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Assessment of delayed matching in preschoolers with autism

Hannorah O. Thurman
Northeastern University

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Assessment of Delayed Matching in Preschoolers with Autism

A Thesis Presented

by

Hannorah O. Thurman

The Department of Counseling and Applied Educational Psychology

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Author: Hannorah O. Thurman

Department: Counseling and Applied Educational Psychology

Approved for Thesis Requirements of Master of Science Degree

Cammarie Johnson, MA, LMHC, BCBA

Date

D. Daniel Gould, Ph.D., BCBA

Date

Pamela M. Olsen, MEd, BCBA

Date

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by

Hannorah O. Thurman

B.A., University of California, Davis

Submitted in partial fulfillment of the requirements for the degree of
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Table of Contents

ABSTRACT	1
INTRODUCTION	2
METHOD	19
Participants.....	19
Setting and Materials	20
Measurement.....	20
Reliability.....	21
Procedure	21
RESULTS	23
DISCUSSION.....	25
REFERENCES	29
TABLE.....	31
FIGURE CAPTIONS.....	32
FIGURES	33

Abstract

In delayed match-to-sample (DMTS), there is a delay between the removal of the sample stimulus and the onset of the comparison array. Correct responding in this condition requires control by a conditional discriminative stimulus that is absent at the time of responding. An assessment of delayed matching was conducted to determine the delay thresholds, that is, the maximum delay at which accurate responding occurs, for 6 preschoolers with autism. Using empirical data to determine delay thresholds can help develop and establish appropriate curricula for improving delayed matching in children with autism.

Assessment of Delayed Matching in Preschoolers with Autism

The match-to-sample arrangement has been a critical paradigm in discrimination training and research. The incorporation of a delay between the removal of a presented sample and the subsequent presentation of an array of comparison stimuli creates a temporal separation between the conditional stimulus and the discriminative stimulus associated with the correct response. Correct responding after a delay and in the absence of the conditional stimulus requires remembering, otherwise described as control by a stimulus that is absent during responding. Research in delayed match-to-sample explores this type of responding and the factors that control it.

One factor that influences delayed-matching accuracy is precurrent behavior. Precurrent behavior is the emission of a response which increases the likelihood of a subsequent response being reinforced (Skinner, 1968). In an analysis of precurrent behavior, Torgrud and Holborn (1989) trained typical 5-year-olds to emit responses between presentation of the sample and comparisons in a match-to-sample task with color stimuli. In this study, participants were exposed to a baseline condition, two training conditions, and a test condition of oddity matching performance. During all conditions, the delay between presentation of the sample and presentation of the comparisons varied randomly at 1, 3, 5, 10, and 15 seconds. Baseline sessions consisted of delayed matching-to-sample tasks with no mediating response trained. In the differential mediating response condition, experimenters trained participants to emit a mediating response specific to the sample that was presented. The differential mediating responses were key presses to one of two keys, depending on the sample. Participants were to emit the responses until the comparison stimuli appeared. In the common mediating response condition, experimenters trained a mediating response that was the same regardless of the sample

presented: key presses to one particular key. In addition to key-pressing during the interval between sample and comparison presentation in both conditions, the participants were trained to recite a list of numbers presented on the screen. This was to prevent rehearsal of the sample color name. In the oddity match-to-sample test condition, experimenters told participants to engage in any response or no response during the interval between presentation of the sample and the comparisons. This test condition determined which mediating response persisted in the absence of instruction; experimenters anticipated the mediating response that functioned as precurrent behavior (was maintained by reinforcement) would persist.

Baseline results for all participants indicated that as the delay between sample and comparison presentation increased, performance accuracy decreased. Data from the common mediating response condition were similar to baseline, while results of the differential mediating response condition were highly accurate. During test conditions, when participants could emit any or no response during the interval between presentation of sample and comparisons, participants tended to emit the mediating response of whichever condition was run just before the test condition. Performance on oddity match-to-sample tests was highly accurate when the participant emitted differential mediating responses. Low accuracy was demonstrated when the participant emitted common mediating responses in oddity matching tests. Criterion accuracy scores were achieved only when differential mediating responses were emitted; this responding maintained stimulus control during the delay.

Constantine and Sidman (1975) evaluated another form of precurrent behavior – differential naming during the delay interval between sample offset and comparison onset – as a facilitator for correct responding in four participants with severe mental retardation. They found that three of the participants who could name pictures could also match pictures to their auditory

sample in a delayed match-to-sample arrangement, but were unable to match pictures in a visual-visual delayed match-to-sample arrangement. Incorporating an instruction to name the sample stimulus into the visual-visual delayed match-to-sample task improved accuracy to mastery criterion.

