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# *ACQUISITION OF ARBITRARY CONDITIONAL DISCRIMINATIONS BY YOUNG NORMALLY DEVELOPING CHILDREN*

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Three experiments investigated conditions designed to facilitate acquisition of arbitrary conditional discriminations in 3- to 6-year-old normally developing children. In Experiment 1, 6 subjects failed to master the arbitrary match-to-sample task under conditions of differential reinforcement alone, but 7 subjects did so when instructions or instructions and sample naming were added. In Experiment 2, sample naming introduced in a blocked-trial arrangement resulted in acquisition, but only when the sample name was a nonsense syllable provided by the experimenter (5 of 7 subjects) and not when the sample name was generated by the subject (0 of 5 subjects). Experiment 3 demonstrated the effectiveness of a training sequence involving thematically related stimuli as an intermediate step facilitating the transition from identity to novel arbitrary relations. The difficulties in mastering arbitrary conditional discriminations shown here imply that further analyses with young children will be particularly important in efforts to investigate the development of theoretically important stimulus relations.

*Key words:* arbitrary conditional discrimination, match to sample, instructions, sample naming, object displacement, mouse click, children

Recent interest in emergent relational stimulus control (e.g., Hayes, 1989b; Horne & Lowe, 1996; Sidman, 1994; Zentall & Smeets, 1996) increases the importance of understanding the development of the arbitrary conditional discriminations that give rise to novel relations. Due to the rich and varied histories that normal adults bring into the laboratory, one appropriate research strategy is to focus on young children in an effort to study variables that are related to acquisition and emergence of control by stimulus relations. However, studies involving children have revealed mixed findings with respect to the acquisition of symbolic match-to-sample (MTS) performances.

Some researchers have found conditional discriminations to be acquired readily by normally developing children (Devany, Hayes, & Nelson, 1986; Michael & Bernstein, 1991) as well as by those with developmental disabilities (Devany et al., 1986). In contrast, a number of studies have documented difficulties in teaching conditional discriminations, at least in the absence of special training procedures, both for normally developing children (e.g., Augustson & Dougher, 1991; Etzel, Milla, & Nicholas, 1996; Lipkens, Hayes, & Hayes, 1993; Schilmoeller, Schilmoeller, Etzel, & LeBlanc, 1979; Zygmont, Lazar, Dube, & McIlvane, 1992) and for individuals with developmental disabilities (e.g., with children, Eikeseth & Smith, 1992; with adults, McIlvane, Dube, Kledaras, Iennaco, & Stoddard, 1990; Saunders & Spradlin, 1989, 1990, 1993; Zygmont et al., 1992). Training procedures and experimental conditions varied widely across these studies, and the procedural variables critical to differences in acquisition patterns remain to be determined.

For example, in the Lipkens et al. (1993) study, a normally developing child was exposed to discrimination training from age 12 to 16 months using a computer touch-screen, figures on cards, and toys, but failed to acquire either simple discriminations or conditional discriminations via differential reinforcement. In contrast, verbal interventions did prove to be effective. A first conditional discrimination was established by explicitly training tact relations between animal-like fig-

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ures and their names, while establishing a second conditional discrimination based on a history of verbal relations between animals' names and the noises that they make. Sophisticated verbal abilities were inextricably involved with these particular training procedures, and the nature of the contributions of these verbal processes to acquisition of the conditional discriminations remain unclear. Given current debate about the role of verbal processes in the development of complex relational control (see, e.g., Horne & Lowe, 1996, and commentaries), examination of these issues is also of considerable theoretical importance.

Some studies with normally developing children have reported successful acquisition of arbitrary MTS performances using only trial-and-error training arrangements (Devany et al., 1986; Michael & Bernstein, 1991). However, many of the studies done to date have utilized apparatus and procedures that require some orienting instructions or direct physical or visual contact with the experimenter. The approach taken in the present work was to begin with the simplest possible training arrangement (contingency-shaped responding and uninstructed exposure to differential reinforcement of MTS performances) while minimizing experimenter–subject contact. Experiment 1 arranged for the systematic addition of training elements in the event that conditional discrimination acquisition was not observed, and focused especially on the contribution of instructions. Experiments 2 and 3 tested for facilitative effects of sample naming and a thematic matching procedure, respectively.

Table 1

Sex and age of each participant.

| Participant | Experiment | Sex | School | Age on first session (years/months) |
|---|---|---|---|---|
| S1 | 1 | F | A | 4/9 |
| S2 | 1 | M | A | 3/3 |
| S3 | 1 | F | A | 4/10 |
| S4 | 1 | M | A | 6/9 |
| S5 | 1 | M | A | 4/9 |
| S6 | 1 | M | A | 6/2 |
| S7 | 1 | F | A | 4/7 |
| S8 | 1 | F | A | 4/6 |
| S9 | 2 | F | A | 5/1 |
| S10 | 2 | M | A | 5/8 |
| S11 | 2 | M | A | 5/0 |
| S12 | 2 | F | A | 4/7 |
| S13 | 2 | F | A | 5/7 |
| S14 | 2 | F | A | 3/10 |
| S15 | 2 and 3 | F | A | 5/0 |
| S16 | 2 and 3 | M | A | 6/7 |
| S17 | 2 | M | A | 4/5 |
| S18 | 2 | F | A | 3/11 |
| S19 | 2 and 3 | M | A | 4/7 |
| S20 | 3 | F | B | 5/1 |
| S21 | 3 | F | C | 4/6 |
| S22 | 3 | F | C | 5/3 |
| S23 | 3 | M | C | 5/9 |
| S24 | 3 | F | B | 4/1 |
| S25 | 3 | F | B | 3/7 |

## EXPERIMENT 1

### Method

*Subjects*

Subjects were 8 normally capable children (see Table 1) who were experimentally naive when the study began.

*Apparatus and Stimuli*

The subject sat with a research assistant on one side of a small table holding a Wisconsin General Test Apparatus (WGTA), modified for use with children (e.g., Overman, Bachevalier, Turner, & Peuster, 1992). An experimenter sat on the opposite side of the WGTA. The WGTA was an open-ended wooden box (17 cm by 24 cm by 60 cm) in which subject and experimenter each had visual and physical access to half of the apparatus. A sliding door bisected the box, and a wooden partition (65 cm high) prevented visual contact between experimenter and subject.

Experimental stimuli were abstract three-dimensional objects of various shapes, colors, and materials with no obvious physical similarities, approximately 2 cm by 2 cm by 1 cm in size and mounted on black cardboard squares (5 cm by 5 cm) (see Pilgrim & Galizio, 1990, for further description of some of these objects). Stimuli were arranged on a Plexiglas stimulus tray (25 cm in length) and presented manually by the experimenter. Each stimulus covered one of five concave wells in which food reinforcers (e.g., fruit, etc.) could be hidden. The food wells were arranged horizontally, across the length of the stimulus tray. The experimenter arranged and presented all stimulus displays and recorded each comparison choice; the research assistant sat behind the child and encouraged active participation in the task but did not attend to stimulus presentations.

