

*DELAYED MATCHING TO TWO-PICTURE SAMPLES BY
INDIVIDUALS WITH AND WITHOUT DISABILITIES:
AN ANALYSIS OF THE ROLE OF NAMING*

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Delayed matching to complex, two-picture samples (e.g., cat–dog) may be improved when the samples occasion differential verbal behavior. In Experiment 1, individuals with mental retardation matched picture comparisons to identical single-picture samples or to two-picture samples, one of which was identical to a comparison. Accuracy scores were typically high on single-picture trials under both simultaneous and delayed matching conditions. Scores on two-picture trials were also high during the simultaneous condition but were lower during the delay condition. However, scores improved on delayed two-picture trials when each of the sample pictures was named aloud before comparison responding. Experiment 2 replicated these results with preschoolers with typical development and a youth with mental retardation. Sample naming also improved the preschoolers' matching when the samples were pairs of spoken names and the correct comparison picture matched one of the names. Collectively, the participants could produce the verbal behavior that might have improved performance, but typically did not do so unless the procedure required it. The success of the naming intervention recommends it for improving the observing and remembering of multiple elements of complex instructional stimuli.

DESCRIPTORS: matching to complex samples, naming, individuals with mental retardation, children without disabilities

Special educators routinely use matching-to-sample procedures to teach components of language, academic, and other skills (e.g., Leaf & McEachin, 1999; Sundberg & Partington, 1998; B. A. Taylor & McDonough,

1996). Because of this, laboratory studies of matching to sample often provide information relevant to applied research and practice (e.g., Horne & Lowe, 1996; Stromer, Mackay, & Remington, 1996). For example, teachers may take advantage of laboratory findings that supplemental oral naming enhances acquisition of matching (e.g., Eikeseth & Smith, 1992; Saunders & Spradlin, 1990) and that naming facilitates remembering pictures on delayed matching tasks (Bonta & Watters, 1981; Constantine & Sidman, 1975; Geren, Stromer, & Mackay, 1997). Delayed matching procedures used in laboratory studies of observing and remembering complex stimuli (e.g., Stromer, McIlvane, Dube, & Mackay, 1993) also have been adapted for computer-assisted teaching

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of reading and spelling (e.g., Lane & Critchfield, 1998; Stromer & Mackay, 1992).

When instructional stimuli are complex, difficulties may arise because only some of the relevant component stimuli exercise control (Allen & Fuqua, 1985; Dube & McIlvane, 1999; Schreibman, Charlop, & Koenig, 1982; Schreibman, Kohlenberg, & Britten, 1986; Stromer et al., 1993). Again, supplemental naming may be beneficial, as in an application to overcome difficulties teaching a student to write lists of picture names (Stromer, Mackay, McVay, & Fowler, 1998). Other interventions, like activity schedules and textual scripts to improve social communication, rely on students being able to learn to name selected components of complex stimuli (e.g., Krantz & McClannahan, 1998). Analyses of the effects of naming on delayed matching may contribute to refinements in interventions that hinge on positive functional relations among verbal and non-verbal behaviors (e.g., Duarte & Baer, 1994; Guevremont, Osnes, & Stokes, 1988; Risley & Hart, 1968).

Standard matching tasks arrange a series of sample or instructional stimuli that cue which of two or more comparison or choice stimuli are discriminative for reinforcement. In a typical procedure, the presentation of a sample (e.g., a picture or dictated picture name) begins a trial and an observing response, like a touch to a computer screen, results in the display of a positive comparison and one or more negative comparisons (e.g., two or more pictures). In simultaneous matching, the samples are always present. In delayed matching, the samples are removed at the time the observing response occurs; the comparisons then appear immediately (a 0-s delay) or after a delay (e.g., 1 s, 5 s, or 10 s). Delayed matching tasks are useful in analyses of the effects of simply naming stimuli (e.g., pictures) to which one must later respond.

When touching is the observing response,

it is considered “nondifferential” because its topography is the same for each sample across trials. Constantine and Sidman (1975) demonstrated that “differential” observing—saying the name of the sample pictures—exercised control over delayed matching of identical pictures. The accuracy of delayed identity matching improved when the participants with mental retardation were instructed to name each picture sample aloud. Without the instructions, accuracy returned to baseline levels. So, the participants could produce the differential verbal responses that might have resulted in correct delayed picture–picture matching, but they did not do so unless instructed. These findings have been replicated using individuals with disabilities and names related to pictures that were spoken (Geren et al., 1997) and signed (Bonta & Watters, 1981).

To extend the preceding research, the present two experiments examined delayed matching and the effects of sample naming with individuals with mental retardation and preschoolers without disabilities. Unlike prior studies on naming (Bonta & Watters, 1981; Constantine & Sidman, 1975; Geren et al., 1997), the present protocols included matching tasks with complex, two-element samples similar to those used by Stromer et al. (1993). Stromer et al. included 0-s delay matching trials in which touching a two-element (abstract forms) sample removed it from the display at the same time that a pair of single-element comparisons appeared. The positive comparison was identical to one of the sample elements. Even though reinforcement was maximized only if both of the sample stimuli exerted discriminative control, delayed matching was more accurate with single-element samples than with two-element samples.

The procedures in Experiment 1 were similar to those in Stromer et al. (1993), but the stimuli were common pictures that the participants with mental retardation could

name rather than abstract forms (see below for an exception). Errors on trials with two-picture samples provided a baseline for assessing the effects of a sample-naming intervention. Experiment 2 expanded the analysis with preschoolers without disabilities and a new participant with mental retardation. We also included trials with pairs of dictated names as samples. Errors on trials with two-name samples provided a baseline for assessing any collateral effects of a naming intervention applied on trials with two-picture samples: Repeating dictated sample names may improve matching pictures to them (cf. Glat, Gould, Stoddard, & Sidman, 1994). We also recorded the occurrence of unprompted spontaneous naming in both experiments to evaluate its potential relation to matching performance when the naming intervention was not in effect.

EXPERIMENT 1

Phase 1 sought to replicate and extend the demonstration by Stromer et al. (1993) that participants with mental retardation may show decrements in delayed matching to two-element samples. Phase 2 examined the effects of naming each of the pictures of a two-picture sample before selecting a comparison picture during delayed matching. Phase 3 examined longer delays with new pictures and the effects of sample naming on performance.

METHOD

Participants

The participants were Cathy (age 53 years) and Bill (age 32 years), 2 individuals with moderate mental retardation. Mental age-equivalent scores from the Peabody Picture Vocabulary Test were 4 years 8 months for Cathy and 7 years 9 months for Bill. Both had previous experience with the computerized matching tasks using different stimuli.

Apparatus and Setting

A Macintosh® computer with a touch-sensitive screen presented stimuli and recorded data. The screen displayed five white keys (4.5 cm by 4.5 cm) on a gray background. Sample pictures appeared on the center key, and comparison pictures appeared on two of the four outer keys. One or two sessions occurred 2 or 3 days per week in a quiet area at a school or residence; each lasted 10 to 15 min. Names spoken by the participants and verbal instructions given by the experimenter were tape-recorded.

