/A2 contingencies reliably reversed their selections on the second round of B-probes. Results, therefore, suggest that B1 and B2 acquired functions similar to A1 and A2, respectively, by virtue of stimulus relations established during the AB training.

Results from the symmetry probes showed that B1 and B2 also acquired other functions of A1 and A2, and vice versa; either could function as sample or comparison stimulus. Moreover, the symmetry tests would seem especially stringent because the comparisons, A1 and A2, continued to serve as S+ and S- on A1/A2 trials. The fact that no subject ever failed to select A1 and A2 conditionally upon B1 and B2, respectively, shows that control by the samples effectively overcame any potential influence of the A1/A2 history.

One may ask to what extent subject population was a variable in producing these results. Normally capable adult subjects have highly developed behavioral repertoires. One feature is the ability to formulate and use rules (Skinner, 1969), which may influence performances established by reinforcement contingencies (cf. Lowe, 1979). It would not be surprising, for example, if some or all subjects labeled the S+ and S- forms as "Correct"

and "Incorrect" or "Right" and "Wrong" or something similar. The extensive preexperimental instructions, in fact, could be expected to encourage the development of rules such as "(Form B1) goes with the correct one" and "(Form B2) goes with the incorrect one." Confronted with the B-probes, subjects may well have covertly verbalized previously formulated rules, perhaps leading to the formulation of additional rules that ultimately influenced the probe behavior (Lowe, 1986).

The issue of potential rule-governed behavior is one of a larger set of questions that concerns the influence of developmental history on performance in discrimination procedures. This question seems especially relevant when considering behavior that emerges without direct training. When such behavior is demonstrated, as in the present case, it is always of interest to ask whether the emergent behavior would also be shown if the subjects were less capable. To answer this question, Experiments 2 and 3 examined the performance of developmentally limited populations.

EXPERIMENT 2

This experiment systematically replicated the procedures of Experiment 1 with preschool children as subjects.

METHOD

Subjects

Subjects were two females, SJ and SA, and two males, GM and DN. Their ages (years-months) were 4-7, 4-8, 4-5, and 5-6, respectively. All were considered normally capable and attended nursery school or kindergarten.

Setting and Apparatus

Sessions were held in a quiet room in the home of one of us (VCG). The subject sat at a child-sized table, and the experimenter sat in a chair to the child's immediate right. On the table were a photo album, mounted on a stand at the child's eye level, and a graduated cylinder used to hold pennies delivered as token reinforcers in the course of the experiment. The album contained a series of discrimination trial displays. Also in the room were a video-camera and videotape recorder used for videotaping all sessions.

General Procedures

Stimuli. Stimuli used in this experiment are illustrated in Figure 2. They consisted of (a) two circular patches, one red and one green; (b) four forms; and (c) four Greek letters. The circular patches were 2 cm in diameter, and forms and letters were 2 to 5 cm in height. All stimuli were centered within white rectangles (6.4 cm by 10.8 cm) and mounted on cardboard sheets (21.6 cm by 27.9 cm) in photo albums. The rectangles were analogous to the keys used in the first experiment. They were mounted in either two or three locations depending upon whether a given display required simple (two stimuli) or conditional discrimination (three stimuli). On simple-discrimination displays, the two rectangles were each mounted 7 cm from the top of the cardboard sheet and separated by approximately 4 cm. The sheet on which they were mounted was held within the photo album and positioned approximately perpendicular to the tabletop. On conditional-discrimination displays, a third rectangle was mounted within the album on a second cardboard sheet centered 7 cm from its bottom. This sheet was positioned below the first and lay parallel to the tabletop. Stimulus presentations were controlled with oaktag dividers that the experimenter moved to cover and uncover the forms.

Response definition. The required response was that of touching one of the stimuli. Because the stimuli were widely separated, it was not difficult to judge which stimulus the child selected. To obtain reliability measures, an independent observer viewed about 40% of the session videotapes and made a supplemental record of the subjects' responses.

Programmed consequences. In some conditions, responses on all trials were followed by differential consequences. Whenever a child selected a stimulus defined as correct, the experimenter said "Good," covered the trial stimuli with a divider, and placed a penny in the graduated cylinder. If the child selected a stimulus defined as incorrect, the experimenter said "That's wrong. Let's try the next one." and covered the stimuli.

Pennies were exchanged for a toy selected by the child from a variety available at the start of each session. Throughout the session, the toy selected was in full view but out of reach. The child was given the toy when pen-

Fig. 2. Illustrative stimulus displays given in Experiment 2, showing pretraining, training, and probe procedures. Pretraining stimuli were forms and color patches. Training stimuli were Greek letters.

nies filled the graduated cylinder up to a point marked with a rubber band. An added "bonus" procedure was implemented when the children were required to master conditional discriminations with Greek letters (see below). The children were permitted to keep their pennies if all selections were correct in a session.