### *Procedure*

*General procedure.* A two-choice MTS procedure was arranged, unless otherwise noted. Each trial began when the experimenter raised the door of the WGTA and presented the stimulus tray with a sample stimulus covering the center food well. When the subject responded by displacing the sample stimulus, the tray was retracted and then re-presented with the sample object again covering the center well and two comparison stimuli covering the most lateral wells. Displacement of the comparison designated as correct revealed a small piece of food and resulted in verbal praise (e.g., ''good girl'') from the experimenter. Displacement of the comparison designated as incorrect revealed an empty well and no verbal consequences were presented. A 20-s intertrial interval preceded the next trial.

Subjects were tested individually, on weekdays, at one of three preschools or afterschool programs (see Table 1). Four to five sessions were conducted per week, excepting absences, conflicting school activities, and so forth. Each daily session lasted approximately 15 to 20 min and consisted of 16 trials. Following the last session of each week, subjects were allowed to choose a small toy from a ''treasure chest'' contingent on participation during each scheduled session.

*Pretraining.* Prior to their first session, each subject was invited to ''play a game'' with the experimenter and research assistant. Once the subject was seated in front of the WGTA, an explicit set of shaping steps was used to establish responding. Subjects progressed from removing food bits from a well on an otherwise empty tray to obtaining a food bit from beneath a comparison stimulus presented after an observing response to the sample stimulus. No verbal instructions or models were presented.

*Experimental training conditions.* Each subject was exposed to a series of experimental training conditions. Although the order of conditions varied across subjects, the general strategy was to assess training manipulations for any facilitative effect on acquisition of an arbitrary conditional discrimination. Each training condition was in effect until the mastery criterion was met (i.e., two consecutive sessions with 14 of 16 trials correct) or until convincing evidence of stable subcriterion performance was obtained (generally, a minimum of 10 sessions with no evidence of increasing trends). Training conditions are described below; the order and number of sessions in each condition will be presented along with each subject's results.

In the arbitrary matching condition, differential reinforcement was arranged for a two-choice MTS task involving two sample stimuli (A1 and A2) and two comparison stimuli (B1 and B2). When Sample A1 was presented, choosing Comparison B1 revealed a food bit and choosing Comparison B2 revealed an empty well. When Sample A2 was presented, choosing B2 revealed the food and B1 revealed the empty well. Verbal praise also accompanied each correct choice. Within each session, both samples appeared equally often, and comparisons appeared equally often in the two most lateral positions. The same sample could not appear on more than three trials in succession, and the same comparison stimulus could not appear in the same location for more than two trials in succession. The correct comparison could not appear in the same location for more than three trials in succession and neither could it alternate between lateral positions for more than three trials in succession. If the AB conditional discrimination was mastered, others (e.g., AC) were presented in subsequent phases.

In the instruction conditions, verbal instructions were presented immediately prior to each of the first five trials of a session and immediately prior to the next trial following any incorrect response. Instructions were omitted once the mastery criterion had been met. For the general instruction condition, the experimenter held up the next sample to be presented and said ''Look at this one. This one will tell you where the prize is.'' For the specific instructions condition, the experimenter held up the next sample and stated, ''When this one is in the middle, pick this one'' and held up the correct comparison. Following the instruction, the trial was presented as usual.

In addition to the specific instructions, a naming condition was sometimes superimposed on the arbitrary matching procedures.

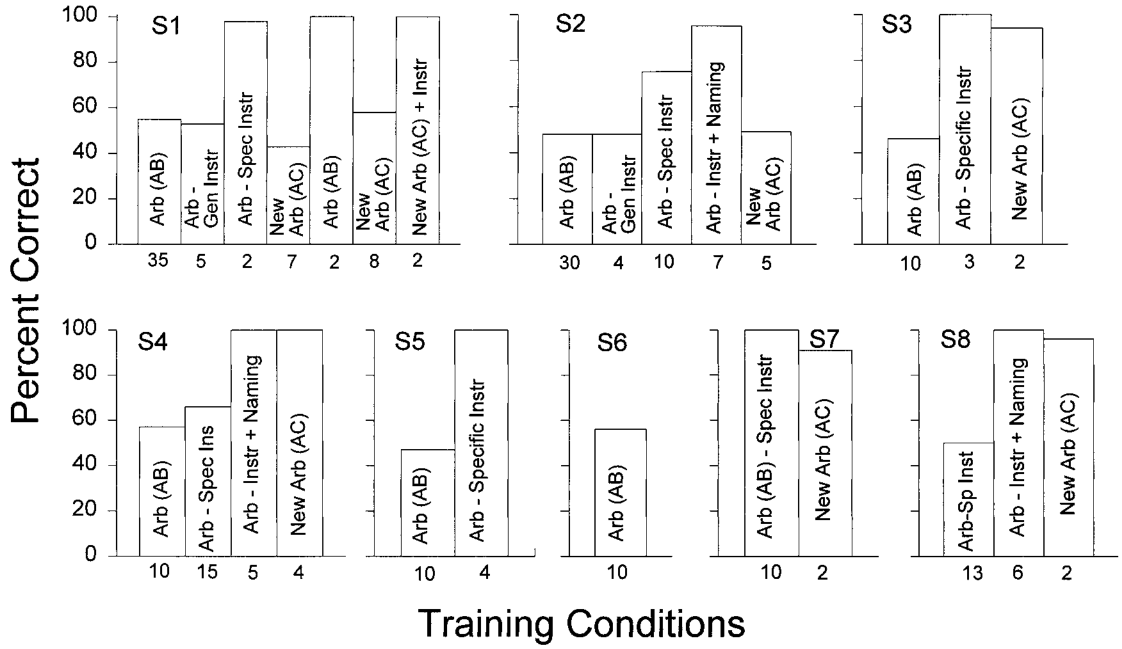


Fig. 1. Mean percentage of correct responses for the final two 16-trial sessions of each condition shown from Experiment 1. Numbers under each bar indicate the total number of sessions completed in that condition.

At the beginning of the first session in this condition, the subject was shown Sample Stimuli A1 and A2 and was told "Today we need some names for these things. What would you like to call this [A1]? What would you like to call this [A2]?" On each trial thereafter, before comparison stimuli were presented, the subject was required to name the sample. Verbal prompts ("What is this?") were presented on early trials, and then were gradually delayed until the subject named each sample upon its presentation. For training phases subsequent to the naming condition, naming had no programmed consequences.

Subjects S1 through S4 were exposed to the arbitrary matching condition immediately after the pretraining. When Subjects S1 and S2 failed to master the arbitrary task despite extended exposure (20 sessions), simpler procedures were introduced to assess reinforcer efficacy, stimulus discriminability, and general procedural complexity (i.e., simple discrimination training and identity MTS with different stimuli, blocked-trial procedures, and position prompts; with S4 and S5, some of these procedures were intermixed with the experimental conditions). Because these simpler procedures showed no signs of facilitating conditional discrimination acquisition, S3 and S4 were presented with specific instructions immediately after failing their first arbitrary training phase. Subjects S5 and S6 began with training phases in which each of the comparison choices was correct on all trials of a session, to provide histories of reinforcement for each choice, prior to their first arbitrary matching condition. Finally, S7 and S8 received specific instructions in their first training phase.