Procedure

Phase 1: Assessment of simultaneous and delayed matching. In Phase 1, simultaneous and 0-s delayed matching were examined with the three stimuli in Set 1 (Figure 1). Each session consisted of 24 trials with single-picture samples and 24 trials with two-picture samples. The type and location of the comparison stimuli changed unsystematically from trial to trial. The simultaneous and delayed matching conditions alternated in blocks of six sessions in a reversal design.

Trials began with the presentation of a single-picture (cat, dog, bee) or two-picture sample (top-bottom pictures: cat-dog, cat-bee, dog-bee, dog-cat, bee-cat, and bee-dog). The participant then had to touch the sample in order to display two comparisons, each a single picture. One of the comparisons (the correct comparison) was identical to one of the two pictures that served as the sample. A flashing screen, a pleasant auditory tone, and the delivery of a penny followed a touch to the correct comparison. After each session, the pennies were exchanged for coins to be used in nearby vending machines. Touching the nonidentical comparison was an error and resulted in a dark screen for 3.5 s. The keys were blank for 1.5 s between trials. Figure 1 (upper two panels) illustrates trials with two-picture samples. In

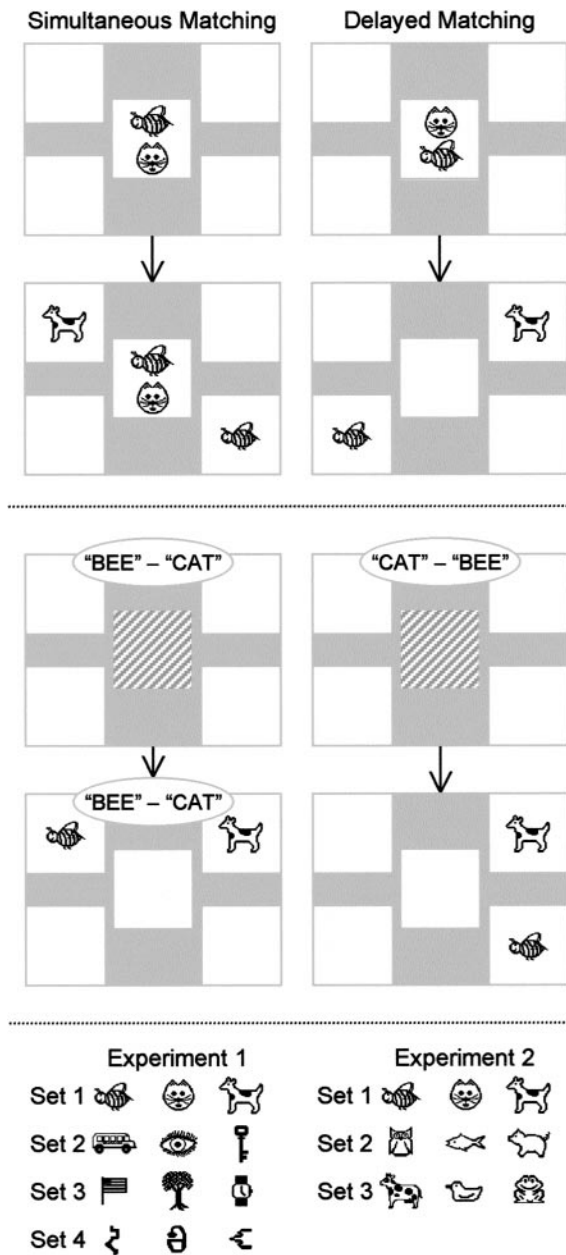


Figure 1. Top panels illustrate trials with two-picture samples: In simultaneous matching, the sample remained displayed after it was touched and a comparison picture was selected. In delayed matching, the sample disappeared after it was touched. Bottom panels illustrate trials with two-name samples: In simultaneous matching, after the dark key was touched, the comparisons appeared and pairs of dictated names were repeated until a comparison was touched. In delayed matching, a pair of names occurred once. Stimulus sets used are shown at the bottom.

simultaneous matching (left), the sample remained on the screen when the comparisons appeared. In delayed matching (right), the sample disappeared after it was touched and the comparisons appeared immediately (a 0-s delay).

Phase 2: Delayed matching and prompts to name. In Phase 2, matching performances were examined during conditions with and without naming prompts. The stimuli in Set 1 were used. Each session consisted of 48 trials of 0-s delayed matching with two-picture samples. Participants were exposed to (a) a no-prompt condition, in which the sessions were conducted as in Phase 1, and (b) a prompt condition, in which the experimenter verbally instructed the participant on each trial (by saying "name") to name the pictures of the sample before touching the sample area of the screen. If the pictures were named correctly, the participant was permitted to touch the sample and complete the trial. If an error occurred (no response within 3 s of the prompt, or one or both pictures named incorrectly), the experimenter modeled the correct response and prompted naming again. To counterbalance for order, Cathy was exposed to the no-prompt condition first and Bill was exposed to the prompt condition first.

Phase 3: Delayed matching with longer delays and new pictures. Phase 3 examined the effects of naming on delays of 0 s, 5 s, and 10 s. Each session consisted of 12 trials with 0-s delays, followed by 24 trials with 5-s or 10-s delays, followed by 12 trials with 0-s delays. An equal number of trials with single-picture and two-picture samples were used under each delay. Set 1 pictures were used first to examine matching in sessions with 0-s, 5-s, and 10-s delays.

Cathy (after Sessions 76 and 77) and Bill (after Sessions 71 and 72) then received a picture-naming test with Sets 2 and 3 to confirm that they could name the pictures. Sessions with these pictures under 0-s and

10-s delays then followed to examine the generality of the effects obtained with Set 1. Each of the six pictures was randomly presented three times in each of three test sessions. On each trial, a picture was displayed on the computer screen, and the participant was verbally instructed to name the picture. The experimenter recorded responses by pressing the K computer key when the name was correct and the J key when the name was incorrect. All responses were followed by a 1.5-s intertrial interval; no other consequences were scheduled.

Additional sessions involved slightly different conditions. For Cathy, the use of the stimuli in Set 3 continued in additional unprompted sessions (Sessions 54 to 101) but prompts to name the two-picture samples (as in Phase 2) were added at the end (Sessions 102 to 107). This condition evaluated whether prompted naming might improve performance on trials with both 0-s and 10-s delays. For Bill, naming two-picture samples was not prompted in Sessions 53 to 90 while matching performance was examined.

