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CONTROL OF ADOLESCENTS' ARBITRARY MATCHING-TO-SAMPLE BY POSITIVE AND NEGATIVE STIMULUS RELATIONS

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In Experiment 1, four developmentally delayed adolescents were taught an A-B matching-to-sample task with nonidentical stimuli: given Sample A1, select Comparison B1; given A2, select B2. During nonreinforced test trials, appropriate matching occurred when B stimuli appeared as samples and A stimuli as comparisons, i.e., the sample and comparison functions were symmetrical (B-A matching). During A-B or B-A matching test trials in which familiar samples and correct comparisons were presented along with novel comparisons, the subjects selected the correct comparisons. In tests with familiar samples and both incorrect and novel comparisons, subjects selected the novel comparisons, demonstrating control by both positive ("matching") and negative ("nonmatching") stimulus relations in A-B and B-A arrays. In Experiment 2, 12 developmentally delayed subjects were taught a two-stage arbitrary-matching task (e.g., A-B, C-B matching). Test sessions showed sample-comparison symmetry (e.g., B-A, B-C matching) and derived sample-comparison relations (e.g., A-C, C-A matching) for 11 subjects. These subjects also demonstrated control by positive and negative stimulus relations in the derived relations.

Key words: matching-to-sample, stimulus equivalence, stimulus classes, stimulus control, window press, developmentally delayed humans

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In arbitrary ("symbolic" or "nonidentity") matching-to-sample, subjects are taught to match a sample stimulus to an arbitrarily designated (nonidentical) comparison stimulus (cf., Cumming & Berryman, 1965; Sidman, Rauzin, Lazar, Cunningham, Tailby, & Carrigan, 1982; Sidman & Tailby, 1982). Consider an arbitrary-matching task involving four stimuli: trials begin with a sample stimulus, A1 or A2, displayed on the center one of three windows. When the subject touches the sample, two side windows illuminate with Comparisons B1 and B2. In the presence of A1, touching B1 is reinforced, whereas when A2 is the sample, touching B2 is reinforced. In symbolic notation (Berryman, Cumming, Cohen, & Johnson, 1965; Cumming & Berryman, 1961; Cumming, Berryman, & Cohen, 1965), A-B training may be denoted: A1(B2, B1*), A2(B1, B2*), where samples are designated outside the parentheses, comparisons within, and the asterisk marks the correct comparison (left-right position of the comparisons across trials is irrelevant).

The major aim of this study was to ascertain the sample-comparison relations that control arbitrary matching. Matching performance may be controlled by either or both of two relations between samples and comparisons. These two relations are the positive relation between samples and correct (S+) comparisons, and the negative relation between samples and incorrect (S−) comparisons (Berryman et al., 1965; Carter & Werner, 1978; Cumming & Berryman, 1961). The controlling relation must be inferred from a subject's systematic selection when faced with arrays that include novel stimuli. For example, following A-B training, control of the subject's comparison selections by the sample-S+ relation is demonstrated if, on test trials (nonreinforced) of the type A1(N1, B1), A2(N2, B2), a subject

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continues to select the appropriate B comparisons and not the novel comparisons. Comparison selections under the control of the sample-S− relation would be tested during test trials of the type A1(B2, N1), A2(B1, N2). Control by the sample-S− relation predicts avoidance of S− and selection of the novel comparisons, N1 or N2.

Experiment 1 studied whether control by these two sample-comparison relations describes the A-B matching performance of developmentally delayed humans, as well as their performance on symmetrical B-A matching. Symmetry was tested by presenting the originally trained comparisons as samples and the trained samples as comparisons (Sidman et al., 1982). If sample and comparison functions are symmetrical, subjects should select A1, given test trials B1(A2, A1), and A2 given B2(A1, A2). Symmetry was recently demonstrated with young children (Sidman et al., 1982), but the question of control by sample-S+ and sample-S− relations in B-A performance remains open.

In Experiment 2, the analysis of control by sample-S+ and sample-S− relations was extended to derived matching performances, following training on three two-stage arbitrary-matching tasks (e.g., Lazar, 1977; Sidman, 1971; Sidman & Cresson, 1973; Sidman, Cresson, & Willson-Morris, 1974; Spradlin, Cotter, & Baxley, 1973). Some subjects were trained on an A-B, C-B sequence, then tested for control by the derived relations A-C and C-A. Derived control might develop on the basis of Samples A and C having a common relation with B comparisons. Other subjects received training on an A-B, A-C task and were then tested for derived relations B-C and C-B. These derived relations might develop because of the common relation between B and C comparisons and A samples. And finally, some subjects were taught A-B, B-C matching, then tested for derived A-C and C-A relations. Would derived sample-S+ and sample-S− relations control selections in derived A-C and C-A, or B-C and C-B arrays?

A determination of these controlling relations has important theoretical implications. The matching performance of pigeons seems to be controlled by unidirectional sample-S+ relations, as suggested by the failure to perform correctly on tests of sample-comparison symmetry and on generalized identity-matching and oddity trials (Carter & Werner, 1978; Gray, 1966; Hogan & Zentall, 1977; Rodewald, 1974). Nonhuman primates also fail to show sample-comparison symmetry under similar training and testing conditions (Sidman et al., 1982). It has been suggested that such failures of generalization and symmetry may indicate a lack of control over comparison selection by the relation between samples and S− comparisons (Berryman et al., 1965; Carter & Werner, 1978; Cumming & Berryman, 1961; Urcuioli, 1977; Urcuioli & Nevin, 1975). In contrast, the generalized identity-matching and oddity performance of humans (Levin & Maurer, 1969; Saunders, 1973; Scott, 1964; Sherman, Saunders, & Brigham, 1970) appears indicative of control by both the relation between samples and S+ comparisons and the relation between samples and S− comparisons. The aptness of this analysis is strengthened by a recent demonstration of sample-S− control by children performing identity matching (Dixon & Dixon, 1978). And the complex performance of humans on arbitrary-matching tasks suggests that something more than sample-S+ relations is learned (Dixon, 1978; Dixon & Spradlin, 1976; Lazar, 1977; Sidman, 1971; Sidman & Cresson, 1973; Sidman et al., 1974; Sidman et al., 1982; Sidman & Tailby, 1982; Spradlin et al., 1973; Spradlin & Dixon, 1976). Control by the sample-S− relation might be a general characteristic of human matching-to-sample that holds for arbitrary matching as well.

EXPERIMENT 1
STIMULUS RELATIONS CONTROLLING A-B AND B-A MATCHING-TO-SAMPLE

This experiment assessed the extent to which the relations between sample and correct and incorrect comparisons controlled performance of arbitrary A-B and B-A matching. If the sample-S+ relation controls, subjects presented with novel comparisons along with familiar samples and S+ comparisons should select the S+ comparisons. And if the sample-S− relation controls, subjects should select the novel stimuli on test trials with novel comparisons along with familiar samples and S− comparisons.

Table 1

Subject characteristics: Chronological ages and durations of residency are expressed in years-months. Intelligence quotients were determined by either the Wechsler Intelligence Scale for Children (WISC) or the Wechsler Adult Intelligence Scale (WAIS).

Subject	*CA*	*IQ*	*Length of Residency*	*Etiology*
ED	13-0	67 WISC	1-4	Postnatal Injury
DW	16-5	78 WAIS	0-10	Unknown
JT	15-5	58 WISC	7-4	Psycho-Social Disadvantage
JL	15-6	65 WISC	6-0	Psycho-Social Disadvantage
MP	18-0	52 WAIS[a]	9-1	Unknown
JK	15-3	85 WISC	1-0	Unknown
LE	18-11	80 WAIS	2-0	Unknown
JC	15-5	70 WISC	0-11	Psycho-Social Disadvantage
LM	15-3	50 WISC	1-7	Unknown
NO	15-7	71 WISC	0-9	Unknown
LH	15-7	64 WISC	6-5	Unknown
AP	16-5	72 WAIS	7-5	Unknown
GC	15-9	61 WAIS	1-9	Unknown

[a]IQ determination based on Nonverbal Scale only.

METHOD

Subjects

The subjects were four adolescent male residents of a state hospital-and-training facility; all were unfamiliar with the present experimental procedures. They were chosen on the basis of availability, willingness to participate, and performance on a preliminary A-B matching task. Six candidates received 150 A-B trials under the training conditions described later. The stimuli were the same as those used by Dixon and Dixon (1978) and were not used again after screening. Four residents (ED, DW, JT, and JL) were included in the study who achieved 90 to 100% accuracy during Trials 101 to 150. Table 1 characterizes the subjects for both experiments.

Apparatus

The experimental space contained a stimulus display/response panel, a token receptacle, door chimes, and a buzzer. The display panel was 1 m from the floor and contained three circular windows (32 mm in diameter) that formed a triangle with a base of 50 mm and sides of 83 mm each (measured from the center of each window). The token tray was 12 cm directly above the stimulus/response panel. The door chimes and buzzer were attached near the ceiling. Each window was equipped with a 12-stimulus rear projector (Industrial Electronics Engineers, Inc., Model 2000). White figures (approximately 16-mm character size) on dark backgrounds served as stimuli. Figures 1 to 4 illustrate the stimuli used in both experiments, some of which were adapted from previous research (Caron, 1968; Gibson, Gibson, Pick, & Osser, 1962; Vellutino, Harding, Phillips, & Steger, 1975). Capacitance-sensing switches detected touches of the display windows. Tokens (metal washers) were dispensed via a Davis Universal feeder (Model 310). BRS solid-state circuitry and a Narcor tape reader (Model 1280B) programmed stimulus events from an adjacent room. Responses were recorded on digital counters and a Practical Automation printout counter (Model MMP-6 Moduprint).