In some experimental conditions, blocks of trials were conducted without differential consequences. After all responses, the experimenter said nothing, covered the stimuli, and went on to the next trial. Like the schedule used in Experiment 1, this schedule resembled extinction. However, the child received sup-

plementary pennies at the end of blocks in which this schedule was in effect. Prior to every trial block with this schedule, the experimenter gave subjects the following instructions: "In this game, I'm not going to tell you if you're right or wrong, and I'm not going to put any more pennies in the tube. Work hard and at the end I will fill up the penny tube. Then, you can get your toy and keep the pennies."

Procedure. When the experimenter judged that the child was looking at the display, she initiated a trial by moving an oaktag divider that concealed stimuli from the subject's view during the intertrial interval. For a simple-discrimination trial (e.g., A1/A2), the S+ and S- forms were displayed, the child pointed to a form, and the experimenter then provided the consequences appropriate to the prevailing schedule. For a conditional-discrimination trial (e.g., AB), the experimenter displayed only the sample, and the child was required to point to it. Then, the experimenter revealed the comparison stimuli; the sample remained present throughout the trial. When the child pointed to a comparison, that response was followed by consequences appropriate to the prevailing schedule. Any additional responses to the sample had no programmed consequences.

Sessions consisted of 36 or 40 trials. A session was divided into two trial blocks: The first block consisted of 18 trials and the second of either 18 or 22 trials, depending on the experimental condition. Sessions lasted about 10 min and were separated by at least 24 hr.

Experimental Conditions

The experiment was conducted in two phases as illustrated in Figure 2. The first phase, pretraining, was designed to familiarize the children with simple- and conditional-discrimination procedures. The second phase was a systematic replication of Experiment 1: A1/A2 and AB discriminations were trained, subjects were adapted to trials conducted without differential consequences, and B-probes were presented.

Pretraining. On simple-discrimination trials, the triangle and the square (see Figure 2) were displayed simultaneously. Selections of the triangle, but not the square, were followed by "Good" and the delivery of a penny. The conditional discrimination was taught with similar procedures except that the experimenter prompted the first two selections by saying,

"This (sample) goes with this (comparison)" while pointing to the appropriate forms. The next two trials were not prompted. If a subject made an error on either unprompted trial, the instructions were repeated on two more trials. On these and subsequent unprompted conditional-discrimination trials, reinforcers followed selections of the rectangle in the presence of the green patch and the tilde in the presence of the red patch (see Figure 2).

The simple and conditional discriminations were established in separate trial blocks. For each performance, the criterion for ending pretraining was 11 of 12 correct trials at the end of the block.

Baseline training. Procedures and learning criteria were the same as in pretraining except that the stimuli were Greek letters, designated as A1, A2, B1, and B2 in Figure 2. For all subjects, the A1/A2 task was taught first and the AB task second.

Next, six A1/A2 trials and 12 AB trials were intermixed in one or more mixed-baseline blocks. No more than two A1/A2 or two AB trials occurred consecutively. Criterion for proceeding was errorless performance on one mixed-baseline block.

Subjects were then given a block of 22 trials in which selections were no longer followed by differential consequences. The children's first exposure to nonreinforced simple-discrimination trials presented the pretraining stimuli, the triangle and the square. These trials, termed triangle/square trials, were presented to minimize possible disruption of the A1/A2 performance when A1 selections were no longer followed by pennies. The first 18 trials of this block consisted of 12 triangle/square trials intermixed with six AB trials. The last four trials of the block were A1/A2 trials, presented to verify maintenance of that performance. Criterion for advancing to the following probe phase was errorless performance on one block of unreinforced trials.

B-probes. B-probe blocks also consisted of 22 trials. In the first 18 trials, six B-probes were interspersed among six AB trials and six triangle/square trials. The last four trials of the block were A1/A2 trials. Probe blocks were presented twice to each subject; no differential consequences followed selections. All probe blocks were preceded by an 18-trial mixed-baseline block (six A1/A2 trials and 12 AB trials) with differential consequences.

To minimize the likelihood that B-probe selections might be influenced by the subject's most recent B-stimulus selection on an AB trial, two constraints were imposed on B-probe trial sequences. First, probe trials were always scheduled to follow one of the triangle/square trials so that the subject's immediate history was selecting a triangle and not B1 or B2. Second, two different trial sequences were used. Sequence 1 was arranged such that the subject's most recent B-stimulus selection prior to the first probe trial was likely to be B1. Sequence 2 was arranged such that the most recent selection was likely to be B2. Two subjects were given Sequence 1 on their first B-probe block and Sequence 2 on the second. The order was reversed for the other 2 subjects.

RESULTS

Figure 3 shows percentage correct on simple- and conditional-discrimination trials and percentage selections of B1 on B-probe trials for each subject. Simple-discrimination data (i.e., from triangle/square, A1/A2, and B-probe trials) are plotted on the upper ordinates, and conditional-discrimination data (i.e., from pretraining and AB trials) are plotted on the lower ordinates. Striped, open, and dark bars represent pretraining, training, and probe trials, respectively. When both blocks of a session presented the same trial types under the same reinforcement conditions, performance is shown by a single bar. For example, one bar is drawn to show Subject SA's performance in her first session because both 18-trial blocks presented triangle/square trials. When conditions in the two blocks of a session differed, data from each block are indicated with a separate bar or set of bars. In SA's second session, for example, the first block required simple discrimination (triangle/square) and the second block required conditional discrimination. If simple- and conditional-discrimination trials were intermixed, as in the second block of SA's fifth session, then the bar representing the former is drawn immediately above the bar representing the latter. The square brackets join the probe performances with those on other trials presented in the probe block.