Bill also received sessions to examine delayed matching with abstract forms (Set 4, Figure 1). These stimuli had no standard names, so Bill had to supply any names actually used. Improvements in performance that followed the introduction of naming would extend the relevance of the intervention to conditions in which an individual must invent new names for stimuli to be remembered. Before Sessions 91 and 92, an assessment of form naming was conducted in which 10 forms were presented three times per session over three sessions. Each form was presented individually on the center key, and Bill was asked to name it. Based on these data, Set 4 was constructed of three forms that Bill never named consistently. Using Set 4, matching was examined under the no-prompt (Sessions 91 to 108) and prompt (Sessions 109 to 114) conditions. (During the prompt condition, Bill was merely told

to "name." A correction procedure was not used because there were no incorrect responses.) As described previously, each session consisted of 24 trials with single-picture samples and 24 trials with two-picture samples. Half of the trials with each type of sample contained 0-s delays, and the other half contained 10-s delays.

Tape recordings began in Phase 2, in Sessions 25 and 36 for Cathy and Bill, respectively, and continued through Phase 3. We analyzed naming responses that occurred, with or without prompts, and that corresponded to the picture or pictures that appeared on the sample for a particular trial. The unprompted spontaneous naming included all of those uttered from sample onset to comparison offset. When abstract forms were used with Bill (Sessions 91 to 114), naming responses were those uttered during the naming testing prior to Sessions 91 and 92.

Reliability. To assess reliability, two observers scored tape recordings made during the picture-naming testing and the matching sessions. The observers scored the tapes for (a) names among the experimental stimuli that were spoken by the participant during the direct tests of naming and during the sessions or blocks of trials of matching, (b) the recording performed by the experimenter, and (c) the instructions provided by the experimenter. Approximately 37% of these sessions for Cathy and Bill were scored for reliability. The observers usually agreed that (a) the names spoken by the participants on the naming tests and matching trials were the names of the pictures presented ($M = 94\%$ agreement), (b) the experimenter accurately recorded correct and incorrect trials (100%), and (c) the experimenter provided the instructions described above ($M = 94\%$) where appropriate.

RESULTS

Figure 2 shows Cathy's matching performances across the three phases and naming

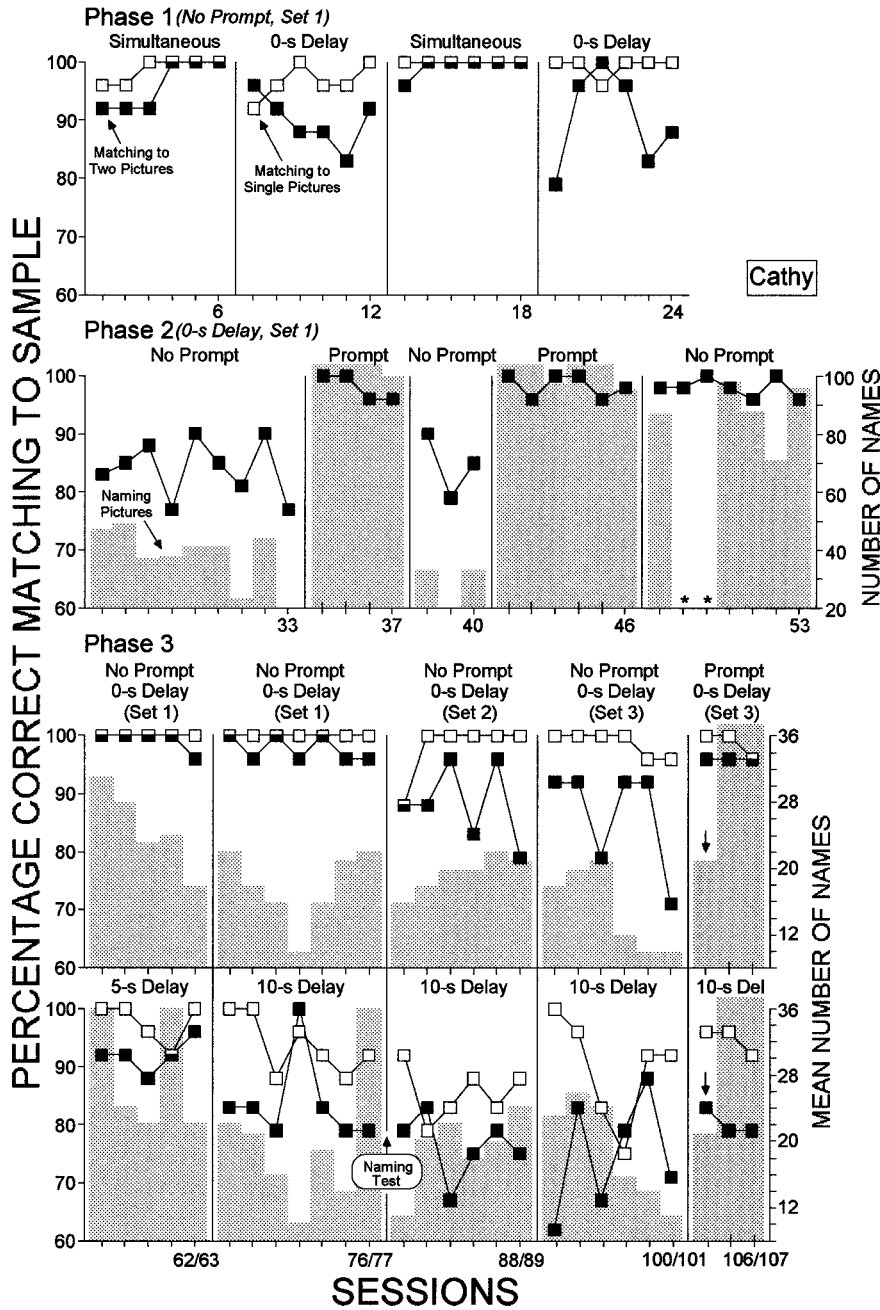


Figure 2. Results for Cathy across simultaneous, delay, prompt, and no-prompt conditions: Open and solid squares reflect percentages of correct matching. Shaded bars reflect the number of names spoken. Bars with extended tic marks on the abscissa indicate that the number of names exceeded 100 (Phase 2) or 36 (Phase 3). Asterisks at Sessions 48 and 49 indicate that names were not recorded. In Phase 3, sessions involved trials with both 0-s delays and either 5-s or 10-s delays. Phase 3 data are plotted in two-session blocks. The arrow at Sessions 102 and 103 indicates that prompts to name were only given on the first five trials.

(both prompted and spontaneous) that occurred in Phases 2 and 3. In Phase 1 (Sessions 1 to 24), accuracy was typically high in simultaneous matching with both single- and two-picture samples. Accuracy was also high in the 0-s delayed matching with single pictures. Delayed matching with two-picture samples was typically the least accurate.

In Phase 2 (Sessions 25 to 53), Cathy always named the sample pictures correctly when prompted (shaded bars in Figure 2). The minimum number of spoken names required during a session with prompts was 96, two on each of the 48 trials. Note that self-corrections, repeated names, or names spoken in the presence of the comparison stimuli increased the number of names spoken during some sessions. The accuracy of matching was lower during the first and second no-prompt conditions when correct naming was infrequent than during the two prompt conditions when correct naming always occurred. Accuracy remained high during the final no-prompt condition when correct naming remained fairly high.