## Results and Discussion

Figure 1 presents data from the arbitrary matching and instruction conditions for Subjects S1 through S8. Each bar represents the mean percentage correct for the final two sessions in each of the training conditions shown. For Subjects S1 and S2, these two sessions were the endpoint of an extensive training history, as described above. Subject S1 failed to show acquisition of arbitrary matching during three separate exposures to that condition for 35 total sessions, but did show rapid mastery of several simpler, intervening tasks (two simple discriminations: a blocked-trial procedure in which blocks of eight and then four trials of the same type were presented in succession, and identity matching), indicating control by the reinforcement contingencies in effect. A similar pattern was shown by S2, who failed to acquire arbitrary matching during three exposures for 30 total sessions or identity matching over 10 sessions but mastered several tasks involving simple discriminations with the same reinforcers. Similarly, S5 and S6 rapidly mastered two simple discriminations prior to their first arbitrary matching condition, and S4 and S5 did so in training phases that immediately followed either the first arbitrary condition (S5) or the specific instructions condition (S4). S5 also failed to acquire identity matching immediately prior to the addition of specific instructions.

Subjects S1 through S6 were exposed to the arbitrary matching condition prior to any instructions, and none showed signs of acquisition. In contrast, 3 of these subjects (S1, S3, and S5) went on to show rapid acquisition in the specific instructions condition. Neither S1 or S2 had acquired the discrimination with general instructions. Subjects S2 and S4 required the addition of naming to the specific instruction condition before reaching mastery. Subject S6 left the study before instructions could be presented. When specific instructions were presented in the first training phase, S7 showed rapid mastery (like that of S1, S3, and S5), and S8 required the addition of naming (as had S2 and S4). Four of 6 subjects who mastered a first arbitrary matching task (AB) mastered a second (AC) without instructions or naming requirements (S3, S4, S7, and S8), but 2 did not (S1 and S2).

The results of Experiment 1 seem to imply that the acquisition of arbitrary conditional discriminations was not a simple process for these young children. In fact, none of the subjects mastered the arbitrary task under conditions of differential reinforcement alone, and 3 subjects showed no sign of acquisition even after performances had been explicitly instructed, until sample names were trained. Differential responding to sample stimuli has been shown to facilitate the acquisition of conditional discriminations in many studies, involving humans (e.g., Horne & Lowe, 1996; Saunders & Spradlin, 1990, 1993) and nonhumans (e.g., McIntire, Cleary, & Thompson, 1989; Urcuioli, 1996; Zentall, 1996). Experiment 2 was designed to examine the influence of sample naming independent of the instructions used in Experiment 1. In addition, in previous studies with sample naming, the experimenter provided arbitrary names for the subjects to use (e.g., Saunders & Spradlin, 1990, 1993), whereas in Experiment 1 the subjects generated their own names. Recent theoretical debate over the role of untrained naming (e.g., Horne & Lowe, 1996; McIntire et al., 1989) suggests that a direct comparison of self-generated and experimenter-given names could be of interest. This issue was also explored in Experiment 2.

## EXPERIMENT 2

### METHOD

*Subjects*

Subjects were 6 female and 5 male normally capable children (see Table 1) who were experimentally naive when the study began.

*Procedure*

Apparatus, general procedures, pretraining, and MTS procedures were as described in Experiment 1. The new feature of Experiment 2 was a condition in which sample-stimulus names were introduced in a blocked-trial arrangement, in the absence of specific instructions.

In Experiment 2A, nonverbal training stages like those in Experiment 1 (identity and arbitrary conditions) were replicated with 3 subjects. If conditional discriminations were not acquired, blocked trials were presented, with or without the addition of a requirement that the sample stimulus be named. In the blocked-trial arrangement, the same sample stimulus was presented on each of a block of consecutive trials, and then alternated with the other sample for an equal number of trials (either eight or four), while position of the comparison stimuli varied quasirandomly. Two subjects (S10 and S11) were exposed to blocks of eight and four trials without names, and when no signs of acquisition were shown on the subsequent arbitrary MTS task (standard mixed-trial arrangement), the naming requirement was imposed with blocks of four trials. For the 3rd subject (S9), blocked trials

Table 2
Stimulus names generated by each participant.

| Experiment | Participant | Stimulus description | Name given |
|---|---|---|---|
| 1 | S7 | A1: abstract line drawing | ‘‘Snail’’ |
| | | A2: abstract line drawing | ‘‘Bird’’ |
| | S8 | A1: pink tube | ‘‘Rectangle’’ |
| | | A2: plastic eye | ‘‘Circle’’ |
| 2A | S9 | A1: red abstract shape | ‘‘Pizza’’ |
| | | A2: white abstract shape | ‘‘Bones’’ |
| | S10 | A1: red abstract shape | ‘‘Piano’’ |
| | | A2: white abstract shape | ‘‘Fence’’ |
| 2B | S17 | A1: pink tube | ‘‘Teenage bulb’’ |
| | | A2: clear hemisphere | ‘‘Shrimp’’ |
| | S18 | A1: pink tube | ‘‘Belly button’’ |
| | | A2: clear hemisphere | ‘‘Hair’’ |
| | S19 | A1: purple button | ‘‘Roger’’ |
| | | A2: red hemisphere | ‘‘Josh’’ |

and naming were introduced immediately following her first failure to acquire arbitrary MTS. Names were generated by 2 of the subjects (S9 and S10), but for the 3rd subject (S11), names were nonsense syllables provided by the experimenters. Because S11's performance differed from that of the other 2 subjects, Experiment 2B focused on a systematic manipulation of the source of the names with additional subjects. As they began the study, 3 subjects in Experiment 2B were assigned to the self-names condition and 5 were assigned to the names-given condition. Two subjects in the self-names condition (S17 and S18) were later exposed to the names-given condition with new stimuli.

Throughout Experiment 2 (Parts A and B), in the self-names condition, procedures replicated those of the naming condition in Experiment 1. Subjects were asked to provide a name for each of the sample stimuli, and were then required to give that name on each trial upon presentation of the sample stimulus. In the names-given condition, the following instructions were presented by the experimenter. ‘‘From now on, we need some names for these things. This one [Sample A1 was held up] is named Wugs. Can you say that? And this one [Sample A2 was shown] is named Niz. Can you say that? Whenever you see this [A1] or this [A2], I want you to say its name, OK?’’ On each subsequent trial, subjects were required to correctly name the sample prior to comparison presentation. Verbal prompts (‘‘What is it?’’) were provided on early trials and then were gradually delayed until subjects named each stimulus immediately upon its presentation without an experimenter prompt. If errors were made in either of the naming procedures, the experimenter prompted the correct response prior to comparison presentation.

For subjects in Experiment 2B, blocked trials with naming was the first condition arranged, with blocks of eight followed by blocks of four. When the mastery criterion had been met, the standard mixed-trial arbitrary arrangement was presented. Naming was still required during this condition. For 3 of the subjects (S12, S13, and S14), mastery of the AB conditional discrimination was followed by training on a second, AC conditional discrimination, in which names were no longer required.

## Results and Discussion

All of the subjects readily acquired consistent use of the sample-specific names in the first experimental phase in which the naming requirement was introduced. Naming was maintained throughout all naming conditions at close to 100% accuracy. Table 2 presents a description of the sample stimuli and provides the stimulus names generated by each subject who was asked to do so.