For sessions in which reliability was assessed, there was 100% agreement between the

experimenter's and the observer's session records.

Pretraining

All children learned these discriminations promptly. Subject SA required two sessions to meet the pretraining criteria; the other 3 subjects each met the criteria in a single session.

Baseline Training

All subjects met criterion for the A1/A2 task within two trial blocks. They all met criterion for the AB task within three trial blocks.

When A1/A2 and AB trials were intermixed within the same block of trials, only SJ achieved perfect accuracy scores immediately. Most of SA's and DN's incorrect selections occurred on A1/A2 simple-discrimination trials. SA selected A2 for the first time at this point (Session 5, second block). In her next two sessions, only A1/A2 trials were presented, and her performance was again perfect. In her next mixed-baseline block (Session 8, second block), she made no further incorrect selections.

With Subject DN, simple-discrimination inaccuracy persisted for several sessions. Between Sessions 3 and 12, mixed-baseline blocks were presented several times. Accuracy scores on AB trials were typically high throughout these sessions, although DN did make single incorrect selections in Sessions 8 and 9. Performance on A1/A2 trials however, was inaccurate in Sessions 3, 4, 6, 8, and 9. Incorrect selections occurred only in the context of mixed-baseline blocks. When AB trials were not presented in Sessions 5 and 7, DN performed perfectly on A1/A2 trials. After 72 consecutive correct A1/A2 trials (Sessions 10 and 11), simple- and conditional-discrimination trials were intermixed without accuracy decline in Session 12.

Most of Subject GM's incorrect selections occurred on AB conditional-discrimination trials. After two early errors, he met the initial accuracy criterion for the AB task in the first block of Session 3. On the second block of Session 3, his first mixed-baseline block, GM made one incorrect selection on an A1/A2 trial and two on AB trials. When the AB task was reviewed in the following sessions, his inaccuracy continued until the first block of Session 6. The second block of Session 6 was a mixed-

Fig. 3. Data from Experiment 2. The bars show percentage correct on simple- and conditional-discrimination trials and percentage selections of B1 on B-probe trials. Simple- and conditional-discrimination data are plotted on the upper and lower ordinates, respectively. Striped bars, open bars, and dark bars represent pretraining, training, and probe performance, respectively. Each session consisted of two-trial blocks, plotted separately unless both presented the same trial type(s). A bar on the upper ordinate plotted immediately above one on the lower shows that simple- and conditional-discrimination trials were intermixed in that block. Bars divided into open and striped sections indicate that both baseline and pretraining simple-discrimination trials were presented; performance on probe trials is shown separately next to the divided bars. The braces show that baseline, pretraining, and probe trials were all presented in the same block. No differential consequences followed selections in trial blocks marked with asterisks.

baseline block, and his performance was perfect.

Subjects always performed perfectly in their first session that included a trial block without differential consequences (SJ: 5, SA: 9, GM: 7, DN: 13). Thus, accuracy was maintained

even though selections were no longer followed by pennies or praise.

B-Probes

For all subjects, performance on baseline trials was perfect in all probe sessions. When

B1 and B2 were displayed without a sample, 3 of the 4 subjects selected B1 on every probe trial in their first probe session (SJ: 6, SA: 10, DN: 14). Subject GM selected B1 on five of six probe trials (Session 8); the B2 selection occurred on the first probe trial. The A1/A2 and AB tasks were reviewed in his next five sessions. He made incorrect selections in the first three of these sessions, on A1/A2 trials in Sessions 9 and 10 and on AB trials in Session 11. Accuracy scores were perfect in Sessions 12 and 13. When the B-probes were repeated in Session 14, GM again selected B1 on five of six probe trials, and again selected B2 on the first trial.

All other subjects received their second set of B-probes in the session immediately following their first. Two subjects, SJ and DN, again selected B1 on all six trials. Subject SA, however, now selected B1 on only five of six trials; she selected B2 on the third probe trial.

The particular sequence of probe trials did not seem to affect probe performance. Across subjects, there were only three selections of B2. Two occurred with Sequence 1 and one with Sequence 2.

DISCUSSION

Although the children were less capable than the adult subjects studied previously, the probe results of this experiment were virtually identical to those of Experiment 1. During baseline acquisition, however, some children showed a pattern that may merit systematic analysis in its own right. We refer to the apparent disruption of baseline discriminations that occurred when simple- and conditional-discrimination trials were intermixed. The clearest evidence of disruption was shown by DN's nearly perfect A1/A2 accuracy scores in Sessions 2, 5, and 7 and by his persistently imperfect scores in Sessions 3, 4, 6, 8, and 9 (see Figure 3).