Stromer, McIlvane, Dube, and Mackay (1993) conducted an analysis of delayed matching with complex and simple stimuli in simultaneous and delayed match-to-sample arrangements, particularly exploring restricted stimulus control by complex stimuli. There were seven participants, ages 17 through 76 years, all diagnosed with mental retardation. Trials consisted of simple (one picture element) or complex (two picture element) stimuli as the sample, the comparisons, or both. Trial types were denoted by letters indicating the stimulus roles. In a 3-letter arrangement, the first letter indicated the sample type, the second letter indicated the S+ type, and the third letter indicated the S- type. CSS trial types had a complex sample, a simple correct comparison stimulus (S+), and a simple incorrect comparison stimulus (S-). Trial types SCC had a simple sample, complex S+, and complex S-. In SSS trials, the sample and both comparisons were simple stimuli. For CCC trials, the sample and both comparisons were complex: the S+ contained both elements matching the sample, and the S- contained one of the same elements and one different element.

For 3 of 4 participants, simultaneous matching performance on SSS, SCC, CSS, and CCC trials was above 90% mean accuracy. The authors suggest that the participant for whom accuracy on simultaneous matching in CSS trials was lower may not have engaged in effective observation behavior. Of all participants, he had the shortest response latency on simultaneous matching trials, and did not look a second time at the sample stimulus after looking at the

comparison array upon presentation. These data are similar to data from delay trials for other participants, in which extended observation of the sample is not possible.

When 0- and 1-s delays were in place, a decrease in correct responding occurred only for those trial types in which sample stimuli were complex. Results for other arrangements of simple and complex stimuli (SCC, for example) did not result in fewer correct responses, indicating that the difficulty in CSS trials was not due to difficulty matching complex and simple stimuli in general; stimulus control was compromised only when a complex stimulus served as the sample. In a second experiment, the authors implemented further manipulations to trial types. Two new complex sample trial types were added: CSC and CCS. Performance during these trials would provide information regarding the control of the two elements in the complex sample.

When the arrangement required the discrimination of two elements in the sample stimulus, accurate performance decreased. Of the two new trial types, the lowest accuracy was shown when the same number of elements appeared in the sample and S-, but only one (identical to sample) element was present in the S+ (CSC); higher accuracy levels were evident when the sample and S+ contained the same number of elements and the S- had fewer (CCS). The authors discuss the possible control exerted by the number of elements in such trials, as opposed to the content of the elements. They explored this issue in a later experiment.

Performance accuracy on CSC and CSS trials in the previous experiment was further evidence of restricted stimulus control; only one of the two elements in the complex sample was necessary for discriminative control over responding to the positive comparison. To manipulate these relations, the next experiment involved another trial type: CCC*, in which a complex

sample was presented, followed by a complex S+ (same two elements) and a complex S- with one of the same elements as the sample and one different element. These trials required discriminative control by both elements of the complex sample. Control by only one sample element would occasion incorrect responses to the complex comparison containing only one element related to the sample.

All participants demonstrated lower accuracy on CCC* delayed matching trials in comparison to trials in which discriminative control by two elements was not necessary for correct matching. Additionally, all participants initially demonstrated low accuracy during simultaneous matching; dual control in simultaneous arrangements was weak at first. Performance improved over trials, and a return to simultaneous matching resulted in higher accuracy for 4 of 5 participants. The following experiment further examined performance on CCC and CCC* trials by increasing exposure to the arrangement as compared to those trials for which control by only one element was necessary for correct responding. CCC and CCC* trial numbers were doubled (32 as compared to 16), and a subsequent phase consisted of 32 each of SCC and CSS trials.

Data for all participants supported the assumption that restricted stimulus control was relevant in trials for which discriminative control by both elements of the sample was necessary for correct responding. In Phase 1 trials, CCC results were consistently more accurate than CCC* results. On CCC* trials, one of the two elements of the S- comparison matched one of the two elements of the sample, thus controlling responses to the S-. Rather than the two elements of the complex sample acting as one discriminative stimulus, restricted stimulus control occurred: responding was controlled by the one element of the complex sample which matched one of the elements of the complex S-. Delayed matching performance was especially affected

by this phenomenon. Results for CSS as compared with SCC demonstrated similarly restricted stimulus control. CSS performance was consistently lower, especially in delay trials, than SCC. This suggested that both elements of the complex sample were not exerting control; participant responses to the S- demonstrated a lack of control by the matching element from the sample, which indicated both elements were not controlling responding. Extended exposure to these trial types relative to trials with simple samples did not positively affect accuracy.