Design

Various test conditions were evaluated against a baseline of criterion matching. Figures 1 and 2 depict exemplar training and novel test arrays. After learning the initial A-B matching task with Stimulus Set I, a subject proceeded through 18 test conditions, i.e., nine different tests, each given twice. Another A-B task was then trained with Stimulus Set II and the nine tests were administered twice again (36 test sessions in all). ED and JT were assigned to Sets Ia and IIa as illustrated in the figures; DW and JL were assigned to different sample-comparison arrangements during training and testing; e.g., the illustrated B2 was used as the B1 stimulus, B1 was used as B2, N2

Table 2

Sequence of conditions for subjects of Experiment 1. Tests 1 to 9 are listed in their order of occurrence for each subject. Figures 1 and 2 illustrate stimulus arrays corresponding to the training and testing conditions for each subject.

ED	*DW*	*JT*	*JL*	*ED*	*DW*	*JT*	*JL*
1. Initial A-B Training[a] *2. Administer Tests*[a]				*3. Replication A-B Training*[b] *4. Administer Tests*[b]			
1	1	1	1	1	1	1	1
2	5	7	8	8	7	5	2
3	4	6	9	9	6	4	3
2	5	7	8	8	7	5	2
3	4	6	9	9	6	4	3
4	6	9	3	3	9	6	4
5	7	8	2	2	8	7	5
4	6	9	3	3	9	6	4
5	7	8	2	2	8	7	5
1	1	1	1	1	1	1	1
7	8	2	5	5	2	8	7
6	9	3	4	4	3	9	6
7	8	2	5	5	2	8	7
6	9	3	4	4	3	9	6
9	3	4	6	6	4	3	9
8	2	5	7	7	5	2	8
9	3	4	6	6	4	3	9
8	2	5	7	7	5	2	8

[a]Stimulus Sets Ia and Ib were used for the initial conditions.
[b]Stimulus Sets IIa and IIb were used for the replication conditions.

as N1, etc. Table 2 describes the sequence of conditions for each subject.

Test Series I and II (see Figures 1 and 2) examined whether A-B matching is controlled by sample-S+ and sample-S− relations. Series III and IV asked whether similar relations controlled subjects' responses to symmetrical B-A arrays. Figures 1 and 2 show that each test series included a test with novel comparisons for control by the sample-S+ relation (Tests 2 and 6), or a test with novel comparisons for control by the sample-S− relation (Tests 4 and 8), and a test for preferences between novel comparisons when they were pitted against each other in the presence of familiar samples (Tests 3, 5, 7, and 9). Table 2 shows that these preference tests were administered before and after the tests for control by sample-S+ and sample-S− relations.

Training Procedures

Sessions of 84 trials each were held at the same time six days per week. At the end of each session, tokens were exchanged for money at the rate of three tokens to one cent under 100%-feedback contingencies. The token-penny ratio was shifted to 1:1 when intermittent-feedback contingencies were in effect.

Trial and consequences. Trials began with a sample displayed on the center window. Sample stimuli were randomized across trials with the restriction that the same sample occurred no more than two consecutive times. A single touch of the sample illuminated the comparison windows with S+ and S− comparisons. The sample remained illuminated until the subject touched a comparison. The left-right position of the comparisons alternated randomly with a maximum of three successive trials on the same side. Each comparison appeared equally often in the left-right positions, and each sample occurred an equal number of times. When feedback was programmed, touching S+ resulted in chimes, delivery of a token, a 3-sec intertrial interval with all windows dark, and the next trial. Incorrect selections produced a .5-sec buzzer, the intertrial interval, and the next trial (noncorrection).

Instructions. During the initial session, subjects were seated before the display panel with all windows dark. The experimenter began the first demonstration trial and provided the following instructions while physically guiding the subject to touch the sample and comparison:

> When you see this thing come on (the sample), touch it with your finger, then touch this thing (the correct comparison). Good, you made the bell go on and you got a token. You can trade the tokens for money when we are done. To help you earn tokens, a buzzer will go on when you choose the wrong thing. Let me show you. When this thing comes on (sample), don't touch this thing (incorrect comparison). See, you made the buzzer go on. You don't get a token when the buzzer goes on.

After eight demonstrations of correct trial sequences, the experimenter said, "OK, see how many you can get right on your own. I'll wait outside for you. Work until I tell you to stop." The programming tape was restarted and the recorded session began.

A-B training. These procedures were used to train both the initial A-B task with Stimulus Set I and the replication with Stimulus Set II. A-B training consisted of the following stimulus arrays: A1(B2, B1*), A2(B1, B2*), e.g., Figures 1 and 2. A-B training continued until a subject met a criterion of one session of at least 95% correct selections under continuous feedback. Next, intermittent reinforcement was programmed so that only 33% of the trials resulted in either the chimes and token, or buzzer (28 feedback trials). Feedback occurred on a maximum of two consecutive trials, whereas no more than six successive no-feedback trials occurred. An equal number of feedback trials was programmed on the left and right comparison windows. Intermittent reinforcement was introduced to accommodate the nonreinforced probe trials during later test sessions. To facilitate the transition from continuous to intermittent feedback, the experimenter informed the subject:

> For the next few days you won't get a token every time you choose the right thing, only some of the time. The bell and buzzer won't come on every time either. But now, the tokens you get will be worth one penny each, so you can still earn the same amount of money. Work hard and see if you can get all the tokens.

A-B matching under the 33% schedule continued until a subject selected correctly on at least 95% of the 84 trials per session for three consecutive sessions.

Testing Procedures

The 33%-feedback schedule remained in effect throughout testing. Each daily session included 72 standard A-B trials plus 12 randomly interspersed probe trials without feedback. Test sessions were introduced without explanation.

Test 1. B-A matching. This condition tested for symmetry of the A-B relations: B1 and B2 were presented as samples and A1 and A2 as comparisons (Figures 1 and 2). Would subjects select A1 given B1, and A2 given B2?

Tests 2 and 6. Control by sample-S+ relation with "matching" A and B stimuli and novel comparisons. Test 2 assessed the extent to which the original A-B training established control by the relation between samples and S+ comparisons. Test-2 trials took the form A1(N1, B1), A2(N2, B2). Test 6 provided a similar analysis of the B-A arrays: B1(N5, A1), B2(N6, A2). During both tests, selections of the appropriate B or A comparisons were scored as correct.

Tests 4 and 8. Control by sample-S− relation with "nonmatching" A and B stimuli and novel comparisons. Test 4 evaluated control by the relation between samples and S− comparisons. On Trials A1(B2, N3) and A2(B1, N4), selections of the novel comparisons were scored as correct. Test 8 asked the same question concerning the B-A arrays: B1(A2, N7), B2(A1, N8).

Tests 3, 5, 7, and 9. Control of preferences between novel comparisons by A and B samples. These tests served as control measures for any preference for particular novel comparisons in the presence of A or B samples. Subjects were given a familiar sample and two novel comparisons e.g., for Test 3 the trials were A1(N1, N2), A2(N1, N2) (see Figures 1 and 2).

Arrangement of comparisons during Tests 2, 4, 6, and 8 following preference tests. Subjects who began a test series with a test for control by sample-S+ or sample-S− relations did so with stimulus arrays similar to those illustrated in Figures 1 and 2. For example, Test 2 took the form, A1(N1, B1), A2(N2, B2); and Test 4, A1(B2, N3), A2(B1, N4). These arrays were also used with subjects initially exposed