In Phase 3 (Sessions 54 to 107), Cathy always named the pictures correctly during the naming tests with Sets 2 and 3. Each shaded bar in Figure 2 reflects the mean number of names spoken for a block of two sessions and for naming that occurred on trials with both single- and two-picture samples. During 0-s delayed matching with the single- and two-picture samples from Set 1, matching accuracy remained nearly perfect. Cathy's accuracy with Set 1 also remained above 90% on both trial types under the 5-s delay. Under the 10-s delay, accuracy remained high on single-picture trials ($M = 91\%$) but declined on trials with two-picture samples ($M = 85\%$). Unprompted naming declined and appeared to be unrelated to matching accuracy. With Sets 2 and 3 (no prompts) at the 0-s delay, accuracy remained almost perfect on trials with single-picture samples, but decreased to a mean of 88%

(Set 2) and 86% (Set 3) on trials with two-picture samples. The relation between accuracy and naming remained weak across sessions with Sets 2 and 3. With Set 2, accuracy on trials with two-picture samples decreased and became variable across sessions while naming increased. For Set 3, accuracy remained variable and declined slightly but unprompted naming decreased, particularly over the last three sessions. Under the 10-s delay, accuracy on trials with single-picture ($M = 86\%$) and two-picture ($M = 77\%$) samples was lower for Set 2 than for Set 1. However, naming increased across the sessions. With Set 3, accuracy on trials with single- and two-picture samples varied widely ($M = 90\%$ and 76% , respectively), and naming decreased over the last few sessions.

The last prompt condition of Phase 3 (Set 3) required a minimum of 24 spoken names (two for each of the 12 two-picture samples) on 0-s delayed trials and 24 names on 5-s or 10-s delayed trials. Cathy not only named correctly on all of the targeted two-picture trials but she also named accurately on the single-picture trials. On 0-s delayed matching trials, accuracy remained nearly perfect on trials with single-picture samples, and errors became less frequent on trials with two-picture samples. With 10-s delays, accuracy on trials with single-picture samples was typically higher (above 90%) than on trials with two-picture samples (near 80%). The effect of the naming on matching accuracy with 10-s delays was unclear.

Figure 3 shows Bill's matching and naming performances. In Phase 1 (Sessions 1 to 24), accuracy was typically high in simultaneous matching to both single- and two-picture samples. Accuracy was also high in the 0-s delayed matching to single pictures. Delayed matching to two-picture samples was typically the least accurate. In Phase 2 (Sessions 25 to 52), Bill always named the sample pictures (Set 1) correctly when prompted. Matching accuracy increased during the

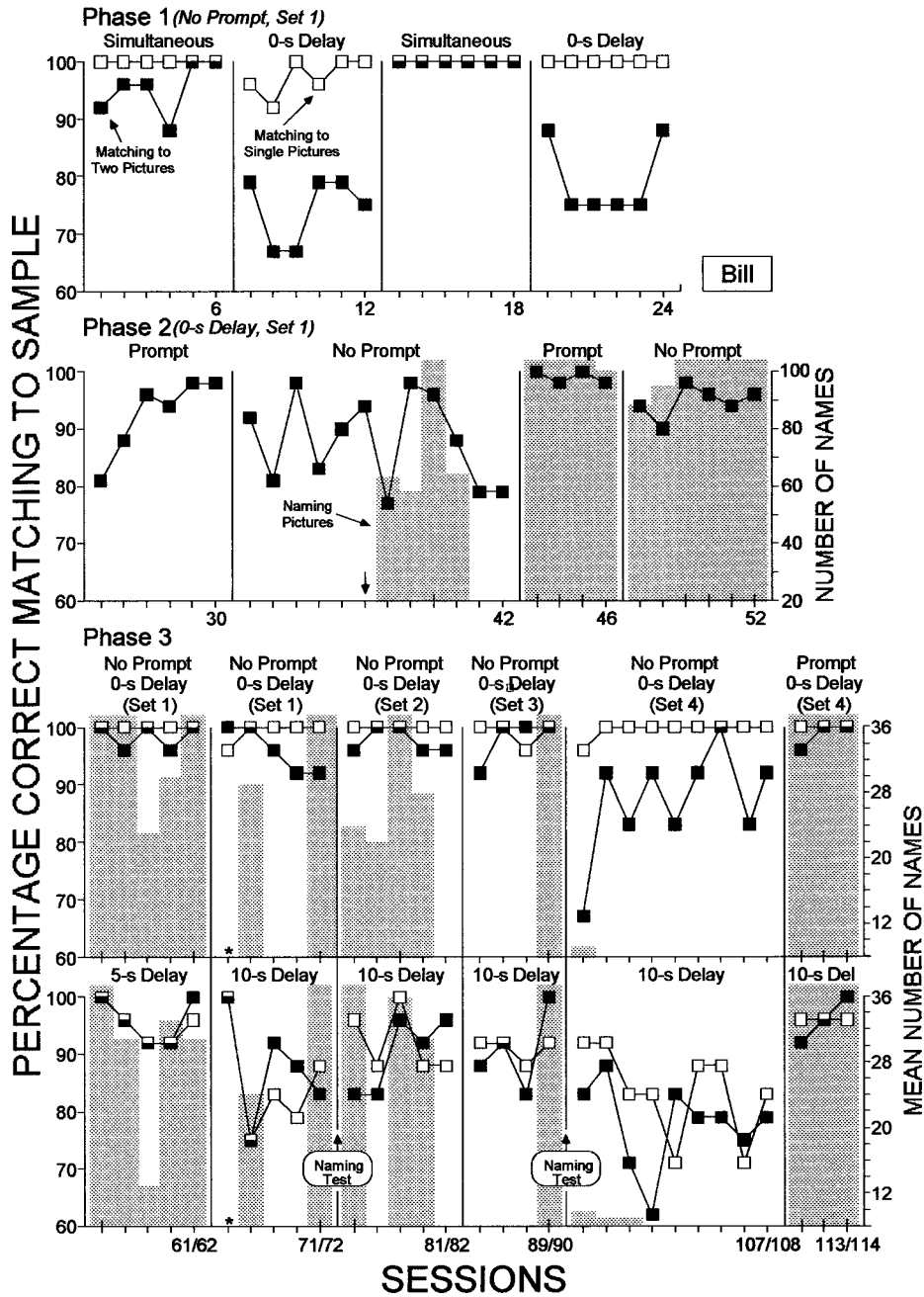


Figure 3. Results for Bill across simultaneous, delay, prompt, and no-prompt conditions: Open and solid squares reflect percentages of correct matching. Shaded bars reflect the number of names spoken. Bars with extended tic marks on the abscissa indicate that the number of names exceeded 100 (Phase 2) or 36 (Phase 3). The arrow at Session 36 indicates when recordings of names began. In Phase 3, sessions involved trials with both 0-s delays and either 5-s or 10-s delays. Phase 3 data are plotted in two-session blocks. An asterisk at Sessions 63 and 64 indicates that naming was not recorded.

first prompt condition. This was followed by variable performance during the subsequent no-prompt condition and the resumption of reliably accurate matching when the prompt condition was reinstated. As with Cathy, high accuracy persisted during the final no-prompt condition.