Figure 2 shows the results from subjects in Experiment 2A. Despite the rapid acquisition of identity MTS by S9 and S11, there were no signs of acquisition on the arbitrary task, nor were there for S10 who began with the arbitrary discrimination condition. S9 reached mastery rapidly with blocks of eight when she

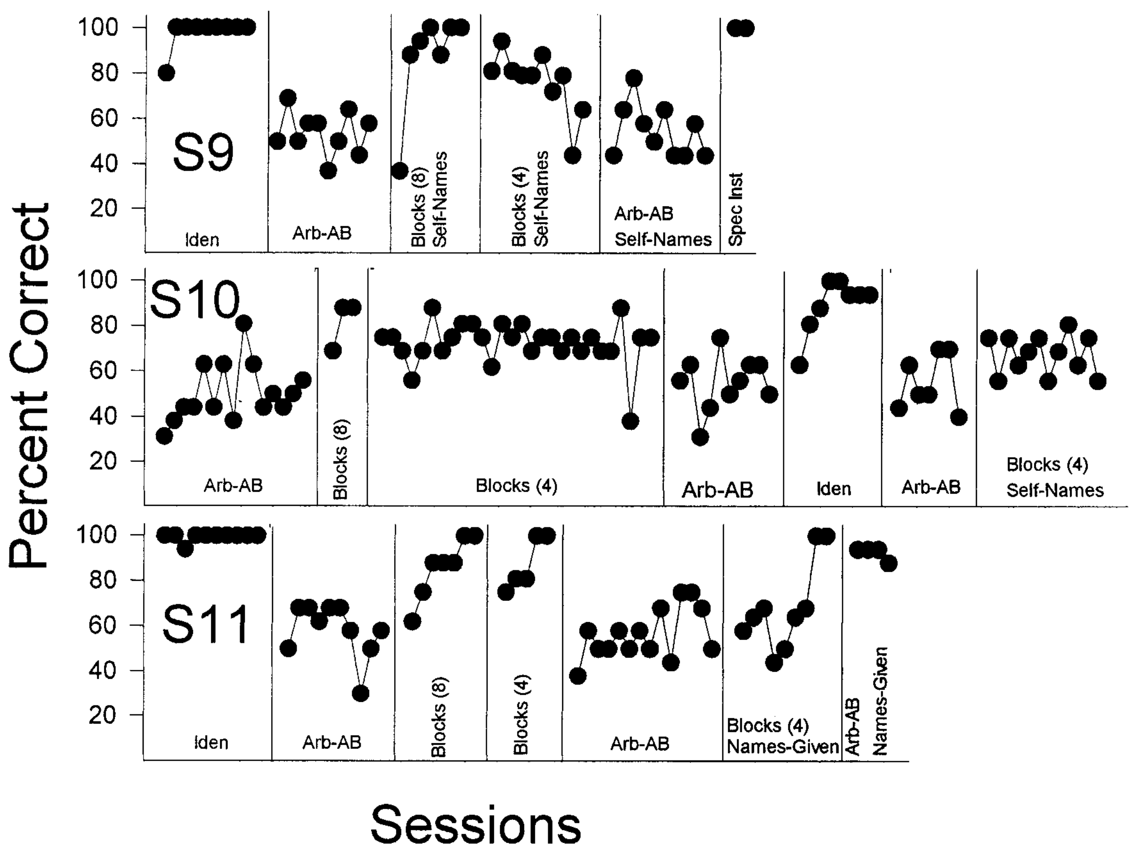


Fig. 2. Percentage of correct MTS responses on each consecutive 16-trial session for subjects in Experiment 2A.

named the sample stimuli (self-names), but matching accuracy decreased with blocks of four and continued to decrease when she was required to name both the sample and the comparison stimuli (an addition made only for S9 when accuracy started to fall). With specific instructions, the arbitrary task was mastered immediately. S10 met criterion in the blocks of eight condition without names, but did not attain mastery with blocks of four for 28 sessions. S10 showed no improvement during a subsequent exposure to arbitrary discrimination with mixed trial types, but mastered identity matching with little problem. The conditional control shown during successful identity training did not transfer to the mixed arbitrary discrimination. Finally, S10 was exposed to blocks of four while naming the sample stimuli (self-names), but did not meet criterion in 12 sessions. He showed no indication of improvement in this phase relative to his earlier exposure to blocks of four that did not include sample names.

The early performances of S11 were similar to those of the first 2 subjects, in that he mastered identity matching quickly but did not do so for the arbitrary discrimination. Blocks of eight and then four were readily acquired, but again, there were no facilitative effects on the subsequent arbitrary task. S11 was then given names for the sample stimuli (names-given), and in this case, his accurate performances with blocks of four gave way to near perfect performance on the mixed arbitrary task. Because this was the first instance of acquisition without instructions, replication might suggest that experimenter-provided names had some different function than those generated by the subjects themselves, a possibility explored in Experiment 2B.

Figure 3 presents data from the 5 subjects who were given names for the sample stimuli

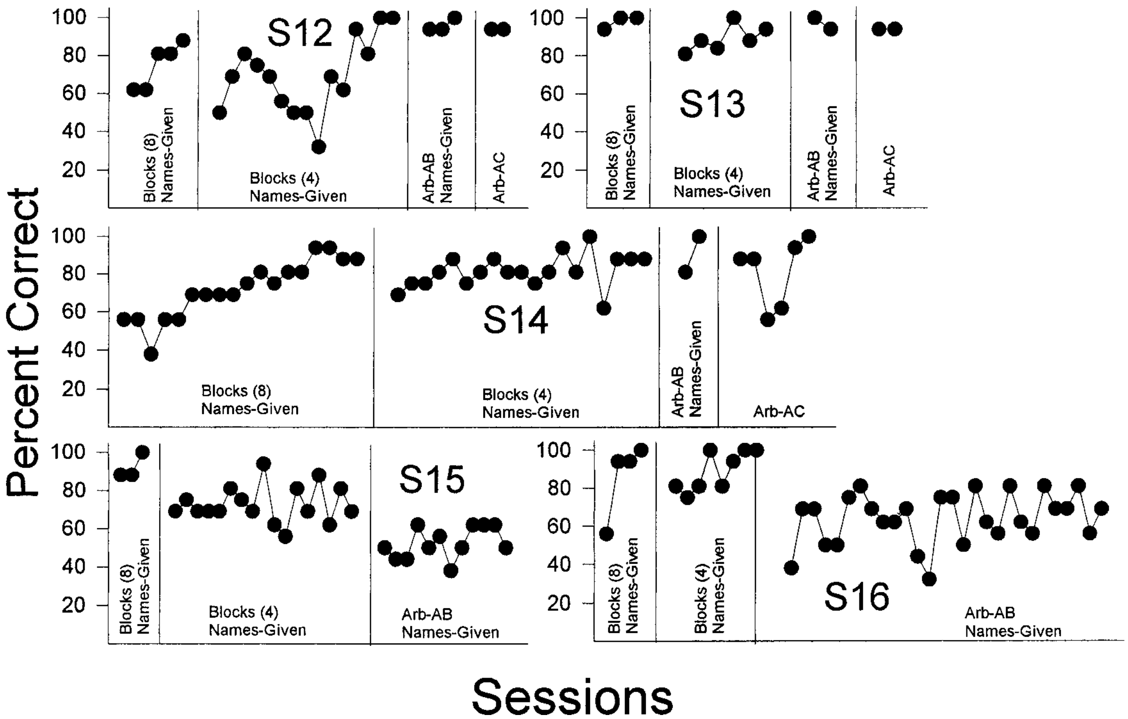


Fig. 3. Percentage of correct MTS responses on each consecutive 16-trial session for subjects who began training in the names-given condition of Experiment 2B.

in their first training condition, blocks of eight. All subjects met criterion on blocks of eight, and the rate of acquisition was relatively rapid for all subjects but S14. Three of the 5 subjects (S12, S13, and S14) then mastered blocks of four (again, at varying rates) and went on to show virtually immediate mastery of the mixed AB arbitrary conditional discrimination. After mastery of the AB discrimination, the second conditional discrimination was learned rapidly (the minimum two sessions for S12 and S13 and six for S14), even though naming was not required. These performances stand in marked contrast to the uninstructed patterns seen on the standard arbitrary task in Experiments 1 and 2A.