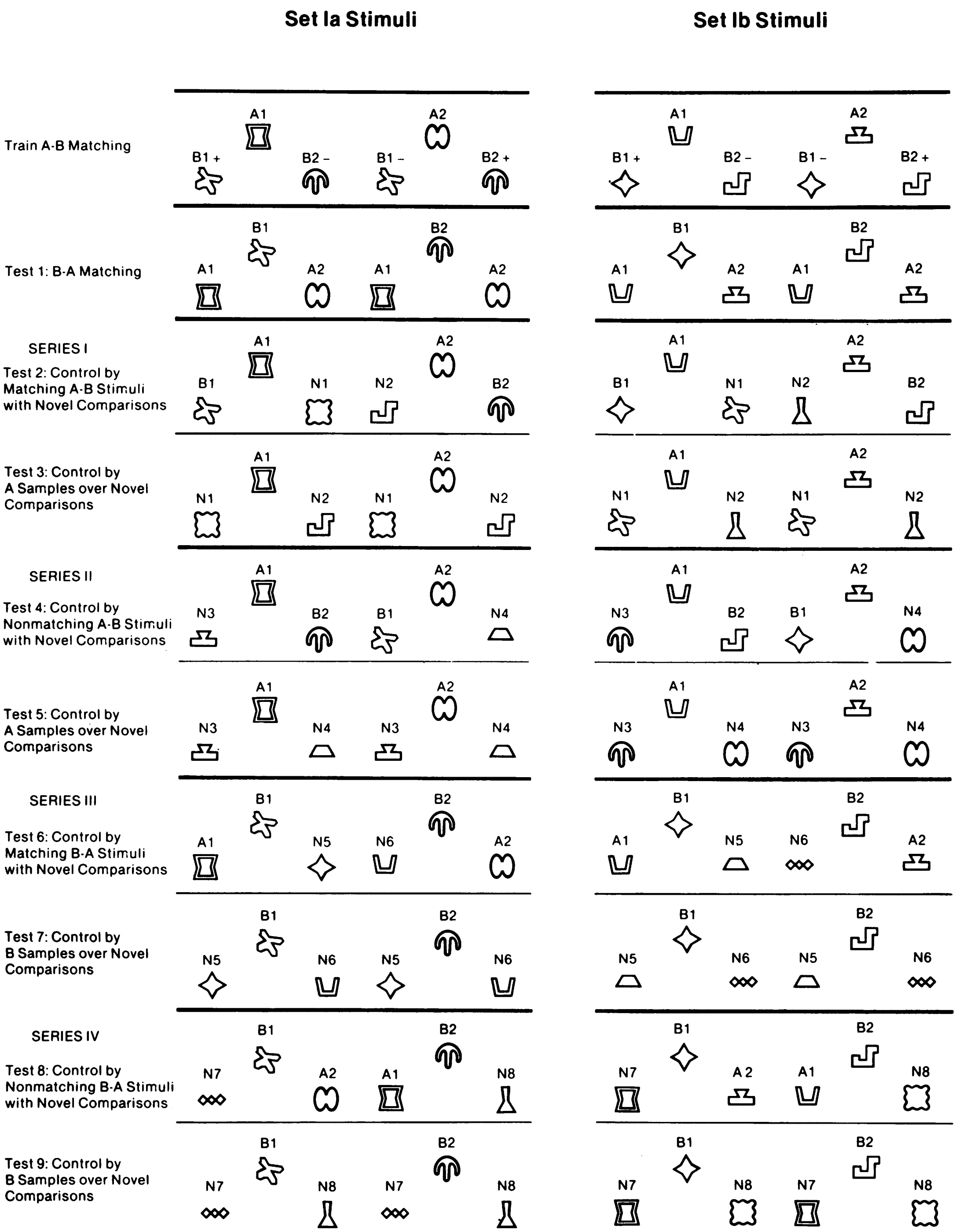

Fig. 1. Representative stimulus arrays during initial training and testing conditions of Experiment 1. Sample: top-center figure of each triad; comparisons: side figures. "+" and "−" denote reinforced and nonreinforced selections respectively, during training. All test trials were nonreinforced. Letter/number designations (A1, B2, etc.) correspond to the trial notation in Tables 3 and 4.

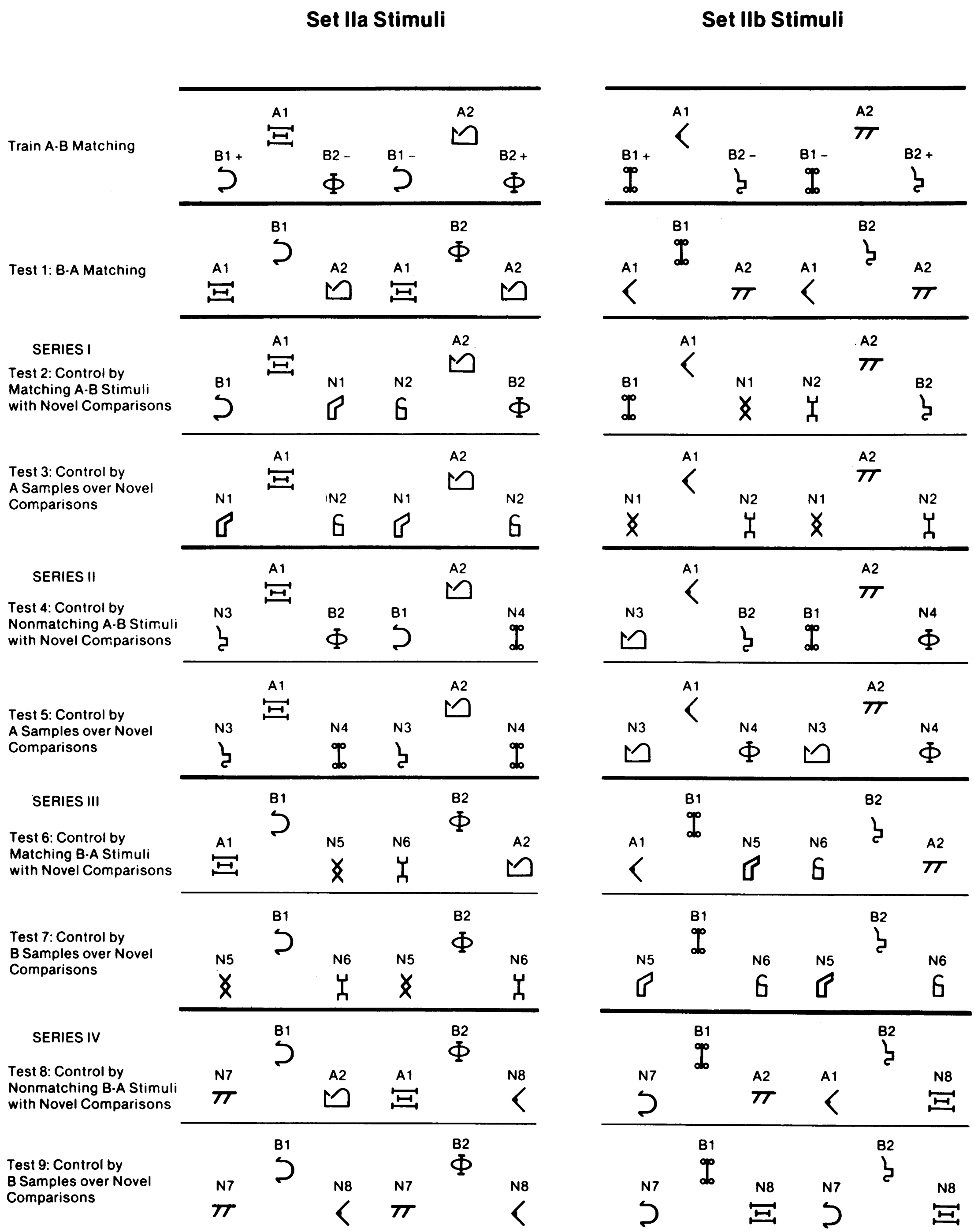

Fig. 2. Representative stimulus arrays during replication training and testing conditions of Experiment 1. See Figure 1 for details.

to a preference test (see Table 2) and who exhibited a single-stimulus or position preference, or simply alternated between the novel comparisons. However, an alternate stimulus array was possible for each S+ and S− test by manipulating the N comparisons: e.g., Test 2 could be presented as A1(N2, B1), A2(N1, B2); and Test 4 as A1(B2, N4), A2(B1, N3). The alternate stimulus array was used during the second test for control by sample-S+ or sample-S− relations if the prior preference test generated the alternation pattern of comparison selection, or stimulus or position preferences. Subjects who showed any conditional preferences for the novel stimuli were given one or both versions of the test in a series, depending on the nature of their preferences. For example, a subject might consistently select N1 over N2 when given novel comparisons N1 and N2 and Sample A1; whereas in the presence of A2, always select N2 over N1 (Test 3). Then the subsequent test for control by the sample-S+ relation (Test 2) attempted to shift control away from the preferred novel comparisons by presenting test arrays: A1(N1, B1), A2(N2, B2). Thus, for tests of the sample-S+ relation, preferred novel stimuli were presented along with familiar S+ comparisons. However, a test for control by the sample-S− relation employed nonpreferred novel comparisons in conjunction with familiar S− comparisons. For example, suppose that during Test 5 a subject always selected N3 over N4 given Sample A1, and N4 over N3 given A2. Then Test 4 would present trials: A1(B2, N4), A2(B1, N3), in an attempt to shift control to the nonpreferred novel comparisons (see Table 4).

Results

A-B Matching

Subjects DW and JT met criterion on the first A-B task within the minimum four sessions; ED and JL took five sessions. All subjects met criterion on the second task within four sessions. Throughout testing, A-B matching never fell below 96% accuracy. The percentages within parentheses in Table 3 show representative A-B accuracy levels during all test sessions.

Test Sessions

Test 1. This test examined sample-comparison symmetry (B-A matching). Table 3 shows that B-A matching was perfect during 14 of 16 test sessions. During two sessions, DW and JL matched 92% of the B-A arrays correctly (11/12 trials).

Tests 2 and 6. During Tests 2 and 6, subjects were given A or B samples along with familiar S+ and novel comparisons. Table 3

Table 3

Experiment 1 results. Tests for symmetry (Test 1), and control by positive (Tests 2 and 6) and negative (Tests 4 and 8) stimulus relations. Tests listed in third and fourth rows were administered after training the second matching task. Percentages in parentheses depict performance during standard A-B trials of test sessions.