One possible explanation for disruption of the A1/A2 discrimination is that A2, the S-, acquired a reinforcement history when it was incorporated into a chain of behavior that terminated with reinforcement. This could occur on AB trials in which A2 was the sample. When a child touched A2 to begin a conditional-discrimination trial, this response was immediately followed by the presentation of

the comparison stimuli, B1 and B2, and then by a reinforcer if B2 was selected. When the children learned the AB task, the presentation of the comparison stimuli may have come to function as a conditioned reinforcer, thereby reinforcing the touch to the sample, A2. Perhaps this history increased the likelihood that the child would touch A2 at other times, that is, on A1/A2 simple-discrimination trials. This analysis leads to two predictions: (a) Conditioned reinforcement following touches of A2 would be most likely to affect the A1/A2 discrimination when A1/A2 and AB trials were intermixed—the outcome we observed. This is because conditioned reinforcement for touching A2 (as a sample) is maintained under such conditions, thereby providing an immediate history to compete with the reinforcement contingencies prevailing on A1/A2 trials. (b) The effects of the competing history would be most pronounced when an A1/A2 trial immediately followed an AB trial on which A2 was the sample. In such a case, the subject's most recent history with respect to A2 would be conditioned reinforcement for touching it; the history of A2 serving as S- on A1/A2 trials would be less recent. Supporting prediction (b), trial-by-trial analysis on DN's data revealed that 71% of his A1/A2 errors occurred on trials that immediately followed AB trials on which A2 was the sample. This percentage seems especially meaningful because that particular juxtaposition of trial types occurred on fewer than 20% of the trials programmed.

The conditioned reinforcement account may oversimplify matters, however. The account is most applicable when sample touches are required to produce the comparison stimuli. In Experiment 1, however, DR also showed disruption of the A1/A2 discrimination when such trials were intermixed with AB trials on which no sample touches were required. Perhaps another way to account for the disrupted performance is the formation of stimulus classes that include not only the stimuli to be discriminated on simple- and conditional-discrimination trials, but also the consequences related to those stimuli (see Dube, McIlvane, Mackay, & Stoddard, 1987). If such class formation occurred, indirect relation of A2 with reinforcing consequences could perhaps lead to occasional A2 selections, despite the prevailing simple-discrimination contingencies.

Fig. 4. Schematic diagram of conditional relations examined in Experiment 3. Boxes containing letter/number combinations represent stimuli displayed on conditional-discrimination trials (see Figures 5 and 6). Arrows point from samples to comparisons. Solid arrows show relations established by direct training. Dashed arrows show tested relations that might emerge without further training. Shaded boxes indicate that those stimuli did or could potentially function as S+ on simple-discrimination trials.

EXPERIMENT 3

This experiment had two purposes. The first was systematic replication of the procedures with a third subject population, mentally retarded adults. The second was to find out whether simple discrimination would emerge if the stimuli to be discriminated were only indirectly related to stimuli that had served as S+ and S- on simple-discrimination trials. Direct versus indirect relations to S+ and S- stimuli will be explained with reference to Figure 4. Boxes in Figure 4 represent stimuli used in training. As in the previous experiments, A1 and A2 served as S+ and S-, respectively, on simple-discrimination (A1/A2) trials. B1 and B2 were comparison stimuli selected conditionally upon A1 and A2, respectively; the solid arrows indicate that those conditional (AB) relations were taught directly. Arrows point from sample to comparison stimulus.

In Figure 4, C1 and C2 (left diagram) and D1 and D2 (right diagram) represent stimuli used to extend the basic procedure. C1 and C2 were comparison stimuli selected conditionally

upon samples B1 and B2, respectively (BC relations). D1 and D2 were samples that controlled selections of comparisons B1 and B2, respectively (DB relations). Solid arrows are used to show that the BC and DB relations were also taught directly.

Shading in the A1, B1, C1, and D1 boxes is used to indicate S+ stimuli for simple discriminations that either were taught directly or could potentially emerge. Experiments 1 and 2 showed that when subjects learned the A1/A2 discrimination and were subsequently given AB training, they were then highly likely to select B1 on the B-probes. In the present experiment, BC and DB training was also given. This additional training permitted tests of simple discrimination between two stimuli that were conditionally related to B1 and B2. B1 and B2 differed from A1 and A2 in that the B-stimuli had never appeared on reinforced simple-discrimination trials. Would a subject who had learned to select comparison stimuli C1 and C2 conditionally upon samples B1 and B2, respectively, select C1 and not C2 on simple-discrimination probe trials (C-probes)? Similarly, would a subject who had learned to select comparison stimuli B1 and B2 conditionally upon samples D1 and D2, respectively, select D1 and not D2 on probe trials (D-probes)? In both cases, stimuli involved in the potentially emergent simple discriminations had neither been conditionally related to A1 and A2 nor had they appeared with A1 and A2 on the same trial.

Experiment 3 also tested for the emergence of conditional relations that were not taught directly. Relations tested are shown by the broken arrows in Figure 4. The emergence of CB or BD relations would show symmetry of the directly taught BC or DB relations, respectively. The emergence of AC or AD relations would show transitivity of the AB and BC or the AB and BD relations, respectively.