In Phase 3, Bill always named the pictures correctly during the naming tests with Sets 2 and 3. Matching accuracy on 0-s delayed trials with single- and two-picture samples generally stayed high across the sessions with Sets 1 to 3. Under a 5-s delay, accuracy remained above 90% for both trial types, and unprompted naming occurred frequently during these sessions. Under the 10-s delay with Set 1, matching accuracy and naming declined but, as with Cathy, the data showed little relation between matching accuracy and naming. Under the 10-s delay with Sets 2 and 3, Bill's accuracy was somewhat higher on both the single- and two-picture trials. Naming was variable and unrelated to matching.

With the abstract forms in Set 4, accuracy on single-form 0-s delayed matching was virtually perfect, even without prompts to name the samples. In contrast, errors occurred reliably on the trials with two-form samples ($M = 87\%$). Under the 10-s delay, accuracy on the trials with single- and two-form samples declined over the last five sessions. Naming was infrequent and eventually stopped. In response to naming prompts, Bill invented a different name for each of the forms in Set 4 ("shower," "sink," and "rocket," from left to right, respectively, in Figure 1) and used them consistently throughout the prompt condition. Matching accuracy on all trials became nearly perfect and remained so during the rest of this condition.

Because of the variability of both participants' spontaneous naming during the no-prompt conditions of Phase 3, we examined how naming was distributed across trials

with single- versus two-picture samples. The analysis suggested that the lack of an apparent relation between naming and matching accuracy was not attributable to differences in naming on the two trial types. When naming occurred, it happened on trials with single-picture samples as well as on trials with two-picture samples.

To summarize, participants with mental retardation matched pictures to single-picture or two-picture samples. Under both simultaneous and delayed matching conditions, accuracy was typically high on single-picture trials. Scores on two-picture trials were also high during simultaneous matching but lower during delayed matching. However, scores improved on delayed two-picture trials when each of the sample pictures was named aloud. With new participants, the aim of Experiment 2 was to examine further the effects of oral naming on matching with a protocol that (a) provided ongoing verification of participants' naming repertoires and (b) permitted assessment of collateral effects of oral naming applied on trials with two-picture samples on receptive matching trials presenting pairs of dictated picture names.

EXPERIMENT 2

Matching with two-picture samples was compared to matching with samples that were two dictated picture names. On the trials with two-name samples, the correct comparison picture (e.g., a bee) corresponded to one of two dictated names (e.g., in succession, "bee" and "cat"). In the context of an ongoing baseline of trials with two-name and two-picture samples, the intervention involved prompts to name the two pictures appearing as sample stimuli. Because errors sometimes occurred on both of these trial types, the effects of the prompts to name pictures were examined on the trials with two-name samples as well. Generalization

tests were also conducted using new sets of stimuli. To encourage unprompted spontaneous naming, blocks of imitation and picture-naming trials were conducted immediately before blocks of trials that assessed matching with two-name and two-picture sample stimuli.

METHOD

Participants

Olivia and Dan were 5-year-old preschoolers without disabilities, and Ken was a 13-year-old student with mental retardation (mental age of 6 years 1 month).

Apparatus and Setting

The apparatus was the same as described above. Dictated samples and an auditory instruction to name the samples ("name") were presented through a speaker attached to the computer. Observing responses were made to a dark center key on trials with dictated names, and comparison pictures appeared on two of the four outer keys. One or two 15-min sessions occurred two or three times per week in a school or residence.

Procedure

With a few exceptions, all procedures were the same as in Experiment 1. When matching to dictated samples (e.g., "cat" or "cat" and "dog"), a trial began with a dark sample key. Touching the sample key turned it white and produced the comparisons (see bottom panels in Figure 1). Olivia and Dan received tokens that were exchanged for toys after each session. The consequences for Ken were the same as those described in Experiment 1. For all participants, the computer produced a buzzing sound after an error. This was done so that an observer listening to an audio recording of spontaneous naming could readily detect the end of an incorrect trial.

Preteaching imitation, naming, and matching. These sessions familiarized the partici-

pants with the session format, the dictated and pictured stimuli presented individually, and the consequences for correct and incorrect trials. Each session began with a six-trial block of imitation and picture-naming trials with one of the three-item sets of stimuli (Sets 1, 2, or 3). Each block consisted of three imitation trials and three picture-naming trials (e.g., dog, cat, bee). On imitation trials, a dark box appeared in the center of a white computer screen, and the computer presented digitized spoken names. Participants were instructed to repeat the dictated name. On naming trials, the picture to be named appeared on the center key, and the computer presented the prompt "name." The experimenter entered correct and incorrect responses into the computer as described in Experiment 1. The stimulus set used was the one to be used during a subsequent block of matching trials.

These sessions were followed by 24 matching trials (12 with single-name samples and 12 with single-picture samples). For Olivia and Dan, performance was examined first during simultaneous matching with Set 1 and then in 0-s delayed matching with Sets 1, 2, and 3. With each set of three stimuli, each stimulus appeared as the sample four times per session. The comparisons were always a pair of single pictures. As in Experiment 1, the sample type and locations of the comparisons changed unsystematically from trial to trial. For Olivia and Dan, new stimulus sets were introduced following two consecutive sessions of at least 92% correct (11 of 12 trials) on trials with single-name samples and 92% correct on trials with single-picture samples. For Ken, only Set 1 was used during preteaching because of time constraints.

Delayed matching and prompts to name. Procedures resembled those in preteaching. Each session began with a 12-trial block of vocal imitation and picture-naming trials: Six of the trials required imitating pairs of

names dictated by the computer, and six trials required naming pairs of pictures (e.g., for Set 1, cat–dog, cat–bee, dog–bee, dog–cat, bee–cat, and bee–dog). This gave participants an immediate and ongoing history of saying the names of the stimuli to appear as samples during the matching trials. A 24-trial block of matching trials followed: 12 with two-name samples and 12 with two-picture samples. Each of the six sample types in a stimulus set (e.g., cat–dog in Set 1) appeared twice per session. Simultaneous matching was evaluated first. The plan called for at least two sessions of 92% accuracy or better on each trial type—those with two-name samples and two-picture samples—before delayed matching trials were introduced. The plan changed for Ken because he did not meet the criteria for simultaneous matching. During the delayed trials, the objective was to identify a delay value that engendered errors on both two-name and two-picture trials.

Initially, sessions were conducted under the no-prompt condition. Then, the no-prompt condition was alternated with a prompt condition under which the participants were required to name the pictures in the sample before completing a delayed matching trial. The prompt condition involved only the two-picture samples. Delay values of 1 s and 0 s were used with Olivia and Dan, respectively, because errors reliably occurred on both trial types (two-name and two-picture samples) with these values. Most of Olivia's sessions involved Set 1, except for the final no-prompt sessions using Sets 2 and 3. Most of Dan's sessions involved Set 3, except for the final no-prompt sessions with Sets 2 and 1. Because of time constraints, a 0-s delay and Set 1 were used with Ken throughout.