In the next experiment, Stromer et al. (1993) manipulated experimental stimuli to determine if the number of elements in the sample exerted control over comparison selections. The new sample types were CSC and SCS; the sample and correct comparison never contained the same number of elements. For CSC, the sample stimulus contained two elements and the positive comparison contained one element identical to one of the elements in the sample. For SCS, the S+ contained two elements, one identical and the other nonidentical to the single sample element. Participant responding would help determine whether the number or form of elements in the sample was controlling behavior. Results indicated that in simultaneous matching conditions, 3 of 4 participants performed with above 90% accuracy in all trial types. In delayed matching conditions, all participants' performance decreased to near or below 80% for CSC while all other trial types remained at high performance accuracy. These data do not support uniform stimulus control by the number of elements in the sample stimulus, as performance was highly accurate on trials for which the sample contained one element and the comparison contained two elements.

The authors conducted the next experiment to determine whether the mixed presentation of trials with simple and complex sample stimuli in the same sessions had affected performance on trials with complex sample stimuli. In this experiment, only one trial type was presented.

Conducting only trials for which the sample was complex and the comparisons were both simple (CSS) allowed the authors to analyze data based on extended exposure to complex stimuli with no competing sample types. For all participants, responding was consistently lower in delay conditions. A microanalysis considering the specific stimuli used in each position for each trial suggested within-session changes in stimulus control: control was sometimes observed by one or both of the sample elements and other times by the comparison displays themselves. Important conclusions are drawn from the Stromer et al. (1993) research. Some participants' performances were affected when the S+ contained only one of the complex sample's elements in a simultaneous match-to-sample arrangement; all participants' performances were affected when these same samples and comparisons were presented in a delayed match-to-sample procedure. This finding is consistent with previous research in which restricted stimulus control has been demonstrated largely in delayed matching with complex stimuli. While some previous research (Allen & Fuqua, 1985; Koegel & Schreibman, 1977; Schreibman, Charlop, & Koegel, 1982; cf. Huguenin, 1985; Huguenin & Touchette, 1980) suggested that discriminative control by complex sample stimuli can be achieved by creating contingencies that require it, performance on extended, isolated CSS trials and extended CCC* trials did not improve accuracy in the current study. The removal of the sample stimulus before presentation of the comparisons in delayed matching may prevent the individual from observing both elements of the sample by not allowing for a second reference to the sample after seeing comparison options. Stromer et al. supported this interpretation rather than attributing lower scores to participants' inability to remember the sample elements.

The format of this research (Stromer et al., 1993) addresses important aspects of complex stimuli used in delayed matching paradigms. Discrete elements were used as single stimuli and

as components of two-element, complex stimuli. Analysis is facilitated by the use of simple forms as discrete elements of complex stimuli; identity matching can be conducted with the elements to determine that participants can discriminate them, which is necessary before drawing conclusions regarding discriminative control of complex stimuli over responding. Using this type of complex stimulus, rather than a compound stimulus without discrete elements, facilitates analysis of the discrimination of elements.

Delayed matching performance can be affected by the number of different stimuli used throughout a session. Williams, Dube, Johnston, and Saunders (1998) analyzed performance on conditional identity matching with two samples, conditional identity matching with six samples, and trial-unique identity matching in a match-to-sample paradigm; all conditions used a comparison array containing two stimuli. For conditions using only two samples, each stimulus served as the positive or negative comparison repeatedly in a given session, varying with nearly every trial because both stimuli were always present as comparisons. For conditions using six samples, the function of each stimulus as the positive or negative comparison changed less frequently; each stimulus did not appear on every trial. For trial-unique conditions, no stimulus ever served a different function across trials; each stimulus was only presented one time, as either an S+ or S-. Delays were 0, 4, 8, and 16 seconds. Delays were held constant in some sessions and varied in other sessions.