METHOD

Subjects

Two moderately retarded male adults served as subjects. Both were recruited from a day program for developmentally disabled individuals. MS was 31 years old and experimentally naive. His most recent psychometric evaluation yielded an IQ score of 46 (Wechsler Adult Intelligence Scale). MS was capable of com-

municative speech including phrases and simple sentences. DL was 25 years old and had served in prior research on conditional-discrimination procedures (Dube et al., 1987). His last psychometric assessment yielded an age-equivalent score of 4.7 on the Peabody Picture Vocabulary Test. His speech consisted of single words and simple phrases.

Setting and Apparatus

Sessions were conducted in a quiet room at the subjects' day program. The subject and the experimenter sat on opposite sides of a table with a display apparatus placed between them. The display consisted of two clear Plexiglas compartments (each 15.2 cm by 15.2 cm by 7.6 cm) mounted side-by-side on a base with a hinged, opaque screen that could be raised to shield the contents of the compartments from the subject's view. A display platform (10 cm by 17.5 cm) was mounted slightly above and centered between the comparison compartments. Data recording and stimulus materials were kept on a tray on the experimenter's lap, under the tabletop, and out of the subject's view.

General Procedures

Stimuli. Stimuli were abstract two-dimensional forms, Greek letters, and objects likely to be unfamiliar to the subjects (e.g., electronic components). Forms and letters were drawn in black on white index cards. More detailed stimulus specifications will be given below in conjunction with the experimental conditions.

Programmed consequences. When a continuous reinforcement schedule was in effect the experimenter said "Good" following every correct selection and gave the subject a reinforcer (a penny for MS or an M&M® for DL). After incorrect selections, the experimenter said "No" and immediately advanced to the next trial.

When an intermittent reinforcement schedule was in effect, correct selections were followed by reinforcers on every other trial on average (variable-ratio 2 [VR 2]). On trials in which reinforcement did not occur, the experimenter said nothing and merely advanced to the next trial. For both subjects, the total number of reinforcers provided in each session was approximately the same under the continuous and intermittent reinforcement schedules. With DL, this was accomplished by delivering two

M&M®s on every reinforced trial. With MS, a nickel was delivered periodically during inter-trial intervals.

Procedures. Sessions, usually consisting of 48 discrimination trials, were conducted 4 to 5 days per week. On simple-discrimination trials, the experimenter lowered the screen to reveal a stimulus in each compartment. The subject selected one of them by touching the face of one compartment. On conditional-discrimination trials, the experimenter first placed a sample stimulus on the platform, and the subject was required to touch it. Then, the experimenter lowered the screen to reveal a comparison stimulus in each compartment. Further sample touches had no programmed consequences. The subject's selection was made by touching a compartment.

On both types of trials, if differential consequences were scheduled for that trial, the experimenter said "Good" or "No," as appropriate, when the subject touched a compartment. Then he raised the screen, removed the sample stimulus (on conditional-discrimination trials), and placed the penny or M&M® in front of the subject.

The position of the correct compartment varied unsystematically across trials. Samples also varied unsystematically with the restriction that the same sample did not appear on more than three consecutive trials. Inter-trial intervals were determined by the amount of time necessary to record the subject's selection on a previously prepared scoresheet and to arrange stimuli for the next trial (about 5 to 10 s).

Delayed prompting procedure. Subjects received no verbal instructions prior to training. A variant of the delayed prompting procedure (Touchette, 1971) was used to establish the simple- and conditional-discrimination baselines. Early in training, the experimenter prompted selection of the stimulus defined as correct by pointing to the compartment that contained it. Initially, the prompt was presented immediately after the screen was lowered to reveal the stimuli. After every two consecutive correct selections, prompt presentation was delayed by 1 additional second. As the prompt delay increased over trials, the subject could potentially respond before its presentation. If those unprompted selections were correct, then the subject demonstrated that he had learned the desired discriminations. Any in-

Fig. 5. Illustrative stimulus displays presented to MS during pretraining, training, and probe procedures in Experiment 3. Stimuli designated A1, A2, C1, and C2 were forms. Stimuli designated B1 and B2 were a diode and a pen cap, respectively.

correct selection resulted in a prompt-delay decrease of 1 s on the next trial.

Pretraining. To give the experimentally naive subject, MS, experience with conditional-discrimination procedures, he first learned an identity-matching task. Stimuli were objects and arbitrary forms different from those used later in the experiment. On each trial, a sample object or form was displayed on the platform. When MS touched the sample, the screen was lowered to reveal a comparison in each compartment. One of the comparisons was physically identical to the sample, and MS was to select the compartment that contained it. Correct selections were followed by a penny. Incorrect selections ended the trial (noncorrection). Pretraining was omitted for DL because of his prior experience with conditional-discrimination procedures.

Systematic Replication of Experiments 1 and 2

The first part of this experiment was a replication of Experiments 1 and 2 with a similar sequence of conditions.