Subjects/ Test Order		Test 1: % B-A Matching		Test 2: % Selection of B Comparisons with A Samples and Novel Comparisons		Test 4: % Selection of Novel Comparisons with A Samples and Incorrect B Comparisons		Test 6: % Selection of A Comparisons with B Samples and Novel Comparisons		Test 8: % Selection of Novel Comparisons with B Samples and Incorrect A Comparisons	
ED	1.	(100)	100	(99)	100	(100)	83	(99)	100	(99)	92
	2.	(100)	100	(100)	100	(99)	100	(99)	100	(100)	75
	3.	(97)	100	(97)	100	(99)	100	(100)	100	(100)	100
	4.	(100)	100	(99)	100	(99)	100	(100)	92	(100)	100
DW	1.	(99)	100	(99)	100	(99)	100	(97)	100	(99)	100
	2.	(97)	92	(100)	100	(99)	100	(99)	100	(99)	100
	3.	(100)	100	(100)	92	(99)	100	(100)	100	(99)	100
	4.	(98)	100	(100)	100	(97)	100	(96)	100	(99)	100
JT	1.	(100)	100	(100)	100	(99)	100	(100)	100	(100)	100
	2.	(100)	100	(100)	100	(96)	100	(99)	100	(100)	100
	3.	(100)	100	(99)	100	(99)	100	(100)	100	(100)	100
	4.	(100)	100	(100)	100	(99)	100	(97)	100	(100)	100
JL	1.	(100)	100	(99)	100	(99)	83	(100)	100	(100)	100
	2.	(100)	100	(97)	100	(100)	100	(99)	100	(100)	100
	3.	(100)	100	(100)	100	(100)	100	(100)	100	(100)	100
	4.	(100)	92	(97)	100	(100)	100	(99)	100	(100)	100

Table 4

Experiment 1 results. Percentages of comparison selection during representative tests for control by positive and negative stimulus relations and preference tests (Tests 3, 5, 7, and 9). Percentages in parentheses depict performance during standard A-B trials of test sessions.

Subjects/	Session #	Test Arrays and % Comparison Selection			Subjects/	Session #	Test Arrays and % Comparison Selection		
		Series I					*Series III*		
ED	7	Test 2:	A1(N1, B1)	A2(N2, B2)	JT	32	Test 6:	B1(N5, A1)	B2(N6, A2)
		(99)	0 100	0 100			(100)	0 100	0 100
	8	Test 3:	A1(N1, N2)	A2(N1, N2)		33	Test 7:	B1(N5, N6)	B2(N5, N6)
		(99)	100 0	0 100			(99)	0 100	83 17
	9	Test 2:	A1(N1, B1)	A2(N2, B2)		34	Test 6:	B1(N6, A1)	B2(N5, A2)
		(100)	0 100	0 100			(97)	0 100	0 100
	10	Test 3:	A1(N1, N2)	A2(N1, N2)		35	Test 7:	B1(N5, N6)	B2(N5, N6)
		(100)	100 0	0 100			(100)	0 100	100 0
		Series II					*Series IV*		
DW	5	Test 5:	A1(N3, N4)	A2(N3, N4)	JL	42	Test 9:	B1(N7, N8)	B2(N7, N8)
		(100)	17 83	67 33			(100)	50 50	33 67
	6	Test 4:	A1(B2, N3)	A2(B1, N4)		43	Test 8:	B1(A2, N8)	B2(A1, N7)
		(99)	0 100	0 100			(100)	0 100	0 100
	7	Test 5:	A1(N3, N4)	A2(N3, N4)		44	Test 9:	B1(N7, N8)	B2(N7, N8)
		(100)	100 0	0 100			(99)	33 67	50 50
	8	Test 4:	A1(B2, N4)	A2(B1, N3)		45	Test 8:	B1(A2, N7)	B2(A1, N8)
		(99)	0 100	0 100			(100)	0 100	0 100

shows that the novel comparisons were virtually never chosen.

Tests 4 and 8. Tests 4 and 8 examined control by sample-S− relations. Except for ED's second exposure to Test 8, all participants selected the novel comparisons instead of the familiar S− comparisons in both tests.

Representative Test Series

Table 4 illustrates preference tests and tests for control by sample-S+ and sample-S− relations. Also illustrated is the strategy of tailoring the specific arrays of Tests 2, 4, 6, and 8 to subjects' preferences for particular novel comparisons. For example, ED began Series I with Test 2 and appropriately selected the B comparisons every time. In the subsequent preference Test 3, ED showed a consistent conditional preference: N1 was always chosen when A1 was the sample, and N2 when A2 was the sample. The next administration of Test 2 therefore pitted the preferred novel comparisons against the B comparisons; ED selected the B stimuli over the novel comparisons. Finally, another preference-Test 3 confirmed ED's preferences when both comparisons were novel. An analogous Series-III sequence is shown for JT where control by the sample-S+ relation was assessed with the B-A stimuli.

The Series-II results for DW exemplify test conditions for the evaluation of control by the sample-S− relation. DW began with preference-Test 5 and some preferential selections occurred: N4 was selected on five of six trials in the presence of A1, and N3 on four of six trials with Sample A2. Since Test 4 looked for selections of novel comparisons, nonpreferred novel comparisons were presented with the familiar A or B S− comparisons. DW chose the novel comparisons every time. During the subsequent preference-Test 5, DW shifted preferences, so the final Test 4 employed the most-recently-nonpreferred novel comparisons. Again, DW avoided familiar B comparisons and selected the novel stimuli. A similar sequence is depicted for JL.

Discussion

The test data demonstrated that subjects' selections were controlled both by sample-S+ and sample-S− relations as a result of the A-B matching training. This finding is congruent with the analysis of childrens' identity matching (Dixon & Dixon, 1978). These controlling relations were evident for both trained A-B arrays and the symmetrical (untrained) B-A arrays. In both cases, novel comparisons were rejected when familiar samples and S+ comparisons were available, but novel comparisons were consistently selected when familiar S− comparisons were presented.

An order effect may have influenced these data. Tests for control by sample-S+ and sample-S− relations always followed tests for symmetry. Though B-A matching went unreinforced, it may be argued that this symmetry-test experience somehow influenced selections in the presence of novel comparisons. Experiment 2 controlled for this possibility.

EXPERIMENT 2
DERIVED STIMULUS RELATIONS CONTROLLING MATCHING-TO-SAMPLE

The results of Experiment 1 suggest that A-B matching generated control by sample-S+ and sample-S− relations. That is, the sample stimulus served a dual function: it determined which comparison was S+ (correct comparison) and which comparison was S− (incorrect comparison). This dual sample function was also found when samples became comparisons and comparisons became samples (symmetrical B-A matching). The present experiment analyzed whether a duel sample function also characterizes arbitrary matching controlled by derived sample-comparison relations. Additionally, direct tests for sample-comparison symmetry were conducted to determine if control by symmetrical and by derived relations coexists.

METHOD

Subjects and Apparatus

Nine developmentally delayed male adolescent residents (selected from 16 screened) from the same facility were added to three subjects from Experiment 1 (one subject left the facility). The new subjects were naive to the experimental procedures. The 12 residents were divided into three groups, each composed of three naive members and one from Experiment 1. The apparatus remained the same.

Design

Figures 3 and 4 illustrate representative training and testing conditions for Experiment 2. A different derived sample-comparison paradigm was used with each group. In Group 1, the tests of derived matching and control by sample-S+/sample-S− relations involved sample and comparison stimuli all of which had been trained as samples (train A-B, C-B; then test A-C, C-A). In Group 2, the tests involved sample and comparison stimuli all of which had been trained as comparisons (train A-B, A-C; test B-C, C-B). In Group 3, the tests involved sample and comparison stimuli that had been trained either as sample or comparison (train A-B, B-C; test A-C, C-A).

Each group was trained on two matching tasks followed by two administrations each of six tests (a total of 24 test sessions). Table 5 gives the sequence of conditions for each subject. Subjects MP and JL, JC and LM, and LH and GC were first trained and tested with Stimulus Set IIIa (Task 1) and then Set IVa (Task 2). Subjects JK and LE, DW and NO, and AP and ED were first assigned to Set IIIb, then Set IVb. Half the subjects (JL, LE, LM, NO, GC, and ED) were exposed to sample-comparison arrays that were the reverse of those in the figures.

Sessions were again held six days per week, but terminated after 168 trials. Token-exchange ratios, trial procedures, and consequences were as in Experiment 1.

Group-1 Procedures

Train A-B, C-B matching. Figure 3 depicts the four kinds of stimulus arrays that comprised A-B, C-B training: viz., A1(B2, B1*), A2(B1, B2*), C1(B2, B1*), C2(B1, B2*). Terminal performance was established in three phases. First, a 168-trial A-B matching problem was trained to a criterion of at least 95% accuracy for one session under continuous feedback. Second, subjects were exposed to 84 A-B trials and 84 C-B trials until one session of at least 95% accuracy occurred. Third, the 33% schedule of feedback was instated and continued until three consecutive sessions showed at least 95% accuracy. Instructions similar to those in Experiment 1 were used.