As described previously, we recorded names spoken by the participants during the prompt and no-prompt conditions; this included naming on trials with the dictated

two-name samples, which was always unprompted. Because there were 12 trials with two-picture samples, the minimum number of names required during each prompt session was 24.

Reliability. Tape recordings were made of all vocalizations that (a) occurred during the direct tests of vocal imitation and picture naming and (b) occurred under prompt and no-prompt conditions during the matching trials. Two observers conducted trial-by-trial analyses of about a third of all sessions for each participant. The two observers were always within 90% to 100% agreement that (a) the participant repeated the name presented by the computer on imitation trials, (b) the name spoken by the participant on picture-naming trials corresponded with the picture displayed on the screen, (c) the experimenter provided the appropriate instructions and consequences on each trial, and (d) an unprompted name of an experimental picture either did or did not occur on a particular trial.

RESULTS

Olivia, Dan, and Ken met the preteaching criteria in 18, 10, and 23 sessions, respectively (not shown graphically). Preteaching established that participants (a) reliably imitated the computerized dictated names and named the computer pictures presented individually, and (b) on 0-s delay trials, they reliably matched pictures to single pictures and to single dictated names. On the blocks of imitation and picture-naming trials conducted at the start of each delayed matching session, Olivia and Dan were always correct and Ken rarely made an error when imitating the pairs of dictated names and naming pairs of pictures (not shown graphically).

Figure 4 (top two panels) depicts Olivia's matching performance and spoken names that occurred either spontaneously without prompts or followed prompts to name the picture samples. Striped and solid bars in

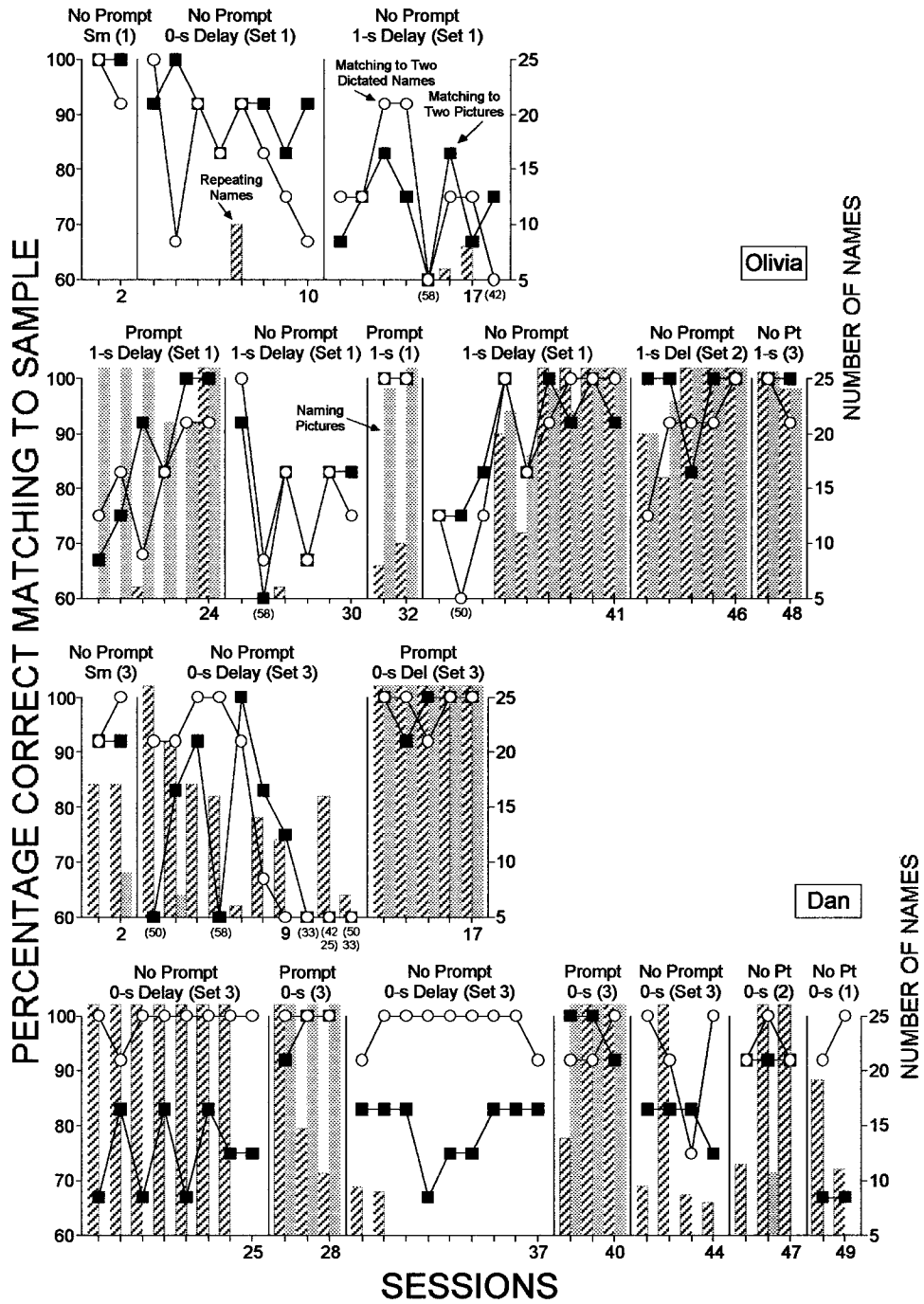


Figure 4. Results for Olivia and Dan across simultaneous, delay, prompt, and no-prompt conditions: Open circles and solid squares reflect percentages of correct matching. Striped bars and shaded bars reflect the number of names spoken on trials with two-name and two-picture samples, respectively. Bars with extended tic marks on the abscissa indicate that the number of names exceeded 25.

Figure 4 reflect names spoken on trials with two-name samples (repeating names) and on trials with two-picture samples (naming pictures), respectively. On trials with two-picture samples, accuracy was high under simultaneous and 0-s delayed matching. However, accuracy declined under 0-s delayed matching with two dictated name samples. Accuracy with both sample types declined under the 1-s delay. Spontaneous naming was infrequent, variable, and most likely to occur on trials with the dictated names as samples.

Next, matching with two-picture samples and two-name samples was assessed under a 1-s delay with and without the naming prompts. Matching accuracy on trials with both picture and name samples improved gradually across the first prompt condition. Little spontaneous naming occurred with dictated names as samples until Session 24. After the naming prompts were withdrawn, spontaneous naming rarely occurred. Matching accuracy was high for one session and then declined for both sample types. Accuracy again increased during the second prompt condition, although spontaneous naming rarely occurred when dictated names were the samples. Performance initially deteriorated when prompts were removed but then improved with both picture and dictated samples. This increase in accuracy was associated with an increase in spontaneous naming with both sample types. Matching performance and spontaneous naming also appeared to generalize to Sets 2 and 3, which were presented without prompts.