Baseline training. A1/A2 and AB tasks were established in sessions consisting of three blocks of 16 trials each. Typically, the first block of each training session presented A1/A2 trials, and the second and third blocks presented AB trials. At this stage of training, sessions were repeated until subjects were 100% accurate for an entire session.

The upper portion of Figure 5 illustrates the trial displays presented to Subject MS. A1 and A2 were arbitrary forms; B1 and B2 were a large diode and a pen cap, respectively. For Subject DL, A1, A2, B1, and B2 were Greek letters, lower case lambda, upper case omega, upper case psi, and upper case phi, respectively, as shown in the upper portion of Figure 6.

After one session of errorless performance on separate 16-trial blocks of A1/A2 and AB trials, the two trial types were gradually intermixed. Initially, A1/A2 and AB tasks alternated in blocks of eight trials each; the blocks were then reduced to four trials, and finally both kinds of trials were scheduled unsystematically. After two sessions of this procedure, the subjects were adapted to intermittent reinforcement over the next eight sessions. For DL, this was accomplished by gradually increasing the proportion of unreinforced trials over sessions; the VR 2 schedule was in effect

for the last two of these sessions. For MS, trials that required the pretraining identity-matching task were reintroduced and interspersed among mixed-baseline trials. Then, an increasing proportion of unreinforced trials was scheduled, first on the pretraining task and then on the mixed-baseline tasks. No pretraining trials were presented in the final two sessions. The criterion for advancing to the probe phase was at least two sessions (96 trials) in which all selections were correct.

B-probes. B-probes were interspersed among intermittently reinforced mixed-baseline trials (see Figures 5 and 6, upper portions). Probes for MS were distributed across three sessions, with four probes presented in each session. Probes for DL were distributed across two sessions, with six probes in each session. Selections on these and all subsequent probe trials throughout the experiment were never followed by reinforcers.

BC Training and Testing

Only MS participated in this part of the experiment.

BC training. The lower portion of Figure 5 illustrates the trial displays that were presented. Using delayed prompting, MS was taught to select two new forms, C1 and C2, conditionally upon samples B1 and B2, respectively. During initial training, sessions consisted of two 16-trial blocks of BC training trials, and a third block that reviewed the A1/A2 and AB tasks. Continuous reinforcement was scheduled for these sessions.

Next, BC trials were gradually intermixed with AB and A1/A2 trials, and the reinforcement schedule was gradually changed from continuous to intermittent (VR 2). Ultimately, each session consisted of 24 BC trials, 12 AB trials, and 12 A1/A2 trials. Criterion for advancing to probe sessions was one session in which all selections were correct under these conditions.

Probe sessions. MS received a total of eight probe sessions. Each probe session included several probe trials of one of the following types interspersed among baseline trials: On C-probes, C1 and C2 were displayed without a sample. On B-probes, B1 and B2 were displayed without a sample. On AC transitivity probes, C1 and C2 were comparison stimuli, and A1 or A2 were samples. On CB symmetry probes, B1 and B2 were comparison stimuli,

Fig. 6. Illustrative stimulus displays presented to DL during pretraining, training, and probe procedures in Experiment 3. All stimuli were Greek letters.

Table 2

The sequence of teaching and probing in Experiment 3, and a summary of the probe results. For the B-, C-, and D-probes, the colon separates the number of selections of B1, C1, or D1 (left) from those of B2, C2, or D2 (right). For symmetry and transitivity tests, the colon separates the number of selections consistent and inconsistent with those relations.

	MS	DL
Teach AB		
B-probes	11:1	12:0
Teach BC (MS only)		
C-probes	15:1	—
B-probes	6:0	—
AC transitivity	18:0	—
CB symmetry	8:0	—
Teach DB		
D-probes	3:3	4:2
B-probes	5:1	6:0
D-probes	10:2	12:0
AD transitivity	6:0	6:0
BD symmetry	8:0	8:0

and C1 or C2 were samples. The first C-probe session included four probes, the final (symmetry probe) session included eight probes, and all other sessions included six probes.

DB Training and Testing

DB training. Both subjects participated. Delayed prompting was used to teach subjects to select comparisons B1 and B2 conditionally upon new samples, D1 and D2, respectively.

For Subject DL, D1 and D2 were Greek letters, lower case sigma and lower case pi, respectively (see Figure 6, lower portion). Training procedures were directly analogous to those used for BC training with MS. First, he was taught the DB task, and the A1/A2 and AB performances were maintained separately under continuous-reinforcement conditions. Next, DB trials were intermixed with AB and A1/A2 trials, and intermittent reinforcement was gradually introduced.

For Subject MS, D1 and D2 were Greek letters, lower case lambda and upper case omega, respectively. MS learned the DB conditional discrimination under a modified intermittent reinforcement schedule. A1/A2 and AB performances were maintained separately also under intermittent reinforcement conditions. Initially, the experimenter said "Good" following every correct selection but delivered pennies on only 50% of these trials. After the

DB discriminations had been learned, unreinforced trials were gradually introduced until the VR 2 schedule was achieved. Then, DB, AB, and A1/A2 trials were intermixed.