Test sessions. The 33%-feedback schedule remained in effect throughout testing. All test sessions had 168 trials: 144 A-B, C-B trials and 24 nonreinforced probes. Figure 3 depicts the stimuli for the various tests.

Test 1. B-A, B-C matching. Test 1 was a test for symmetry. Interspersed among the 144 standard A-B and C-B trials were 12 B-A and 12 B-C trials (Figure 3). Selecting comparisons A1 and C1 in the presence of Sample B1 and

Table 5

Sequence of conditions for subjects of Experiment 2. Tests 1 to 6 are listed in their order of occurrence for each subject. Figures 3 and 4 illustrate stimulus arrays corresponding to the training and testing conditions for the subjects of each group.

Grp 1:	*MP*	*JK*	*JL*	*LE*
Grp 2:	*JC*	*DW*	*LM*	*NO*
Grp 3:	*LH*	*AP*	*GC*	*ED*

1. Initial Training[a]: 3. Replication Training[b]:

A-B, C-B Matching (Grp 1)
A-B, A-C Matching (Grp 2)
A-B, B-C Matching (Grp 3)

2. Administer Tests[a]:				4. Administer Tests[b]:			
1	4	2	6	5	1	3	2
2	3	1	5	6	2	4	1
	4		6	5		3	
3	3	5	5	6	6	4	4
4		6			5		3
3	2	5	1	2	6	1	4
4	1	6	2	1	5	2	3
2	5	1	3	4	2	6	1
1	6	2	4	3	1	5	2
	5		3	4		6	
6	6	4	4	3	3	5	5
5		3			4		6
6	1	4	2	1	3	2	5
5	2	3	1	2	4	1	6

[a]Stimulus Sets IIIa and IIIb were used for the initial conditions.
[b]Stimulus Sets IVa and IVb were used for the replication conditions.

comparisons A2 and C2 in the presence of B2 was taken as evidence of symmetry.

Test 2. A-C, C-A matching. Test 2 assessed control by the derived relations between A and C stimuli: 12 A-C and 12 C-A test arrays were intermixed with the 144 standard A-B, C-B arrays (Figure 3). Control of matching by derived sample-comparison relations would be evidenced by C1 selections given A1 samples, C2 selections given A2 samples, A1 selections given C1 samples, and A2 selections given C2 samples.

Test 3. Control by sample-S+ relation with "matching" A and C stimuli and novel comparisons. Test 3 probed for control by the derived sample-S+ relation in the A-C, C-A arrays. Testing involved arrays of the type, A1(N1, C1), A2(N2, C2), C1(N1, A1), C2(N2, A2).

Test 5. Control by sample-S– relation with "nonmatching" A and C stimuli and novel comparisons. Test 5 tested for control by the derived sample-S– relation in A-C, C-A arrays. Test arrays were of the type, A1(C2, N3), A2(C1, N4), C1(A2, N3), C2(A1, N4).

Tests 4 and 6. Control of preferences between novel comparisons by A and C samples. Figure 3 and Table 5 summarize stimulus arrangements for Tests 4 and 6, and their order of occurrence across subjects. The rationale and procedures for administration were identical to those for Experiment 1, Tests 3, 5, 7, and 9. Each test included 12 trials with A samples and 12 with C samples.

Group-2 Procedures

Train A-B, A-C matching. Figure 4 (left column) shows the stimuli used with Group 2. A-B, A-C matching was trained in the manner described for Group 1. Selecting B1 and C1 given Sample A1, and B2 and C2 given Sample A2 was reinforced.

Test sessions. Figure 4 (left column) and Table 5 outline the test procedures. Test sessions were similar to those in Group 1, but specific stimuli differed. The test for symmetry (Test 1) used B-A and C-A stimuli; the test for control by the derived stimulus relations (Test 2) used B-C and C-B arrays. Tests 3 and 5 ascertained whether or not selections were controlled by derived sample-S+ and sample-S– relations. Tests 4 and 6 tested preferences between novel stimuli.

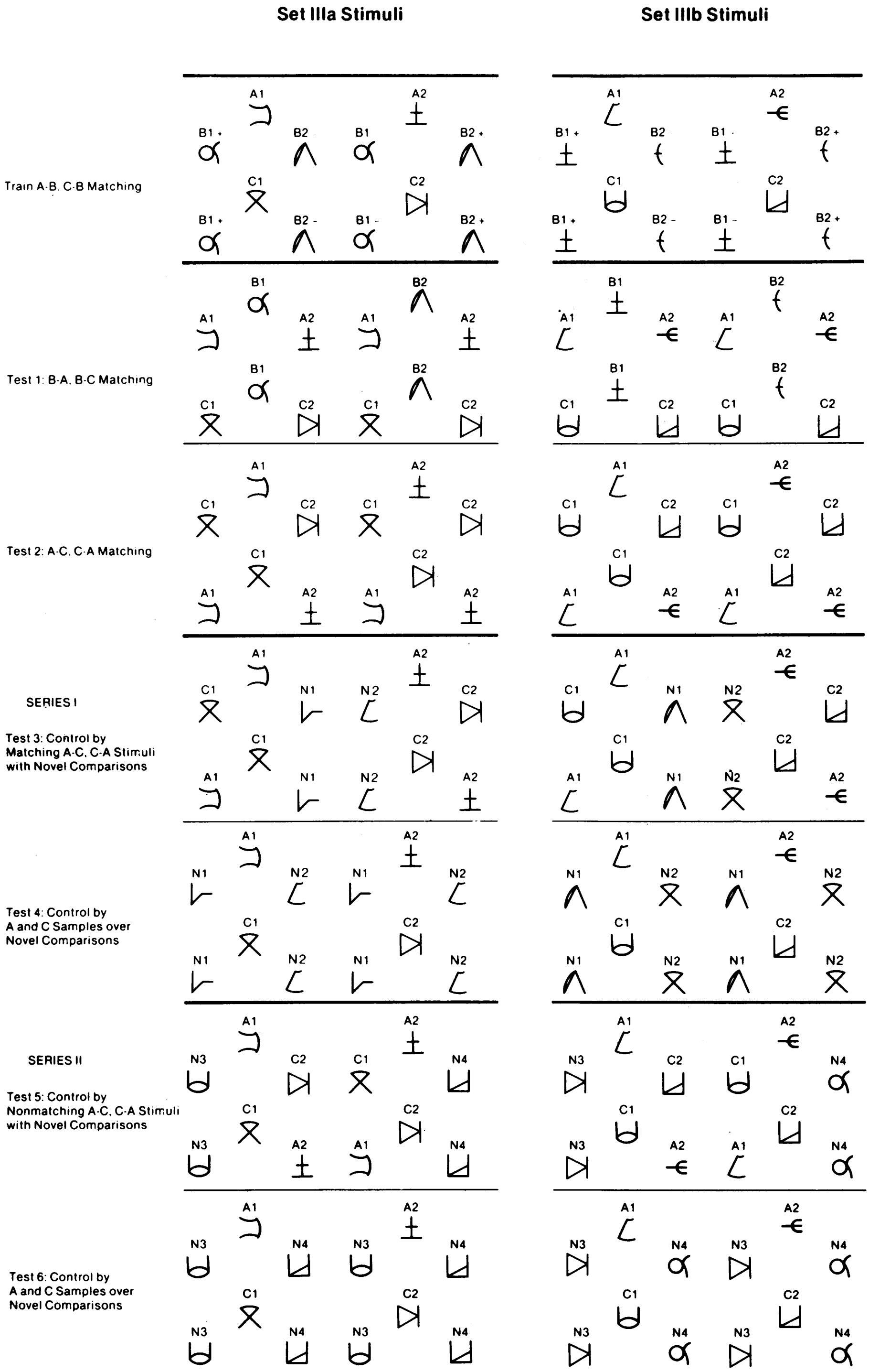

Fig. 3. Representative stimulus arrays during training and testing conditions for Group 1 of Experiment 2. These stimuli were used during the initial conditions for all subjects. Letter/number designations correspond to the trial notation in Tables 6 and 7. See Figure 1 for details.