Results for Dan are shown in Figure 4 (lower panels). For both sample types (Set 3), accuracy was above 90% under simultaneous matching but deteriorated under 0-s delayed matching. Spontaneous naming also declined across these sessions. The introduction of prompts on trials with picture samples was immediately associated with near-perfect performance for both sample types.

Naming occurred on the trials with spoken name samples as well as on the prompted trials with picture samples. When the prompts were withdrawn, Dan's accuracy remained above 90% on trials with dictated samples but decreased on trials with picture samples. Spontaneous naming almost never occurred on the trials with two-picture samples during this condition, but naming was high on trials with spoken name samples.

Reexposure to prompts on trials with picture samples was again associated with high levels of accurate matching. Although naming occurred as expected on the trials with prompts, naming declined on the trials with dictated samples. When the naming prompts were again withdrawn (Sessions 29 to 37), mean accuracy on the picture trials decreased to 80%, and little naming occurred on those trials. Scores remained high on the trials with dictated name samples, even though naming was relatively infrequent. Matching accuracy and naming increased when prompts were provided for a third time. In the final no-prompt condition with Set 3, accuracy on the picture trials decreased to about 80%. On the trials with dictated samples, performance was more variable. Naming occurred on the trials with dictated samples but was variable across sessions ($M = 18$ per session). Matching accuracy on trials with both sample types was high with Set 2 stimuli, but naming primarily occurred on trials with dictated samples. With the stimuli in Set 1, however, matching was low for picture trials and remained high for dictated name trials.

Figure 5 shows that Ken's accuracy was variable under simultaneous matching on trials with two-name samples but averaged 90%. However, on trials with two-picture samples, accuracy was much lower ($M = 75\%$). Accuracy with both sample types declined even further under 0-s delayed matching. During the first exposure to prompts to name the picture samples (Sessions 24 to

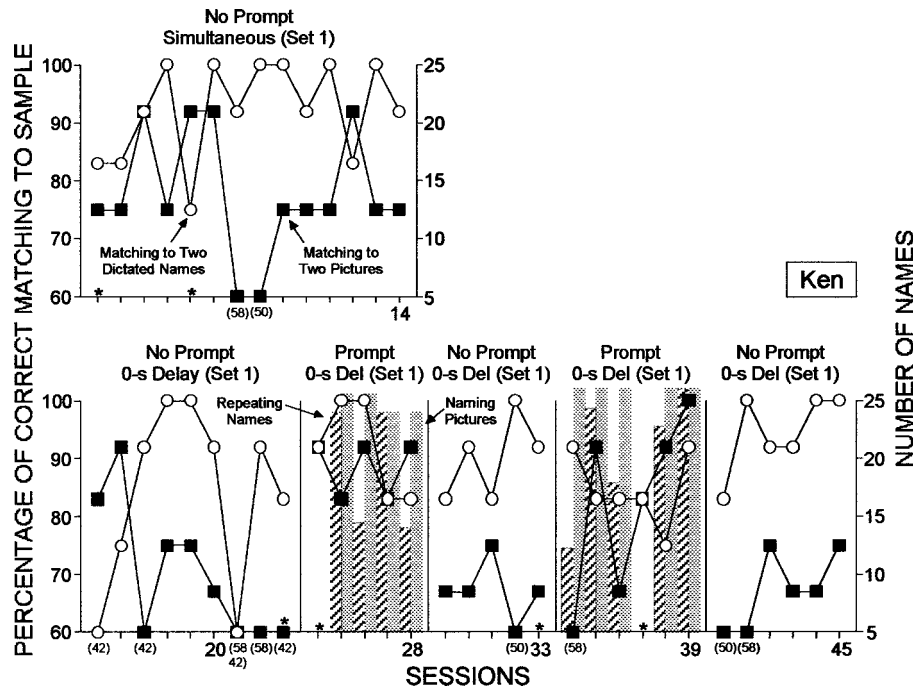


Figure 5. Results for Ken across simultaneous, delay, prompt, and no-prompt conditions: Open circles and solid squares reflect percentages of correct matching. Striped bars and shaded bars reflect the number of names spoken on trials with two-name and two-picture samples, respectively. Bars with extended tic marks on the abscissa indicate that the number of names exceeded 25. Asterisks at Sessions 1, 5, 23, 24, 33, and 37 indicate that naming was not recorded.

28), accuracy improved for both sample types. Without prompts (Sessions 29 to 33), accuracy remained high on trials with dictated samples ($M = 90\%$) but declined on trials with picture samples ($M = 65\%$). These findings were replicated under subsequent prompt and no-prompt conditions. Little spontaneous naming occurred during any of the no-prompt conditions. During the prompt conditions, increases in naming on trials with two-picture samples were accompanied by increases in unprompted naming on trials with two-name samples.

DISCUSSION

These results extended prior research on matching in several ways. First, delayed matching to two-picture samples resulted in errors (e.g., Stromer et al., 1993), even though (a) the contingencies of reinforce-

ment encouraged observing and remembering both of the sample stimuli, (b) participants matched single-picture samples, and (c) they named the individual pictures. Second, delayed matching improved when the participants were prompted to name the two-picture samples, an outcome consistent with past research with single-picture samples (Bonta & Watters, 1981; Constantine & Sidman, 1975; Geren et al., 1997). Thus, participants possessed expressive language skills that might have improved delayed matching but, at least initially, typically did not do so unless the procedure required it. However, some participants' improvements in delayed matching persisted when prompts to name the samples were withdrawn and when new stimuli were presented. The latter finding has not been reported previously.

In Experiment 1, participants with mental retardation (Cathy and Bill) matched picture

comparisons to identical single-picture samples or to two-picture samples in which one was identical to the correct comparison. In Phase 1, Cathy and Bill made more errors on 0-s delayed matching to two pictures than either simultaneous matching with such samples or 0-s delayed matching to single pictures. In Phase 2, prompts to name the pictures improved 0-s delayed matching to two pictures. Afterwards, accuracy initially declined when the prompts to name were withdrawn, but further exposure to naming prompts resulted in improved matching under the no-prompt condition; these outcomes were accompanied by spontaneous naming.

In Phase 3, performance was assessed using 0-s, 5-s, and 10-s delays and trials with single- and two-picture samples. Accuracy stayed high on 0-s delayed matching but declined at 5-s and 10-s delays. It is unclear whether the decrements in matching at longer delays would have occurred had spontaneous naming been more frequent. Accurate matching with 0-s delays did not seem to require high and sustained overt oral naming, but the possibility of covert naming cannot be ruled out (I. Taylor & O'Reilly, 1997). However, 0-s delayed matching began to differ when new pictures were presented: Cathy made errors on trials with new two-picture samples, but Bill's accuracy stayed high. Bill's high scores with the new pictures may reflect a generalized improvement with two-picture samples. In contrast, Cathy's decline in 0-s delayed matching suggested a lack of such generalization.