Experimenter-given names, however, did not facilitate acquisition with every subject. S15 and S16 (bottom panels of Figure 3) both mastered blocks of eight quickly, and S16 performed similarly with blocks of four, but S15 failed to reach mastery thereafter and S16 failed to master the standard arbitrary task even after many sessions.

Figure 4 presents data from 3 additional subjects who began their training in the self-names condition. All 3 subjects mastered blocks of eight, and S17 and S19 eventually did so with blocks of four, but S18's performances stabilized at approximately chance levels. When S17 and S19 were exposed to the standard arbitrary task, performances also fell to chance levels of accuracy and remained there over multiple sessions. S17 and S18 received further training with new stimulus sets for which sample names were provided by the experimenter. In both cases, and again, in marked contrast to their original performances, blocks of eight and four were mastered rapidly. S17 went on to show similarly rapid acquisition of the standard arbitrary discrimination, but S18 left the preschool at this time.

To summarize Experiment 2, 5 subjects received training on a standard arbitrary matching task in which self-generated names for the sample stimuli were required on each trial. None of these subjects met the mastery criterion on the arbitrary task, despite successful performances on at least some blocked arrangements. Seven subjects received training on the standard arbitrary task with sample

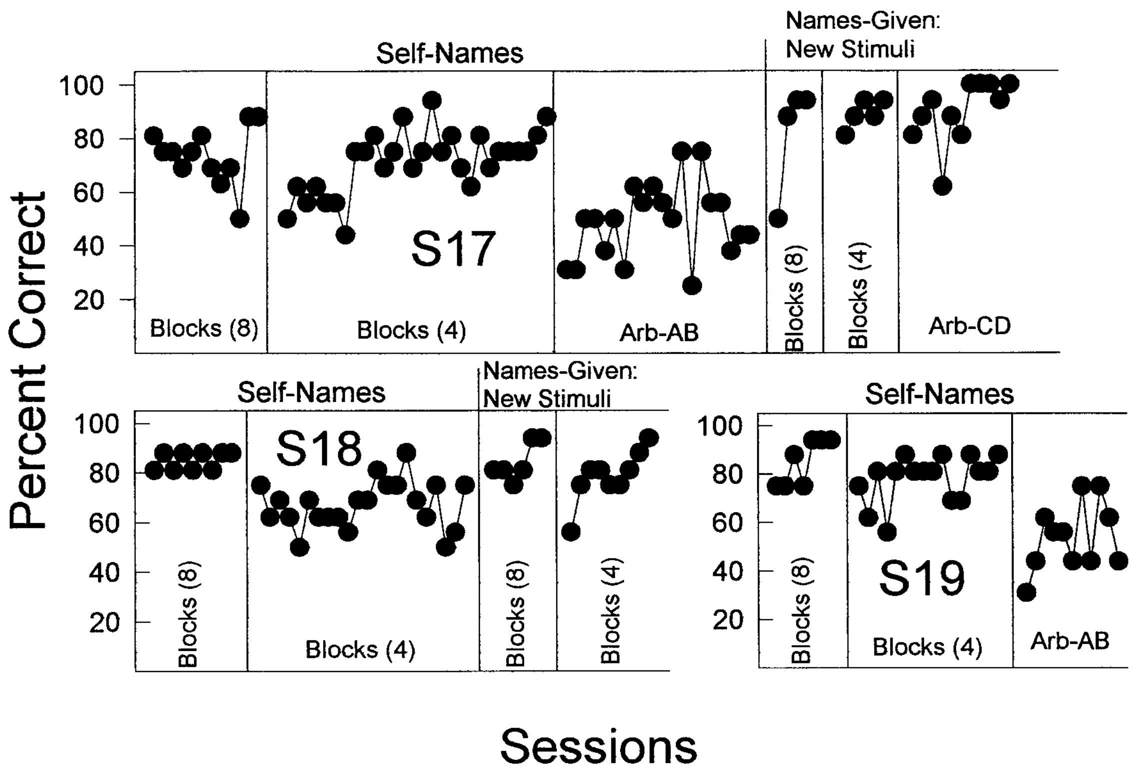


Fig. 4. Percentage of correct MTS responses on each consecutive 16-trial session for subjects who began training in the self-names condition of Experiment 2B.

names originally given by the experimenter. Five of the 7 subjects showed rapid mastery of the arbitrary discriminations. In one case (S17), this occurred after failure to reach mastery in conditions that were identical except for the source of the sample names and the specific stimuli presented. An 8th subject (S18) showed more rapid acquisition of blocks of eight and four with names-given than with self-names, although testing in the standard arbitrary task with names-given was not possible.

Overall, the results of Experiment 2 extend the facilitative effects of blocked trials and naming on conditional discrimination acquisition reported by Saunders and Spradlin (1989, 1990, 1993) to normally developing children, but qualify the effect in terms of name source. As in those studies, the blocked-trial procedure alone was insufficient for fostering MTS performance, but blocked trials combined with experimenter-given names greatly facilitated acquisition. With names or without, mastery of the arbitrary task in the present study did not depend on whether the terminal performances in the blocked-trial phases revealed evidence of perfect conditional control (i.e., correct responses on the first trial of each new block; see S11, S14, S16, and S17 for examples).

Interestingly, the facilitative effect of blocking and naming was not obtained here when the sample names were generated by the children (at least not in the absence of specific instructions as with subjects in Experiment 1). Successive sample discrimination is one necessary component of successful performance on a standard conditional discrimination (Carter & Eckerman, 1975; Saunders & Spradlin, 1989, 1990, 1993), and differential sample responses can be seen as contributing to the maintenance of these necessary successive discriminations. In the present study, however, subjects in the self-names condition were clearly differentiating sample stimuli, as were those subjects in the names-given condition. Thus, other factors must be responsible for the failure to master the arbitrary task.

For example, self-names were often labels for familiar objects that may have controlled selection of idiosyncratically related comparison features, thus interfering with the development of arbitrary relations designated by the experimenter. However, not all subjects provided names that were based on familiar objects in any clear way (e.g., see the names provided in Table 2).