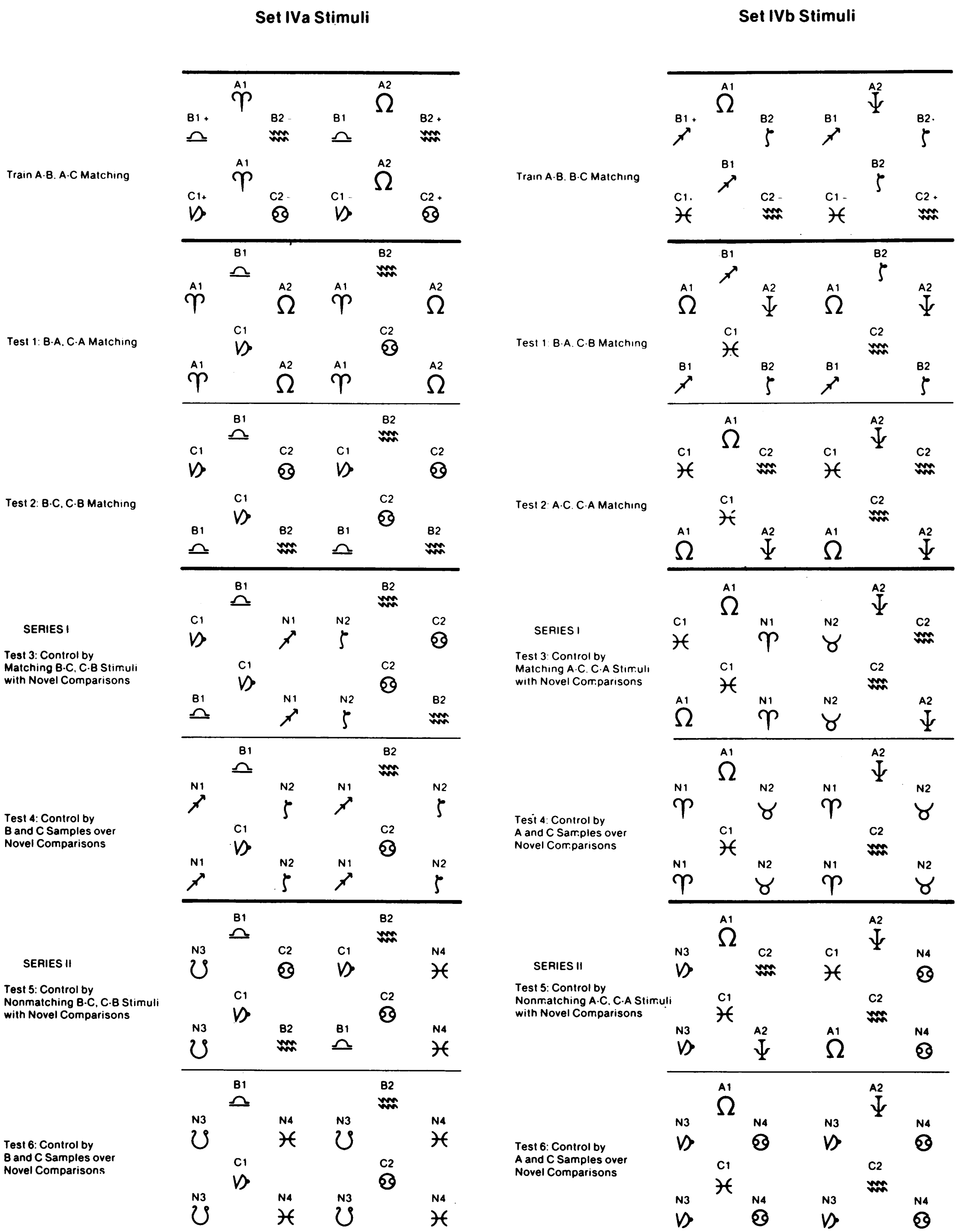

Fig. 4. Representative stimulus arrays during the training and testing conditions for Group 2 (left column) and Group 3 (right column) of Experiment 2. These stimuli were used during the replication conditions for all subjects. Letter/number designations correspond to the trial notation in Tables 6 and 7. See Figure 1 for details.

Group-3 Procedures

Figure 4 (right column) and Table 5 summarize the Group-3 manipulations. The procedures for A-B, B-C training and subsequent testing with A and C stimuli corresponded to those described for Groups 1 and 2. Subjects were trained with stimulus arrays of the type A1(B2, B1*), A2(B1, B2*), B1(C2, C1*), B2(C1, C2*). The test for symmetry used B-A, C-B arrays; tests for control by derived and sample-S+ and sample-S− relations used A-C, C-A stimuli.

RESULTS

Group 1

A-B, C-B matching. The number of sessions taken to reach criterion accuracy on the first matching task and the replication task, respectively, was: MP, 9-7; JK, 6-8; JL, 8-6; and LE, 14-9. Table 6 (percentages in parentheses) shows that performance during standard trials remained high (97 to 100%) during test sessions.

Test sessions. Table 6 summarizes test results for Group 1. Each percentage is based on 12 trials. Each test was administered four times, the first and second time following the initial matching task, the third and fourth after the replication task.

Test 1 (B-A and B-C trials) probed for sample-comparison symmetry. Symmetry was demonstrated by JK, JL, and LE. MP had a 92% symmetry score during the first Test 1, but declined to chance level during the remaining tests. Test 2 assessed control by derived A-C, C-A relations. JK, JL, and LE's performances showed that their selections were controlled by the derived relations. MP, however, responded at or near chance level during all exposures to Test 2. Test 3 assessed control by the sample-S+ relation in A-C and C-A arrays. Subjects were given familiar samples and correct comparisons along with novel comparisons. JK, JL, and LE consistently selected the correct C and A comparisons. Test 5 assessed control by the derived sample-S− relation using familiar samples and incorrect comparisons along with novel comparisons. JK, JL, and LE consistently selected the novel comparisons. Except for the third Test 5, MP's selections were at or near chance level throughout Tests 3 and 5.

Group 2

A-B, A-C matching. Criterion accuracy on the first A-B, A-C task was reached in 7, 6, 8, and 5 sessions by JC, DW, LM, and NO, respectively. All subjects reached criterion accuracy on the replication task within five sessions. Matching accuracy on standard trials never fell below criterion during subsequent test sessions.

Test sessions. Table 6 shows Group 2's test results. All tests were like those for Group 1. All subjects showed perfect symmetry of samples and comparisons in Test 1. Subjects JC, DW, and NO also evinced consistent control by the derived stimulus relations (Test 2), control by the derived sample-S+ relation (Test 3), and also by the derived sample-S− relation (Test 5). LM's performance deviated from that of the other subjects: evidence for control by the derived sample-comparison relations occurred only during the second and subsequent administrations of Test 2. In Test 5, LM began by always rejecting the novel stimuli, then performed at chance level. During the last two exposures to Test 5, however, LM selected the novel comparisons.

Group 3

A-B, B-C matching. LH required six sessions to reach criterion on the first A-B, B-C task and five sessions for the replication; AP, 10 and 6; GC, 11 and 9; and ED, 5 and 9 sessions, respectively. During test sessions, standard A-B, B-C matching remained uniformly accurate (96 to 100%).

Test sessions. The bulk of the test data shown in Table 6 for Group 3 is consistent with the data for Groups 1 and 2. Except for ED's third exposure to Test 1, sample-comparison symmetry and control by derived stimulus relations (Test 2) were demonstrated by all subjects. During Tests 3 and 5, LH, GC, and ED replicated previous findings: control by derived sample-S+ and sample-S− relations was found. AP reliably selected novel stimuli during Test 5 after training on the replication matching task.

Representative Test Series

Table 7 illustrates selected sequences of Series I (tests for control by the sample-S+ relation) and II (tests for control by the sample-S− relation) for the three groups. Prefer-

Table 6

Experiment 2 results. Tests for symmetry (Tests 1 and 2), and control by positive (Test 3) and negative (Test 5) stimulus relations. See Table 3 for details.