For both subjects, the final baseline consisted of 24 DB, 12 AB, and 12 A1/A2 trials per session. All trial types were intermixed and reinforced on the VR 2 schedule. Criterion for advancing to probe sessions was one session in which all selections were correct under these conditions.

Probe sessions. Each subject received seven probe sessions. Each session included six D-probe, B-probe, AD probe, or BD probe trials, interspersed among intermittently reinforced baseline trials. All probe trials within a session were of the same type.

Reliability

An independent observer recorded all stimulus presentations and selections for three of MS's and two of DL's sessions. The experimenter's and observer's records never disagreed.

RESULTS

Table 2 presents the sequence of teaching and probe procedures of this experiment and also gives a summary of the probe results.

Systematic Replication of Experiments 1 and 2

MS and DL required 17 and 16 sessions, respectively, to complete this part of the experiment. Both subjects rapidly acquired the A1/A2 and the AB discriminations. DL made incorrect selections on one A1/A2 trial and five AB trials. MS made incorrect selections on three A1/A2 trials and one AB trial. For both subjects, accuracy was perfect when the two trial types were intermixed. During adaptation to intermittent reinforcement, DL and MS made one and five incorrect selections, respectively. Both subjects were perfectly accurate in their final two sessions under these conditions.

Results of the B-probes were consistent with those obtained in Experiments 1 and 2. DL selected B1 on all 12 probe trials. MS selected B2 on the first probe trial but then selected B1 on the remaining 11 probes.

BC Training and Testing

MS required 17 sessions to complete this part of the experiment. He made only three

incorrect selections during baseline development, all on A1/A2 trials.

On the C-probes, he selected C1 on 15 of 16 trials. The only inconsistent selection was in the second of three probe sessions. When B-probes were presented, he selected B1 on each of six probe trials. In three AC probe sessions, MS always selected C1 conditionally upon A1 and C2 upon A2. In the CB probe session, he always selected B1 conditionally upon C1 and B2 upon C2.

DB Training and Testing

Both subjects acquired the necessary baselines rapidly and accurately. On the first six probe trials, MS and DL selected D1 on only three and four trials, respectively. Both subjects were next given one B-probe session. Reliable selection of D1 on D-probes would be predicted only if subjects continued to select B1 on B-probes. On the B-probes, MS selected B1 on five of six trials and DL selected B1 on all six trials. D-probes were then repeated in two sessions for each subject. MS now selected D1 on five of six probe trials in each session. DL selected D1 on all 12 probe trials.

On AD probes, both subjects always selected D1 conditionally upon A1 and D2 upon A2. On BD probes, both subjects always selected D1 conditionally upon B1 and D2 upon B2.

DISCUSSION

Results systematically replicated those of Experiments 1 and 2 in subjects with comparatively impoverished behavioral repertoires. Subjects in Experiment 3 received no spoken or written instructions during baseline training. The experimenter simply modeled the correct behavior. Explicit verbal instructions (e.g., "[sample A1] goes with [comparison B1]") are apparently not required to produce emergent simple discrimination.

Results from the probes following BC and DB training extend the findings of the first two experiments. Simple discrimination emerged even though C1, C2, D1, and D2 were not directly related to the stimuli, A1 and A2, that served as S+ and S- on simple-discrimination trials. D-probe results were somewhat unusual in that simple discrimination with the D-stimuli was not present at the outset of testing; it emerged in further probing even though no reinforcers followed

probe selections. In this respect, these results resemble the gradual emergence of new conditional discriminations sometimes observed in research on stimulus equivalence (see Spradlin, Cotter & Baxley, 1973).

A question for future research is whether the emergent simple-discrimination performances seen on the C- and D-probes would have been demonstrated if subjects had not first displayed a similar discrimination on B-probes. Would MS, for example, have reliably selected C1 on the C-probes if he had received only AB, BC, and A1/A2 training? A related question is the contribution of the B-probes that intervened between the first and second sets of D-probes. Conceivably, the reliable D1 selections seen only on the second set of D-probes may have depended on a recent history of selecting B1 in the simple-discrimination format. This conclusion, however, requires that reliable D1 selection would not have emerged if the D-probes had merely been repeated without the intervening B-probes.

Another question for future research is whether one can replicate the apparent difference between MS's performance on the C- and D-probes. Prior to the probes, C-stimuli served as comparisons selected conditionally upon samples that had acquired S+ and S- functions, whereas D-stimuli served as samples controlling selection of comparisons that had acquired those functions. Will subjects be more likely to display emergent simple discrimination in the former case than in the latter? The possibility is intriguing in light of current interest in the role of "directionality" of training in producing subsequent emergent behavior (D'Amato, Salmon, Loukas, & Tomie, 1985; Spradlin & Saunders, 1986). If directionality of training proves to be a variable in the present procedures, however, it will be important to determine whether the effect results merely because D-stimuli have only appeared successively as samples and never simultaneously as comparison stimuli prior to the D-probes.