Conditional identity matching with two stimuli never yielded more accurate responding than matching with 6 samples or in trial-unique matching, at any delay. Six of nine participants demonstrated lower levels of accurate responding during 2-sample conditions as compared with 6-sample conditions or trial-unique conditions; the remaining three demonstrated similar responding for all three procedure types. Rather than interpret their results in terms of

hypothesized memory deficits, the authors interpreted the diminished accuracy on delayed matching trials as indicative of intertrial interference in the relation between samples and positive comparison stimuli. Data from trial-unique matching supported this by demonstrating greater than chance levels of performance on matching tasks across all subjects. Data from two-sample matching tasks indicated performance levels below chance. Sessions containing six samples yielded mid-range accuracy. In sessions with only two samples and the same two comparison stimuli on each trial, the changing S+ and S- functions of these stimuli across trials may result in inaccurate responding due to stimulus control from a previous sample overshadowing that of the current sample stimulus. The participant may respond to a comparison stimulus erroneously in the presence of a current sample stimulus, acting under the discriminative control of a previously reinforced response in the presence of a prior sample stimulus. In trial-unique matching sessions, no stimuli ever change functions; a positive comparison in one trial will never be a negative comparison in another, and vice versa. These results indicate that intertrial interference should be considered when conducting matching sessions with stimuli that change function.

Dube and McIlvane (1999) evaluated the use of a differential observing response (DOR) as a behavioral requirement during the delay to facilitate performance in delayed match-to-sample. Participants were three adolescents diagnosed with mental retardation. Matching performance was evaluated in pretests to determine that participants were able to accurately complete simultaneous matching tasks with one-sample and two-sample arrangements. In one-sample matching, the sample and S+ both contained one stimulus. In two-sample matching, the sample contained two stimuli and the S+ was only one stimulus, matching one of the two stimuli

in the sample. In compound matching, both the sample and the S+ contained two stimuli. Pretests also determined intermediate accuracy (66- 71%) on delayed matching to sample.

In the compound DOR condition, an additional response was required between the presentation of the sample and the presentation of the comparison stimuli. A simultaneous identity matching trial was inserted between sample and comparison presentations. Correct responding on the simultaneous identity matching required observation of both elements of the compound sample and comparisons. Upon completion of the simultaneous compound matching, the sample was re-presented, removed, and was followed by a 0-s delay and presentation of single-stimulus comparisons. The same stimuli were presented as comparisons for both the compound DOR and the corresponding delayed matching, and responses during the DOR were not reinforced. Results indicated that incorporating the compound DOR facilitated responding on delayed matching tasks; accuracy increased with compound DOR and decreased with a return to baseline. This study demonstrates that incorporating a differential observing response in delayed matching-to-sample can improve performance.

Gutowski and Stromer (2003) explored the facilitation of accurate match-to-sample performance through naming. In Phase 1, using single-picture and two-picture sample stimuli and without instructions to name the samples, the authors assessed simultaneous and delayed matching-to-sample in two adult participants with mental retardation. Simultaneous matching performance was highly accurate (above 90% in all but one session) for both types of samples. Delayed (0-s) matching performance was affected based on the number of pictures in the sample stimuli: accuracy remained high with single-picture sample stimuli but deteriorated with two-picture sample stimuli.

There were two conditions in the next experimental phase. The first condition was a no-prompt condition; sessions were conducted just as in Phase 1. In the second condition, participants were prompted to name the picture or pictures in the sample when presented in a delayed match-to-sample paradigm. Results showed that naming the sample facilitated accurate responding. Further, participants increasingly named samples without prompts and a concomitant increase in matching accuracy was observed after repeated reversals of prompt and no-prompt conditions.

The final phase of this experiment consisted of extended delays and new stimuli (Sets 2 and 3), still with intermixed single- and two-picture samples. Data were recorded on spontaneous naming responses even though the contingencies did not require naming until the last sessions of this phase. Both participants' results remained highly accurate (above 90%) for stimulus Set 1 single- and two-sample stimuli with both the 0-s and 5-s delays. Naming occurred in some, but not all trials and there was no clear relation between naming and accuracy. For the new sets, both participants demonstrated accuracy above 90% at 0-s (Sets 2 and 3 for one participant and Sets 2, 3, and 4 for the other participant) and 5-s delays (Set 3 for one participant and Set 4 for the other participant) for single-picture sample stimuli. One participant's performance on 0-s delay trials with two-picture samples (Sets 2 and 3) deteriorated. The other participant's accuracy decreased only slightly on 0-s delay trials with two-picture samples (Sets 2 and 3), but a marked decrease in accuracy was noted when samples contained two nonrepresentational forms (Set 4). For both participants, accuracy on these trial types increased to criterion when a naming prompt was provided. For both participants and for all stimuli, accuracy decreased during 10-s delay trials. Spontaneous naming and accuracy scores did not appear to co-vary at the 10-s delay for

either participant. Instructions to name the samples increased naming responses and accuracy above 90% at the 10-s delay for one but not the other participant.