Subjects/ Test Order	*Test 1: % Sample-Comparison Symmetry*			*Test 2: % Derived Matching*			*Test 3: % Selection of C or A Comparisons with A or C Samples and Novel Comparisons*			*Test 5: % Selection of Novel Comparisons with A or C Samples and Incorrect C or A Comparisons*		
Grp 1: (A-B, C-B Trn'd)		*B-A*	*B-C*		*A-C*	*C-A*		*A-C*	*C-A*		*A-C*	*C-A*
MP 1.	(100)	92	92	(99)	58	33	(100)	50	42	(99)	67	58
2.	(99)	50	50	(99)	50	50	(99)	58	50	(97)	67	67
3.	(100)	50	50	(100)	67	33	(99)	50	50	(99)	67	75
4.	(99)	50	50	(100)	50	50	(100)	50	50	(100)	50	50
JK 1.	(99)	100	92	(99)	100	100	(99)	100	100	(98)	100	100
2.	(97)	100	100	(99)	92	100	(100)	100	100	(97)	100	100
3.	(97)	100	92	(97)	100	92	(99)	100	100	(99)	100	100
4.	(100)	100	100	(99)	100	100	(99)	100	100	(99)	100	100
JL 1.	(100)	100	100	(100)	100	100	(100)	100	100	(100)	100	100
2.	(99)	100	100	(99)	100	100	(99)	100	100	(100)	100	100
3.	(98)	92	100	(99)	83	100	(99)	100	100	(99)	100	92
4.	(99)	100	100	(100)	100	100	(99)	100	100	(99)	100	100
LE 1.	(99)	100	100	(99)	83	83	(97)	83	92	(100)	100	92
2.	(99)	100	100	(99)	100	92	(100)	100	100	(100)	100	92
3.	(100)	92	100	(99)	92	100	(99)	100	100	(98)	100	100
4.	(99)	100	100	(99)	92	100	(97)	100	100	(99)	92	100
Grp 2: (A-B, A-C Trn'd)		*B-A*	*C-A*		*B-C*	*C-B*		*B-C*	*C-B*		*B-C*	*C-B*
JC 1.	(100)	100	100	(100)	100	100	(100)	100	100	(99)	100	100
2.	(99)	100	100	(98)	100	100	(99)	100	100	(98)	100	100
3.	(100)	100	100	(99)	100	100	(99)	100	100	(99)	100	100
4.	(100)	100	100	(99)	100	100	(99)	100	100	(99)	100	100
DW 1.	(99)	100	100	(100)	100	100	(99)	100	100	(100)	100	100
2.	(99)	100	100	(99)	100	100	(99)	100	100	(100)	100	100
3.	(99)	100	100	(100)	100	100	(99)	100	100	(100)	100	100
4.	(100)	100	100	(100)	100	100	(100)	100	100	(99)	100	100
LM 1.	(99)	100	100	(99)	33	50	(99)	100	100	(98)	0	0
2.	(98)	100	100	(96)	83	100	(99)	100	100	(99)	50	42
3.	(99)	100	100	(100)	92	100	(98)	100	100	(99)	92	92
4.	(99)	100	100	(98)	100	92	(98)	100	100	(98)	100	92
NO 1.	(99)	100	100	(100)	100	100	(99)	100	100	(100)	100	100
2.	(99)	100	100	(99)	100	100	(99)	100	100	(100)	100	100
3.	(99)	100	100	(100)	100	100	(100)	100	100	(99)	92	100
4.	(100)	100	100	(100)	100	100	(99)	100	100	(99)	100	100
Grp 3: (A-B, B-C Trn'd)		*B-A*	*C-B*		*A-C*	*C-A*		*A-C*	*C-A*		*A-C*	*C-A*
LH 1.	(100)	100	100	(99)	100	100	(99)	100	100	(100)	100	100
2.	(99)	100	100	(100)	100	100	(99)	100	100	(99)	100	100
3.	(99)	100	100	(100)	100	100	(99)	92	100	(100)	100	92
4.	(100)	100	100	(100)	100	100	(100)	100	92	(100)	100	100
AP 1.	(100)	92	92	(99)	83	83	(99)	100	83	(98)	58	58
2.	(96)	92	100	(98)	83	92	(99)	92	92	(99)	67	75
3.	(100)	100	100	(99)	92	100	(99)	100	100	(99)	100	100
4.	(100)	100	100	(97)	92	100	(100)	92	100	(99)	92	100
GC 1.	(99)	100	83	(97)	100	83	(99)	92	92	(98)	100	100
2.	(98)	100	100	(98)	100	100	(99)	92	92	(100)	100	100
3.	(99)	100	100	(99)	100	100	(100)	100	100	(99)	100	100
4.	(97)	92	100	(98)	100	100	(99)	100	92	(98)	100	100
ED 1.	(100)	100	92	(100)	92	92	(100)	100	100	(98)	100	92
2.	(99)	100	100	(99)	100	92	(99)	100	100	(97)	92	92
3.	(100)	75	92	(99)	92	83	(99)	100	100	(99)	100	100
4.	(97)	83	92	(98)	100	92	(99)	100	92	(99)	100	92

Table 7

Experiment 2 results. Percentages of comparison selection during representative tests for control by positive and negative stimulus relations and preference tests (Tests 4 and 6). Percentages in parentheses depict performance during standard matching trials of test sessions.

Subjects/Session #		*Test Arrays and % Comparison Selection*				
		Series I: Grp 1 (A-B, C-B Trn'd)				
MP	12	Test 3:	A1(N1, C1)	A2(N2, C2)	C1(N1, A1)	C2(N2, A2)
		(100)	50 50	50 50	67 33	50 50
	13	Test 4:	A1(N1, N2)	A2(N1, N2)	C1(N1, N2)	C2(N1, N2)
		(100)	50 50	50 50	50 50	50 50
	14	Test 3:	A1(N2, C1)	A2(N1, C2)	C1(N2, A1)	C2(N1, A2)
		(99)	50 50	50 50	33 67	50 50
	15	Test 4:	A1(N1, N2)	A2(N1, N2)	C1(N1, N2)	C2(N1, N2)
		(98)	67 33	50 50	50 50	50 50
JK	7	Test 4:	A1(N1, N2)	A2(N1, N2)	C1(N1, N2)	C2(N1, N2)
		(99)	0 100	100 0	0 100	83 17
	8	Test 3:	A1(N2, C1)	A2(N1, C2)	C1(N2, A1)	C2(N1, A2)
		(99)	0 100	0 100	0 100	0 100
	9	Test 4:	A1(N1, N2)	A2(N1, N2)	C1(N1, N2)	C2(N1, N2)
		(98)	17 83	100 0	17 83	100 0
	10	Test 3:	A1(N2, C1)	A2(N1, C2)	C1(N2, A1)	C2(N1, A2)
		(100)	0 100	0 100	0 100	0 100
		Series II: Grp 2 (A-B, A-C Trn'd)				
LM	11	Test 5:	B1(C2, N3)	B2(C1, N4)	C1(B2, N3)	C2(B1, N4)
		(98)	100 0	100 0	100 0	100 0
	12	Test 6:	B1(N3, N4)	B2(N3, N4)	C1(N3, N4)	C2(N3, N4)
		(100)	100 0	33 67	83 17	67 33
	13	Test 5:	B1(C2, N4)	B2(C1, N3)	C1(B2, N4)	C2(B1, N3)
		(99)	0 100	100 0	17 83	100 0
	14	Test 6:	B1(N3, N4)	B2(N3, N4)	C1(N3, N4)	C2(N3, N4)
		(99)	0 100	0 100	0 100	0 100
NO	6	Test 6:	B1(N3, N4)	B2(N3, N4)	C1(N3, N4)	C2(N3, N4)
		(99)	100 0	0 100	100 0	0 100
	7	Test 5:	B1(C2, N4)	B2(C1, N3)	C1(B2, N4)	C2(B1, N3)
		(100)	0 100	0 100	0 100	0 100
	8	Test 6:	B1(N3, N4)	B2(N3, N4)	C1(N3, N4)	C2(N3, N4)
		(99)	0 100	100 0	0 100	100 0
	9	Test 5:	B1(C2, N3)	B2(C1, N4)	C1(B2, N3)	C2(B1, N4)
		(100)	0 100	0 100	0 100	0 100
		Series I: Grp 3 (A-B, B-C Trn'd)				
AP	11	Test 4:	A1(N1, N2)	A2(N1, N2)	C1(N1, N2)	C2(N1, N2)
		(96)	33 67	67 33	50 50	33 67
	12	Test 3:	A1(N2, C1)	A2(N2, C2)	C1(N2, A1)	C2(N1, A2)
		(99)	0 100	0 100	33 67	0 100
	13	Test 4:	A1(N1, N2)	A2(N1, N2)	C1(N1, N2)	C2(N1, N2)
		(100)	17 83	33 67	33 67	50 50
	14	Test 3:	A1(N2, C1)	A2(N1, C2)	C1(N2, A1)	C2(N1, N2)
		(99)	0 100	17 83	0 100	17 83
		Series II: Grp 3 (A-B, B-C Trn'd)				
ED	35	Test 5:	A1(C2, N3)	A2(C1, N4)	C1(A2, N3)	C2(A1, N4)
		(99)	0 100	0 100	0 100	0 100
	36	Test 6:	A1(N3, N4)	A2(N3, N4)	C1(N3, N4)	C2(N3, N4)
		(97)	83 17	17 83	50 50	17 83
	37	Test 5:	A1(C2, N4)	A2(C1, N3)	C1(A2, N4)	C2(A1, N3)
		(99)	0 100	0 100	0 100	17 83
	38	Test 6:	A1(N3, N4)	A2(N3, N4)	C1(N3, N4)	C2(N3, N4)
		(96)	83 17	67 33	83 17	50 50

ences during Tests 4 and 6 again determined test arrays in the other tests. For example, on Session 7, JK began Series I with preference Test 4. JK showed preferences between novel comparisons that were clearly conditional upon the samples: given Samples A1 and C1, N2 was chosen; given A2 and C2, N1 was chosen all but once. The subsequent Test 3 demonstrated that S+ comparison stimuli were selected even though the alternatives were preferred novel stimuli. These effects were replicated during readministration of the two tests. As illustrated by ED, the tactic for evaluating control by the sample-S− relation (Series II) was different. On Session 35, ED was given Test 5 and the novel comparisons were selected. Some preference between novel comparisons was then found in Test 6. The next Test 5, therefore, pitted a nonpreferred novel comparison against an S−. The nonpreferred novel comparisons were selected, nevertheless.

Discussion

These findings suggest that matching with derived arrays is controlled by both derived sample-S+ and sample-S− relations. The 11 of 12 subjects who showed control by derived relations also selected the derived S+ stimuli when novel comparisons were available, and selected novel comparisons when derived S− comparisons were present. Thus, dual control by sample-S+ and sample-S− relations is not restricted to sample-comparison relations directly trained or their symmetrical counterparts, such as were studied in Experiment 1.

However, the results of Tests 1 and 2 for MP and LM suggest that there are circumstances where sample-comparison symmetry will occur without the development of control by derived stimulus relations. Further, the relationship between control by trained sample-comparison relations and control by symmetrical and derived stimulus relations is unclear. MP demonstrated symmetry during the first Test 1, but showed no control by sample-S+ and sample-S− relations. During Test 3, LM selected derived S+ comparisons when novel comparisons were present, yet only after repeated training and testing evidenced control by derived stimulus relations in Test 2 and control by the derived sample-S− relation during Test 5.