Experiments 1 and 2 were successful in identifying procedures that could facilitate the acquisition of an arbitrary conditional discrimination, but in all cases the procedures involved explicitly verbal manipulations. Because of the controversial role of verbal processes in the stimulus equivalence literature, training procedures that do not rely on language would be of special interest. One difficulty for subjects in the previous experiments involved the transition from identity matching, which was readily acquired in most cases, to arbitrary matching. Although identity matching seems to be important in helping to establish the conditional nature of the task, it also requires control by physical similarity between the sample and comparison stimuli. After training that sort of stimulus control, it might not be surprising that performance on subsequent arbitrary tasks suffers. We reasoned that an intermediate shaping step with familiar stimulus relations involving physically dissimilar stimuli might be effective in facilitating the transition to novel arbitrary relations. Experiment 3 tested this possibility by pretraining subjects on a conditional discrimination between thematically related stimuli (e.g., given a picture of an apple as a sample stimulus, choosing a picture of a banana instead of a baseball was reinforced).

## EXPERIMENT 3

### Method

#### *Subjects*

Subjects were 6 female and 3 male normally capable children (see Table 1). The 3 subjects in Experiment 3A (S15, S16, and S19) had participated in Experiment 2 immediately prior to this study; subjects in Experiment 3B were experimentally naive when the study began.

#### *Apparatus*

In Experiment 3A, the same WGTA was used as in Experiments 1 and 2. In Experiment 3B, stimuli were black-and-white line drawings approximately 1.5 to 2 cm square presented on a white screen background on either a MacIntosh Performa® or Power PC® computer (30 cm diagonal screens), according to specialized MTS programming (Dube, 1991). The sample stimulus always appeared in the center of the screen, and comparison stimuli could appear in any of the corners. Manipulating a mouse moved a cursor on the screen. When the cursor was situated on or near a stimulus, clicking on the mouse registered a response. Following a response designated as correct, a brief fanfare sounded during which colored stars transversed the computer screen, and then the screen darkened for 1.5 s before the next trial was presented. Following a response designated as incorrect, a buzzer sound was produced and the screen immediately went blank for 1.5 s.

#### *Procedure*

All 3 subjects in Experiment 3A had experienced the same sequence of training phases in Experiment 2, and differed only with respect to their naming condition. Experiment 3A began after at least 10 sessions of training in the arbitrary AB condition with no trend toward mastery (see Figures 3 and 4). Subjects S16 and S19 were then exposed to identity matching followed by the thematic training condition, and S15 went directly to the thematic condition. The identity matching condition differed from the arbitrary task only in that the sample and correct comparison on each trial were physically identical objects. One of two different samples and the same two comparisons were presented on each of the 16 trials, with order and position varied quasirandomly. The stimulus sets used for identity, thematic, and arbitrary matching conditions were mutually exclusive. During thematic training, all stimuli were stickers representing familiar objects, attached to black bases. The sample and correct comparison stimuli were related thematically; that is, they were members of common categories that children of these ages might be expected to have learned (see Table 3). Care was taken to choose stimulus arrangements in which

Table 3
Composition of each thematic set.

| Participant | Thematic set | Theme A | Theme B | Theme C |
|---|---|---|---|---|
| S15 | 1 | Xmas tree | Witch | |
| | | Angel | Ghost | |
| | 2 | Cherries | Football | |
| | | Grapes | Baseball mitt | |
| S16 | 1 | Xmas tree | Witch | |
| | | Angel | Pumpkin | |
| S19 | 1 | Pig | Witch | |
| | | Lamb | Ghost | |
| S20, S21, S22, S23 | 1 | Pig | Plane | Ear |
| | | Cat | Boat | Eye |
| | | Cow | Truck | Hand |
| S24 | 1 | Pig | Plane | Ear |
| | | Cat | Boat | Eye |
| | | Cow | Truck | Hand |
| | 2 | Female face | Palm | |
| | | Baby face | Pine | |
| | | Male face | Oak | |
| | 3 | Strawberry | Rose | |
| | | Grapes | Daisy | |
| S25 | 1 | Female face | Palm | |
| | | Baby face | Pine | |
| | | Male face | Oak | |
| | 2 | Strawberry | Rose | |
| | | Grapes | Daisy | |

*Note.* Stimuli listed on the first row for each subject were presented as samples, and those listed on subsequent rows were presented as comparison stimuli.

the correct comparison could not be identified through physical properties held in common with the sample stimulus. Trials involving sample stimuli from each of the two themes and the same two comparisons (one from each theme) were unsystematically intermixed throughout the 16-trial session. Following mastery (14 of 16 trials correct on two consecutive sessions) of the thematic task, the arbitrary AB task was presented again, followed by training on the arbitrary AC relation. Because S15 did not master her first thematic task, she was next presented with identity training, followed by thematic training with a second set of thematically related stimuli, and then arbitrary AB training conditions.

In Experiment 3B, the stimuli were computer-generated shapes and icons, and each session consisted of up to 36 trials. All 6 subjects began their training on three-choice identity-matching tasks, first involving familiar pictures (e.g., heart, flower) and then involving abstract figures. Following mastery of both identity tasks, either a two- (S25) or three-choice (S20 through S24) thematic task was introduced, involving two or three stimuli per theme (see Table 3 for stimuli). All trial types for any given thematic set were presented on an equal number of trials and were unsystematically intermixed. Upon mastery of the thematic relations, subjects received training on either a two-choice and a three-choice arbitrary AB task (S24 and S25) or went directly into three-choice (S20 through S23) arbitrary AB training. Stimuli were abstract figures different from those used during identity training. In the case of failure to acquire either the identity (S25) or the thematic relation (S24), additional manipulations were arranged, which will be described along with the results. After mastering one three-choice conditional discrimination (AB or AC), subjects were trained on a second three-choice discrimination (AC or AB).

## Results and Discussion

The 3 subjects of Experiment 3A represented failures to acquire the arbitrary conditional discrimination even after blocked tri-

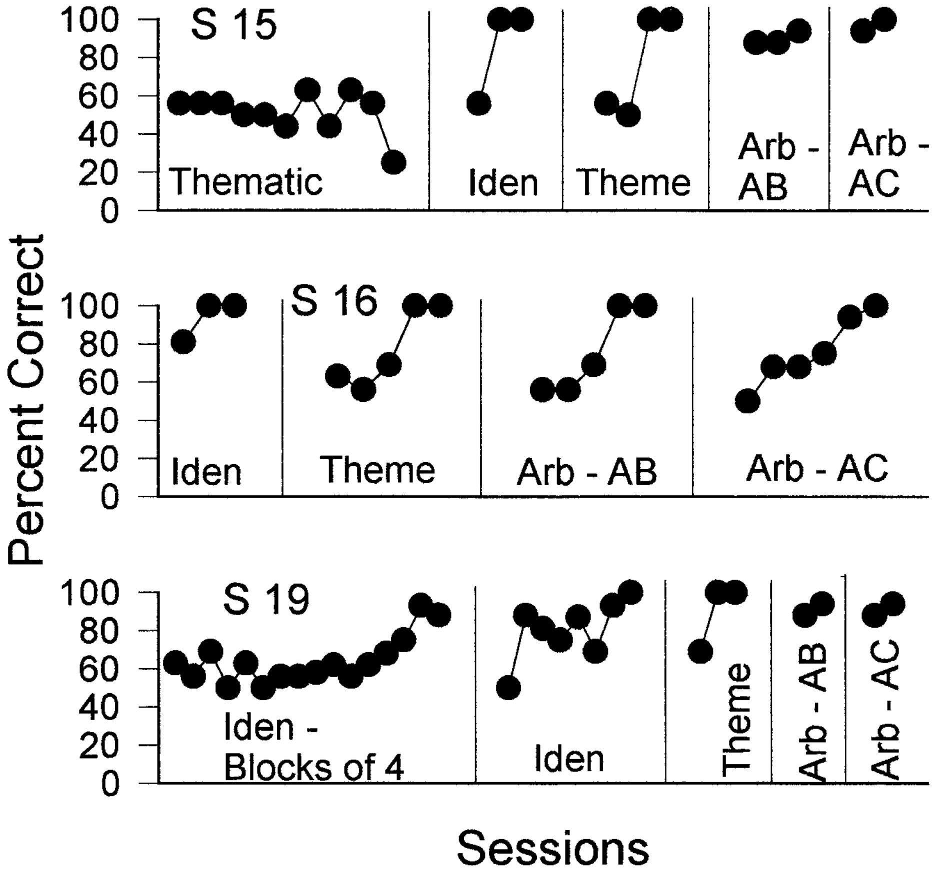


Fig. 5. Percentage of correct MTS responses on each consecutive 16-trial session for subjects in Experiment 3A.