In the second experiment, participants were two typically-developing preschoolers and a 13-year-old boy with mental retardation. All participants were able to vocally imitate (echoic response), name pictures, and respond correctly on 0-s delayed identity match-to-sample trials. Match-to-sample procedures were similar to the first experiment, except each sample consisted of either two simultaneously presented pictures (visual sample) or two successively spoken words (auditory sample). The independent variable was a prompt to name samples (experimenter command: “name”) only during trials with picture sample stimuli. Spontaneous naming was recorded during trials with both types of sample stimuli. This allowed for analyses of matching performances with both auditory and visual sample stimuli as it related to overt naming. Simultaneous match-to-sample trials with no prompting occurred first, then prompt and no-prompt conditions were alternated with a delay.

The first three conditions for the first participant consisted of no-prompt procedures, providing a baseline for simultaneous, 0-s delay, and 1-s delayed matching to sample. This preschooler responded in simultaneous matching sessions at above 90% accuracy for both two-spoken word and two-picture samples. In both delay conditions responding was highly variable. Spontaneous naming occurred infrequently with auditory samples and never with visual ones. The second participant also performed with high accuracy (above 90%) for simultaneous matching with both kinds of sample stimuli, and accuracy was highly variable with a 0-s delay (1-s delay was not conducted) for both kinds of stimuli. This preschooler engaged in frequent echoic responses when the samples were auditory and infrequent naming of visual samples; however, both types of naming responses decreased over time. The third participant (adolescent

with mental retardation) performed above 80% accuracy for two-spoken word samples during simultaneous matching, while performance during trials with two-picture samples was highly variable with a mean of 75% accuracy. He never spontaneously echoed or named the sample stimuli.

After implementing the first prompt condition for 1-s delayed matching, the first participant reliably named the picture samples and showed an increasing trend in correct matching. She rarely (except in the last session) repeated the auditory sample stimuli. Upon removal of the prompt, naming and echoing virtually disappeared and performance dropped to baseline levels for both sample types. Upon reinstatement of the prompt, accuracy increased to 100% for both sample types; naming responses were reliably produced during picture sample trials, and the auditory samples were repeated on some trials. After removal of the prompt, accuracy was similar to baseline for the first four sessions. The participant did not name samples during any of these sessions. In the fifth session, the participant began to name both sample types. Also during this session matching accuracy increased and stayed at high levels for both auditory and visual samples. This participant generalized these skills to two new sets of stimuli in the next two no-prompt, 1-s delayed matching conditions.

The second participant demonstrated an immediate change of great magnitude in correct responding during trials with both sample types in the first prompt condition. Although prompts were only given to name the visual samples, he reliably repeated the auditory samples, too. After implementation of the first no-prompt condition following a prompt condition, the participant spontaneously repeated the sample words in 100% of auditory sample trials. Matching performance was near 100% for these trials. During trials with picture sample stimuli, however, the participant never named the samples and accuracy decreased. A return to prompting (in all

trials with picture sample stimuli) yielded consistent naming responses and an immediate increase in correct matching for picture sample trials and continued perfect responding in trials with auditory samples despite a decreasing trend in repeating the spoken word samples. In the no-prompt condition that followed, naming responses given both sample types was near zero; correct matching during trials with auditory samples remained high, and correct matching to picture samples decreased. The subsequent prompt condition yielded high levels of naming (and repeating) and correct responding. In a return to no-prompt condition, picture samples were never named and correct responding to these samples decreased to previous no-prompt levels; similarly, spontaneous echoing was low and correct responding to auditory samples became variable. This participant was then exposed to a second stimulus set in the no-prompt condition, for which correct responding occurred at and above 90% accuracy for both sample types. With a third set, accuracy was low for picture samples but high for auditory samples. For both new sets, spontaneous naming was very low for picture samples and repeating the spoken word samples was inconsistent.