GENERAL DISCUSSION

Stimulus Control of Arbitrary Matching-to-Sample

Developmentally delayed adolescents learned arbitrary matching-to-sample with visual stimuli. Contrary to research with pigeons (Gray, 1966; Hogan & Zentall, 1977; Rodewald, 1974) and nonhuman primates (Sidman et al., 1982), the present findings demonstrate that humans learn several stimulus relations besides the explicitly taught conditional relations between samples and comparisons. At one level of analysis, Experiment 1 demonstrated that the trained relations were symmetrical: following acquisition of A-B matching, the subjects correctly matched B-A arrays. A similar symmetry was found in Experiment 2: e.g., subjects taught A-B, C-B matching (Group 1) correctly matched B-A and B-C arrays. Experiment 2 extended this finding and showed that derived stimulus relations gained control under three derivation paradigms. After establishing the relation between A as sample and B as comparison in all subjects, control by derived relations developed by training C as a sample for Comparison B (Group 1), as a comparison for Sample A (Group 2), or as a comparison for Sample B (Group 3). The existence of derived controlling relations was verified by appropriate matching on A-C and C-A, B-C and C-B, and A-C and C-A tests. These results replicate previous demonstrations of symmetry (Sidman et al., 1982) and derived matching with humans (Dixon, 1978; Dixon & Spradlin, 1976; Lazar, 1977; Sidman, 1971; Sidman & Cresson, 1973; Sidman et al., 1974; Sidman & Tailby, 1982; Spradlin et al., 1973; Spradlin & Dixon, 1976).

Arbitrary conditional-stimulus relations may be considered stimulus-equivalence relations if the samples and comparisons prove to be interchangeable under tests of reflexivity, symmetry, and transitivity (Sidman et al., 1982; Sidman & Tailby, 1982). Reflexivity, or generalized identity matching (e.g., matching A1 to A1, A2 to A2, etc.), was not assessed; however, the present results confirmed the functions of symmetry and transitivity. Transitivity is demonstrated by performance satisfying the following statement: if relations A-B and B-C control, then the derived relation A-C must also control. This, of course, was the derivation paradigm of Group 3 in Experiment 2. The derived performances of Groups 1 and 2 actually confirmed both symmetry and transitivity (Sidman et al., 1982; Sidman & Tailby, 1982). For example, having learned A-B, C-B matching, Group 1 demonstrated the derived relations A-C and C-A. The relation C-A is accounted for on the basis of symmetry between A-B and B-A, and transitivity of C-B and B-A. Likewise, given that the relation B-C is symmetrical with C-B, then A-C occurs via the transitivity of relations A-B and B-C. A similar analysis applies to the B-C and C-B derivations demonstrated by Group 2 after learning A-B, A-C matching. The results of Experiment 2 suggest that (given reflexivity), training the arbitrary relations under the three derivation paradigms established two classes of equivalent stimuli (viz., A1B1C1 and A2B2C2): each member of a class could function either as sample or comparison for any other member of the class. The comparable efficacy with which the three procedures of Experiment 2 generated derived stimulus control complements previous analyses using similar paradigms (Lazar, 1977; Sidman, 1971; Sidman & Cresson, 1973; Sidman et al., 1974).

In contrast to the findings of Spradlin et al. (1973), also with human subjects, the present results demonstrated that derived controlling stimulus relations between B and C were reliably achieved by training A-B, A-C matching. Spradlin et al. reported that two of three subjects failed to show derived stimulus control under this paradigm. Unlike the Spradlin et al. study, however, the present investigation maintained criterion-level A-B performance while A-C matching was trained and the subsequent B-C and C-B derivation tests were conducted. Thus, the development of derived stimulus control did not depend upon stimulus relations established only during previous sessions. Interweaving training and testing trials within a session may have been important in establishing derived stimulus control, a notion worthy of systematic study.

Sample-comparison symmetry may be necessary for the development of control by derived sample-comparison relations (Jenkins, 1963). The results of Experiment 2 lend some credence to this view: all subjects who showed derived stimulus control also showed symmetry, a finding similar to Sidman and Tailby's (1982). Sidman et al. (1982) also found that nonhuman primates demonstrated neither symmetrical nor derived relations. However, the results of MP and LM demonstrated that symmetry and derived relations are not perfectly correlated. Thus, control by symmetrical relations appears insufficient for the development of control by derived sample-comparison relations. Whether this finding reflects some basic difference between symmetrical and derived relations or procedural factors is an open question (Sidman & Tailby, 1982). Successful symmetry may indicate a kind of compound-stimulus control by sample-comparison relations, the elements of which are still present during the test. That is, the training and testing arrays differ only with respect to the positions of samples and comparisons (e.g., train A-B, test B-A). In derivation tests, however, the linking stimulus (e.g., A) common to the two stimulus relations (e.g., A-B, A-C) is not available for direct comparison during testing (e.g., B-C, C-B).

Previous studies demonstrated that derived stimulus control was not an immediate occurrence for all subjects (Dixon & Spradlin, 1976; Lazar, 1977; Spradlin & Dixon, 1976). Extended testing or explicit training on symmetrical relations over several matching problems may be necessary to produce derived stimulus control with some subjects. Continued training and exposure to the derivation tests may have been responsible for LM's criterion-level test performance. Likewise, had an attempt been made to maintain symmetrical matching during the derivation tests, MP might also have shown derived stimulus control. However, as Lazar (1977) noted, arbitrary matching might be learned simply by rote without the development of equivalence relations. Stimulus-response chains or discriminations based on trial configurations might also be learned (Carter & Werner, 1978). Unfortunately, evaluation of these alternatives was precluded in the present study, and previous research fails to shed light on these questions. An understanding of the stimulus and procedural variables that may contribute to the production of derived stimulus control could be important both theoretically and pragmatically. Since extra-experimental learning histories are obvious variables with older, more competent subjects, future research might profitably focus on persons who evidence severe linguistic deficits (cf. Dixon & Dixon, 1978). Except for MP, all of the present subjects were relatively proficient in expressive language. They frequently engaged in spontaneous conversation with the experimenter and related detailed accounts of past and future activities. MP, however, displayed neither spontaneous expression nor vocal imitation.

Control by Sample-S+ and Sample-S− Relations

Demonstrated sample-comparison symmetry and derived matching suggest that a rather complex form of instructional control was established with the present subjects. Further testing elucidated some of the factors that may have contributed to such control. As in identity matching with children (Dixon & Dixon, 1978), the present arbitrary matching involved the development of control by both sample-S+ and sample-S− relations. Applying the analysis of Cumming and Berryman (Berryman et al., 1965; Cumming & Berryman, 1961; Cumming et al., 1965) to the current data, the sample stimulus served a dual function: it determined which stimulus was S+ and also which stimulus was S− (given a novel comparison as the alternative). Evidence for this dual function of the sample was obtained for the trained A-B and symmetrical arrays (Experiment 1) and for derived arrays as well (Experiment 2). Preference tests showed that comparison selections were controlled not by the samples alone, but by the relations between samples and positive and negative comparisons. Again, these findings contrast with available pigeon data (Carter & Werner, 1978). The demonstration of control by sample-S+ and sample-S− relations provides a beginning determination of the extent to which the stimuli comprising an equivalence relation are in fact equivalent.

Several factors might have encouraged the observed control by sample-S+ and sample-S− stimulus relations and should be considered in future research. Most notable are the explicit verbal instructions and differential feedback during training. Would purely contingency-shaped matching yield control by stimulus relations comparable to that prefaced by verbal instructions? Another question concerns the role of the novel comparisons during tests for the sample-S− relation. It might be argued that the present demonstration of control by sample-S− relations resulted at least in part from a tendency to select novel over familiar stimuli (Dixon & Dixon, 1978). However, such a tendency should have been minimized by exposing the subjects to the preference tests between novel stimuli both before and after tests for control by sample-S− relations. In addition, Dixon and Dixon (1978) demonstrated control by sample-S− relations when the alternate comparison was also familiar (reinforced) but from a different set of training stimuli, thereby controlling for any responding to "novelty" attributable to a history of nonreinforcement.

Future research might also focus on the role of the comparisons in controlling selections of novel stimuli. There are data suggesting that the sample-S− relation is but one source of control over selections of novel comparisons. Humans may also avoid selecting trained comparisons when they are presented with novel samples along with novel comparisons. For example, Dixon (1977), after training relations between spoken words and objects, probed with trials involving a trained choice object, an untrained spoken word, and an untrained choice object. This and other test conditions demonstrated that subjects consistently selected the untrained object. Similarly, research in language comprehension suggests that humans tend to avoid a "known" choice when given a novel spoken word and a novel referent as the other choice (Vincent-Smith, Bricker, & Bricker, 1974). These results suggest an additional analysis of stimuli comprising equivalence relations. Subjects having learned an A-B relation would be expected to select novel comparisons over trained comparisons given arrays of the type: N1(B1, N3), N2(B2, N4). And if the A and B stimuli are indeed equivalent, then one would expect the same degree of control over selections of novel comparisons when the A stimuli were used as comparisons: e.g., N1(A1, N3), N2(A2, N4).

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