als and naming in Experiment 2 (see Figures 3 and 4). For S16 and S19 the thematic task was rapidly mastered following acquisition of identity matching (see Figure 5). Notably, both subjects went on to show rapid acquisition of the arbitrary AB discrimination, followed by similar success on a second conditional discrimination (arbitrary AC). S15 began with thematic training, but failed to show any sign of acquisition until after the rapid acquisition of identity matching (see Figure 5). This success was followed with new thematic stimuli, and mastery was shown promptly. As was the case with the other 2 subjects, the conditional control established in the thematic condition transferred to the arbitrary conditional discriminations (AB and AC).

Results from Experiment 3B are presented in Figure 6. The data from S20, S21, S22, and S23 mirrored those of the subjects from Experiment 3A in their rapid progression from identity to thematic and then to arbitrary discriminations. S24 mastered the identity-matching phases of her training, but failed to acquire either the three-choice thematic discrimination, even after repeated sessions, or a two-choice discrimination involving different thematic stimuli. Following successful reexposure to the identity-matching task, S24 was presented with a third set of thematic stimuli in a two-comparison task. After three

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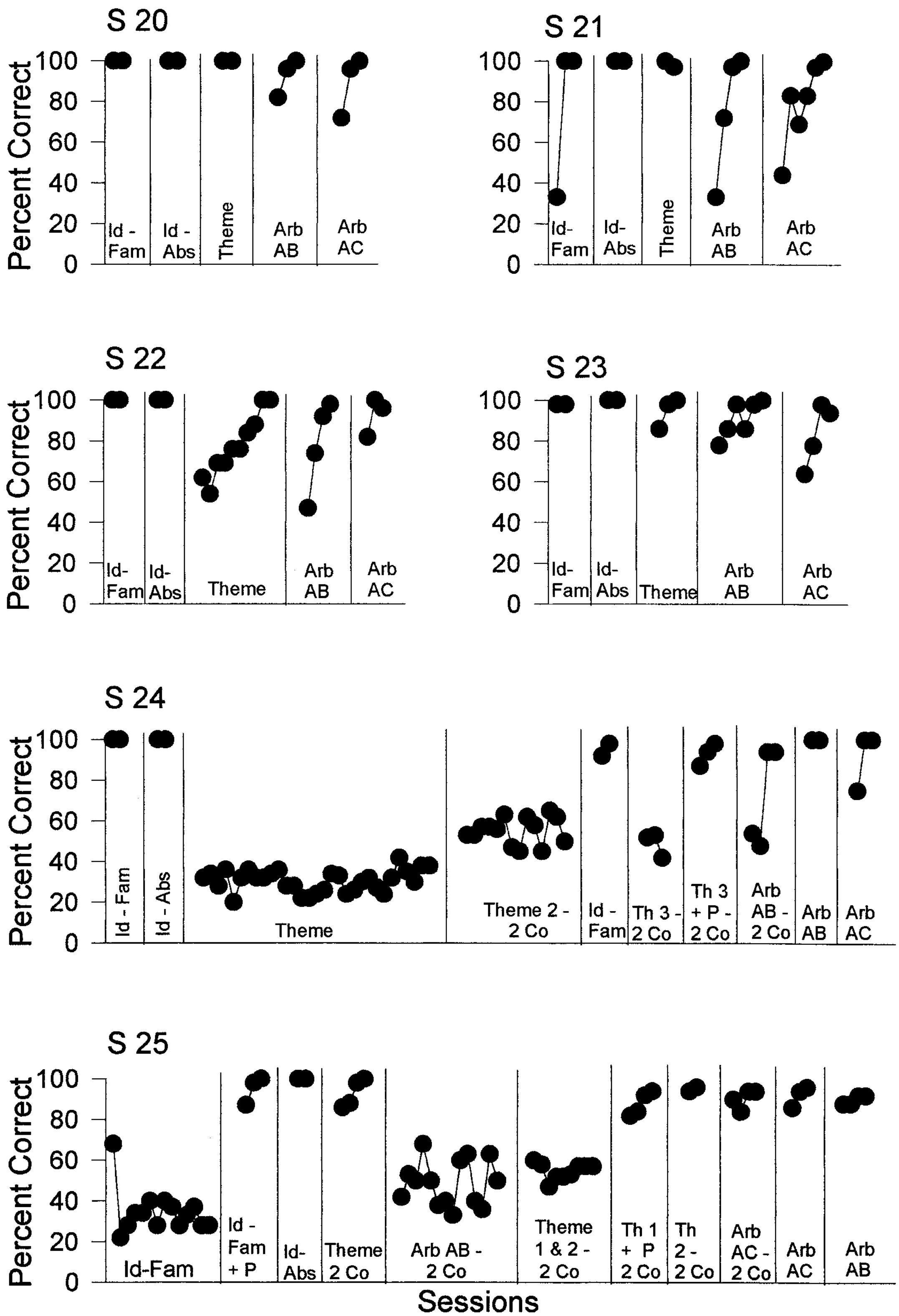
Fig. 6. Percentage of correct MTS responses on each consecutive 24-trial (conditions with two comparison stimuli) or 36-trial (conditions with three comparison stimuli) session for subjects in Experiment 3B. All tasks involved three comparison stimuli unless noted (2 co). P indicates the addition of verbal prompts.


S 20
S 21
S 22
S 23
S 24
S 25
Percent Correct
100
80
60
40
20
0
Id - Fam
Id - Abs
Theme
Arb AB
Arb AC
Theme 2 - 2 Co
Th 3 - 2 Co
Th 3 + P - 2 Co
Arb AB - 2 Co
Id-Fam
Id - Fam + P
Theme 2 Co
Arb AB - 2 Co
Theme 1 & 2 - 2 Co
Th 1 + P 2 Co
Th 2 - 2 Co
Arb AC - 2 Co
Sessions

sessions of chance performance, S24 received verbal prompts on each of the first five trials of the next session. Upon presentation of the two comparison stimuli, the experimenter asked, ''Which ones can you eat?'' and ''Which ones can you put in a vase?'' depending on the sample stimulus presented on each trial (either a fruit or a flower; see Table 3). This manipulation resulted in rapid acquisition of the thematic discrimination, which was followed by rapid mastery of the arbitrary tasks (AB and AC; see Figure 6).