GENERAL DISCUSSION

This study found that simple discrimination emerged between two stimuli that were related indirectly to different consequences. This finding may have wide generality. Discrimination emerged in 15 subjects who differed greatly in

their capabilities and histories. Further, the three experiments used varied stimuli, training methods, and probe procedures. The consistency of results suggests that the emergent discrimination did not result from uncontrolled variables such as primary stimulus generalization. Rather, the critical variable appeared to be the relations of probe stimuli to the S+ and S- in a simple discrimination established by direct training. Future studies will be needed to determine the nature of these relations.

On the face of it, the training contingencies required only (a) invariant relations between A1 and A2 and different consequences on simple-discrimination trials and (b) conditional (if-then) relations among the samples (A1 and A2), comparisons (B1 and B2), and those consequences on conditional-discrimination trials. The subjects clearly learned more, however. Conditional relations, for example, proved to be symmetric (Experiments 1 and 3) and transitive (Experiment 3). These outcomes suggest that stimulus classes had been established, perhaps defined by equivalence. Would similar emergent discrimination be seen in members of species that do not seem to acquire equivalence relations, such as pigeons (D'Amato *et al.*, 1985) or rhesus monkeys (Sidman *et al.*, 1982)? The present procedures seem particularly appropriate for studying potentially emergent behavior in infrahumans because the probes do not require presenting stimuli in new locations (*cf.* Iversen, Sidman, & Carrigan, 1986).

More generally, the present procedures may be helpful in distinguishing stimulus equivalence (Sidman & Tailby, 1982) from what has been termed "functional equivalence" (Goldiamond, 1966). To document stimulus equivalence, one must show that conditional relations among stimuli are reflexive, symmetrical, and transitive. Functional equivalence requires merely a demonstration that two or more stimuli control the same behavior. Classes of functionally equivalent stimuli are defined when variables applied to a subset of class members affect the remaining class members in the same way (Galloway & Petre, 1968; Lazar, 1977; Silverman *et al.*, 1986; Spradlin & Dixon, 1976).

Emergent simple discrimination in the present study demonstrates functional equivalence: When A samples and B comparisons were conditionally related, the latter acquired the sim-

ple-discrimination functions of the former. Experiment 3 extended this finding. The simple-discrimination functions acquired indirectly by the B-stimuli were also acquired by the C- and D-stimuli through conditional relations with B samples or B comparisons, respectively. Formation of three-member (Subject DL) or four-member (Subject MS) classes of functionally equivalent stimuli was shown. Results of the symmetry and transitivity tests also suggested classes defined by stimulus equivalence. These outcomes lead to the question of whether the present procedures will always result in behavior that satisfies both definitions of equivalence. For example, could a subject display emergent simple discrimination but fail stimulus equivalence tests, or vice versa? Either outcome would suggest a meaningful distinction between stimulus equivalence and functional equivalence.

We note, however, that there were no differences in the conditional-discrimination procedures used in Experiment 3 to generate both emergent simple discrimination and emergent symmetry and transitivity. Rather, the functional equivalence versus stimulus equivalence distinction arises primarily from the difference in the tests that documented them. Perhaps the same variables underlie both forms of emergent behavior.

Further studies must also define more precisely the controlling relations in trained and emergent simple discrimination. Procedurally, A1 and B1 functioned as S+ and A2 and B2 as S-. We did not ascertain, however, that stimuli would independently control selection or rejection. This could be done by requiring a successive rather than a simultaneous A1/A2 discrimination: If A1, then select it; if A2, then do not. After AB training, B1 and B2 would then be displayed successively. Would subjects select B1 and refrain from selecting B2? If not, the results would suggest that the apparent S- function of B2 in the present simultaneous procedures may depend on the presence of B1 as an alternative.

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APPENDIX

Instructions Given to Subjects in Experiment 1

This study involves two different types of tasks. They will be described for you here before you are asked to do them. Initially, you will learn performances involving shapes that are drawn on the screen (e.g., a square or an oval). On each trial, you will see two choice items, each displayed within the two white choice areas in the upper corners of the screen. [A picture of the computer screen appeared here, with an oval on one key, a square on the other, and a blank key centered below and between them.] You simply choose one of them by moving the "mouse" until the small on-screen arrow is on your choice, and then pressing the button briefly. (Of course, you will not know which choice is correct.) If you selected the correct choice, the word "Correct" will appear on the screen. If you selected the incorrect choice, the word "Wrong" will appear. The amount of money you will earn depends upon the number of correct choices you make, so it is a good idea to pay attention to when the program tells you if you are correct or wrong.

In the second task, you will again see two choice items, displayed in the corner

choice areas. You will also see a third shape displayed below them, in the center white area. The choices will always be the top two items. [A picture of the display screen appeared here, with a square and an oval on the upper two keys, and a triangle on the lower one.] For example, here your choices are either the square or the oval. You choose one that goes with the triangle. (You do not know which choice is correct, of course.) In other words, when the triangle is displayed in the center area, you choose one item from the choices above that goes with it. Again, move the mouse until the on-screen arrow is on your choice and press the button. The program will again tell you if you have made the correct selection.

Later on in the study, you will not be told whether your choice was correct or wrong. This is part of the study. It does not necessarily mean that you have responded incorrectly.

If you have any questions, ask the experimenter.