In the final prompt condition of Phase 3, Cathy's matching with 0-s delays improved, suggesting again that naming and matching were functionally related. However, her prompted naming did not appear to enhance matching with 10-s delays. In contrast, Bill's delayed matching with the abstract forms improved under both 0-s and 10-s delays when he was prompted to name the forms.

It is noteworthy that Bill's names were the ones he supplied during the naming test with abstract forms. Such differential naming of these forms was absent during the initial screening. Research is needed to clarify the learning history that enabled Bill to derive (invent) names for the pictures of abstract forms, and whether continued analysis would have resulted in his use of the names without prompting.

Experiment 2 extended the subject and procedural generality of Experiment 1. Preschoolers without disabilities (Olivia and Dan) and a student with mental retardation (Ken) matched pictures to two-picture samples and to two-name samples, the latter a receptive matching task. Accuracy was relatively high under simultaneous matching but declined under delayed conditions. The decline usually was greater for two-picture than for two-name tasks. The higher accuracy for delayed matching to two-name samples extends prior research using single-name samples (Bonta & Watters, 1981; Constantine & Sidman, 1975; Geren et al., 1997).

Olivia and Dan showed the same positive effects of the naming intervention even after the prompts to name were withdrawn and the sessions involved new stimuli. Their data are also interesting because the intervention that required naming the two-picture samples improved performance on those trials as well as on the trials with the dictated two-name samples. However, Olivia and Dan differed in their (a) rates of improvement after the prompts to name were implemented, (b) rates of unprompted repetitions of the dictated name samples, and (c) generalization of naming to the no-prompt condition.

Before the naming prompts, Olivia and Ken showed little spontaneous naming. Dan's naming was typically on trials with two-name samples and was variable and seemingly unrelated to his matching performances. After exposure to the naming prompts, the patterns of spontaneous nam-

ing produced by Olivia and Ken appeared to be functionally related to accuracy on matching tasks. In general, if accuracy was high on a delayed matching task without the naming prompts, the frequency of spontaneous naming on that trial type was also high. In contrast, if accuracy was low on a delayed matching task, spontaneous naming was less frequent.

To explain how differential naming of sample stimuli may improve delayed matching requires further research. First, naming may have enhanced discriminative control by the picture samples. Naming ensured observation of the pictures before they disappeared and comparison responding occurred. Merely touching the samples did not guarantee such discriminative control. Second, naming may have established oral names as a basis of comparison selections, rather than or in addition to the sample pictures. In other words, names spoken by the participants may transform nonverbal picture–picture matching into receptive tasks. Performance could improve because receptive matching is sometimes easier than picture–picture matching (e.g., Constantine & Sidman, 1975; Geren et al., 1997; Kelly, Green, & Sidman, 1998). Picture–picture matching may be more difficult because each trial requires looking at least twice, once at the sample and once at the comparisons; matching to dictation requires looking at only comparisons (Michael, 1985). The present data are consistent with either of these explanations.

Third, naming may have mediated the delay between sample offset and comparison onset. To serve as a mediator, a sample name may have to be followed within the trial by the production of the same name, and, in turn, provide a supplemental stimulus that links the sample and correct comparison. Difficulties in matching with 5-s and 10-s delays suggest that neither Cathy nor Bill used naming as a mediator. Developing

methods that establish naming as a mediator might enhance performance with long delays between instructional and discriminative stimuli.

The present and past studies (Constantine & Sidman, 1975; Eikeseth & Smith, 1992; Geren et al., 1997; Glat et al., 1994; Saunders & Spradlin, 1990) recommend teaching methods that integrate naming with the relevant visual and auditory instructional stimuli, simple or complex. The benefits of naming—improved accuracy—may be realized whenever matching and related procedures (e.g., sorting) are used in teaching (e.g., Leaf & McEachin, 1999; Sundberg & Partington, 1998; B. A. Taylor & McDonough, 1996). If the stimuli are complex, as in the present study, differential sample naming might succeed in overcoming error patterns indicative of problems of stimulus overselectivity (Allen & Fuqua, 1985; Dube & McIlvane, 1999; Schreibman et al., 1982, 1986; Stromer et al., 1993).

Interventions that encourage naming across a number of exemplars of each trial type might establish a generalized use of naming to solve nonverbal tasks, the prospects of which were demonstrated in the present study: Naming and accurate matching may have continued because the repeated reversal design resulted in alternating periods of high and low accuracy and, consequently, periods in which reinforcement occurred more and less frequently. Thus, participants were exposed to conditions favoring the development and maintenance of the sample naming related to the higher reinforcement frequency (cf. Stromer et al., 1998). The findings have implications for solving practical problems in which one's generalized verbal skills may be involved (e.g., self-instruction).

Naming may also enhance learning outside traditional discrete-trial formats. Activity schedules, for instance, resemble a series of matching trials (e.g., Kinney, Vedora, &

Stromer, 2003; Krantz & McClannahan, 1998; McClannahan & Krantz, 1999) during which naming may sharpen stimulus control and also function communicatively. Krantz and McClannahan taught children with autism to solicit attention by responding differentially to complex notebook stimuli. A page in the child's notebook combined a photo of the activity to be performed and a written script, *watch me* or *look*. The script was to be said aloud, and then said again to an adult either during the activity ("watch me") or after performing it ("look"). Such differential responding—doing something appropriate with the pictured activities and saying the scripts—resembles the present approach to improve delayed matching to two-picture samples.

Further bridge studies of naming and its relation to nonverbal behaviors could inform efforts to improve methods of teaching functional communication skills (Kimball, Kinney, Taylor, & Stromer, 2003; Stromer, Kinney, Taylor, & Kimball, in press). Such research will help to identify further advantages of using differential observing that involves topographically unique forms of responding rather than topographically similar behaviors like touching the stimuli presented in matching tasks (e.g., Shafer, 1993). Differential behavior like naming (e.g., oral, signed, and written) may enhance learning and remembering, in part, because the stimulus control properties of names may be "transported" from one situation to another (Stokes & Baer, 1977). Understanding the nature of the transportability of names in delayed matching may help to clarify relations among verbal and nonverbal behaviors that are central to applied interventions like self-instruction (e.g., Duarte & Baer, 1994; Guevremont et al., 1988) and correspondence training (Risley & Hart, 1968).

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STUDY QUESTIONS

1. Describe (a) single-picture and two-picture matching and (b) simultaneous and delayed presentation.
2. Briefly summarize the results obtained under (a) single-picture and two-picture matching and (b) simultaneous and delayed presentation conditions.

3. What were the effects of (a) prompting and (b) additional delays on Cathy's and Bill's responding?
4. What did Bill do when prompted to name abstract forms in Phase 3?
5. Briefly summarize the results of each subject's performance (naming and accuracy) in Study 2.
6. Provide a potential explanation for why, in some cases, naming was maintained after prompts were removed.
7. What is the apparent value of acquiring a differential observing response during match-to-sample instruction?
8. What did the authors suggest were the three functions of naming in improving delayed matching?

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