Four-year-old S25 failed to master the initial identity-matching task after 15 sessions. A verbal prompt was then added on each of the first five trials of the 16th session only. After the three comparison stimuli had been presented, the experimenter pointed to the sample and asked, ''Which one is like this one?'' This resulted in rapid mastery of identity matching with both familiar and abstract stimuli (see Figure 6). The two-choice thematic task was then mastered rapidly, but unlike the other subjects, performance remained at chance levels on the arbitrary AB discrimination over multiple sessions. Next, two different sets of thematic stimuli were alternated irregularly across sessions, but conditional control by the thematic stimuli was not recovered until verbal prompts like those presented to S24 were added for Thematic Set 1. The second set of thematic stimuli was then mastered without prompts. Exposure to a new arbitrary relation (AC) then met with rapid success, as did subsequent reexposure to the arbitrary AB task.

With 8 subjects, the conditional control established by one set of thematic relations transferred to arbitrary conditional discrimination. With the 9th subject (S25), two sets of thematic relations were required to produce the same effect. The initial thematic training was acquired readily in 7 of the 9 subjects, and verbal intervention related to the themes was required in two cases. In sum, thematic training has much to commend it as an efficient technique for promoting acquisition of arbitrary conditional discriminations in young children.

## GENERAL DISCUSSION

One of the major conclusions from this series of studies is that arbitrary matching is not readily acquired by young normally developing children without special training procedures. Although this observation has been recognized by researchers working in the area for some time (e.g., Augustson & Dougher, 1991), it has received little explicit attention in the empirical literature, and thus may be underappreciated by scientists working outside of this immediate field. A number of studies have focused on acquisition difficulties in populations with developmental disabilities (e.g., Saunders & Spradlin, 1989, 1990; McIlvane et al., 1990; Zygmont et al., 1992). The absence of similar studies with normally developing children might be interpreted as suggesting that the difficulties are specific to individuals with disabilities. Indeed, such a conclusion might be supported by the rapid acquisition in even very young normally developing children that has sometimes been reported (e.g., Devany et al., 1986). Upon close inspection however, these rapid acquisition patterns have often been accompanied by verbal interactions associated with the training procedures, as discussed previously. In contrast, Experiment 1 of the present study showed that differential reinforcement alone was insufficient for the acquisition of conditional discriminations, despite extended exposure to conditions like those that led to mastery of simple discriminations and identity matching in most cases.

What remains to be determined is the basis for the difficulties in learning that were observed here. After all, nonhumans acquire arbitrary MTS performances without heroic interventions (e.g., Schusterman & Kastak, 1993; Sidman et al., 1982; Zentall, 1996; Zentall & Smeets, 1996), albeit under conditions that allow control over a greater number of variables (e.g., food deprivation, alternative sources of reinforcement for competing behavior). Another possibility with children involves effects of prolonged periods with frequent errors. These could include emotional factors or other reactions to lower frequencies of reinforcement (e.g., increased sensitivity to alternative sources of reinforcement or intermittent reinforcement of competing stimulus-control topographies; Dube & McIlvane, 1996). As an example, consider S25 from Experiment 3B. After failing an arbitrary MTS task for multiple sessions, she also failed to master a thematic matching task that had been readily acquired in its initial presentation. However, if a history of errors does have such disruptive effects, they can be relatively specific to the particulars of the context in which they were experienced. Most subjects readily acquired simple discriminations and identity matching despite early errors and even following extensive error histories on other tasks.

A second possibility is that a problem-solving task in the absence of instructions or a similar verbal context presents a novel circumstance for young normally developing children. For example, the training procedures used by Lipkens et al. (1993) closely resemble those of natural learning situations for children, and perhaps this was one basis for their effectiveness. In contrast, data from a number of studies with adult humans indicate that the absence of experimenter instructions is not a neutral situation and often results in acquisition failure (e.g., Ader & Tatum, 1961; Ayllon & Azrin, 1964; Baron, Kaufman, & Stauber, 1969; Galizio, 1979). Once again, however, subjects did acquire the simpler discrimination tasks without instructions or special programming. It seems possible that the combination of repeated errors with the absence of adult direction may represent a situation sufficiently uncommon for young children that problem-solving repertoires are poorly occasioned.

In any case, verbal interventions (i.e., specific instructions or names) often were effective in facilitating acquisition in these children. For example, in Experiment 1, 6 subjects mastered an arbitrary discrimination following verbal interventions after having been unable to without them. In many cases, the effect of the verbal manipulation transferred to a new conditional discrimination presented in the absence of verbal prompts. Similarly, in Experiment 2, 5 of the 7 subjects who were given names for the sample stimuli went on to master the arbitrary conditional discrimination. These latter results might be seen as consistent with the hypothesis that naming plays a critical role in processes involving conditional discriminations by human subjects (see Horne & Lowe, 1996). However, a simple naming account is insufficient to explain the present data because none of the 5 subjects who generated their own sample names mastered the task. The basis for the difference between self- and experimenter-provided names remains unclear at this point. Experimenter-provided names may provide an instructional function. Developmental psychologists (Kuczaj, Borys, & Jones, 1989; Markman, 1987; Mervis, 1987) have argued that when children hear a new name, such as the nonsense syllable names used here, they then search for referents of that name, or respond to the name as a label for a basic-level category (Markman, 1989). Such effects may be absent with the self-names of the present study. Alternatively, as noted above, self-names based on familiar objects may actually interfere with the development of arbitrary relations, perhaps somehow enhancing control by preexperimentally established relations between the stimuli rather than the experimenter's arbitrary ones. In short, it seems that naming may serve multiple functions, and that the source of the name is at least one determining factor with children. In any case, these data are problematic for accounts of relational learning that assume a necessary role for untrained, naturally occurring stimulus naming (see Hayes, 1989a; McIntire et al., 1989; Saunders, 1989; for discussion of this issue).

Another effective manipulation involved a programmed training sequence in which thematic MTS served as an intermediate step between identity and arbitrary relations. Experiment 3 revealed successful arbitrary discrimination performances in all 9 subjects after one or more exposures to the thematic sequence. Seven of these cases were particularly notable in the present study because they represented the only instances of acquisition in the absence of explicitly verbal manipulations. It is interesting to consider, however, the extent to which control by these thematic relations involved verbal processes. The thematic training capitalized on subjects' preexperimental histories, and the importance of verbal aspects of those histories is unclear. In the cases in which thematic matching was not shown readily, verbal prompts were effective in establishing thematic control. Interestingly, the verbal prompts involved queries about stimulus function, raising the question of whether MTS tasks involving experimentally established functional classes would have the same effect.

Despite the possible role of verbal processes in acquisition in the present study, data from other laboratories suggest that nonverbal interventions can be effective in promoting acquisition with normally developing children. Sophisticated stimulus-control shaping procedures have been developed (e.g., Etzel et al., 1996; Zygmont et al., 1992) in which the stimuli involved in identity relations were gradually made more and more physically disparate while a conditional relation between them was maintained, thereby resulting in an arbitrary relation. However, these procedures require relatively complex stimulus-presentation technology as well as many programming decisions about progressing through the extended sequence of fading steps. The thematic procedure introduced here is a relatively simple program that may provide an alternative in cases in which other training procedures are unsuccessful.

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