Results of this study indicated that naming can facilitate delayed matching to complex visual and auditory sample stimuli. The authors discussed possible aspects of naming that might increase correct responding in this paradigm. The differential vocal response associated with a given sample stimulus may exert supplemental control over the relation between visual or auditory sample and comparison stimuli. The data did not support the hypothesis that correct responding was completely controlled by differential covert naming, as levels of accuracy typically remained above chance without naming; therefore, a more parsimonious interpretation of naming is that it provides additional stimulus control. The authors discussed the role of

stimulus overselectivity in match-to-sample performance errors and suggested that the differential vocal response associated with the sample may serve to decrease overselectivity.

Williams, Johnston, and Saunders (2006) explored the sources of possible interference between trials in the delayed matching-to-sample paradigm. Previous research (e.g., Williams et al., 1998) had suggested that reinforced responding on a given trial may then exert control over the response on the subsequent trial during the presentation of the sample, the delay, or the comparisons. In the current study, they conducted experimental analyses of performance in matching procedures manipulated in terms of stimulus variation and intertrial interval length.

After pretraining performance on conditional matching to sample, experimental sessions were conducted involving random presentation of trial-unique (nonconditional identity matching) and two-sample trial types (conditional identity matching). During two-sample trials, the positive comparison was always one of only two stimuli used during the session, and the function (S+ or S-) of each comparison stimulus changed conditionally upon which one of the two stimuli served as the sample. Different stimuli were used in each two-sample session. During trial-unique sessions, no stimuli were repeated across trials; therefore, the function of the comparison stimuli did not change. In the first experiment, blocks of trial-unique and two-sample matching sessions were conducted in random order. Responses were analyzed based on accuracy in relation to the response on the previous trial.

Results indicated that accuracy was higher for trial-unique than for two-sample tasks across delay values. The decrease in accuracy as a function of delay value during delay sessions was steeper for two-sample matching. An analysis of responding in two-sample sessions as related to the previous trial's response indicated that accuracy was highest when the correct

response (S+) was the same stimulus in the previous trial, suggesting that intertrial interference was a controlling factor for inaccurate responding.

The authors manipulated intertrial interval (ITI) length in a second experiment. Previous research supported the enhancement of performance accuracy in matching-to-sample as a function of longer ITIs. Using trial-unique and two-sample matching procedures, experimenters manipulated ITI durations to determine their effect on both matching types. Intervals were 2-s or 8-s. Given the unique stimuli in every trial of trial-unique sessions, intertrial interference would not be expected with either ITI. If an effect were found in both conditions, including trial-unique, consideration of other factors contributing to faulty stimulus control by the sample in two-sample matching performance would be needed.

Results indicated that for delays at or above 4-s, accuracy in trials with 2-s ITIs was lower than in trials with 8-s ITIs. Analysis of ITI duration on a trial-by-trial basis indicated that on trials for which the S+ was different from the S+ on the previous trial, performance accuracy increased with increased ITIs. This suggested that with a longer ITI, errors due to intertrial interference were decreased. Data from trial-unique performance did not suggest an effect of manipulation of ITIs. The authors discussed the benefits of controlling repeated exposures to the same sample in a matching session; intertrial interference is avoidable by using trial-unique procedures or increasing the ITIs.

The reviewed research suggests two general tactics to increase response accuracy in delayed match-to-sample tasks. One tactic is the use of differential observing or mediated responses. Constantine and Sidman (1975) found a correlation between higher accuracy on delayed identity matching with picture stimuli and participants' naming of the sample stimuli.

Gutowski and Stromer (2003) included instructions to name in some but not all delayed matching conditions and also found that accuracy vastly improved when participants were instructed to and did name the sample during the delay. Dube and McIlvane (1999) found that a nonvocal DOR similarly improved delayed matching accuracy with compound samples. Their procedure incorporated a simultaneous identity matching trial prior to the delay interval. Lastly, Torgrud and Holborn (1989) found that accuracy was notably higher when differential nonvocal mediating responses as compared to when common mediating responses were emitted. In their differential mediating response procedure, participants were taught to respond to a button associated with the presented sample during the ensuing delay interval. The use of naming as a differential mediating response has implications for match-to-sample training. Further research could determine other types of differential observing responses that would be more efficient (require less set-up time and materials) for use in the applied setting. The second tactic shown to improve delayed matching performances involves manipulations to the experimental arrangement. Stromer et al. (1993) demonstrated that the complexity of the sample stimuli affects delayed matching accuracy. Decreased accuracy was found when sample stimuli contained two picture elements (complex), as compared to when sample stimuli contained one element (simple). Williams et al. (1998) showed that the type and number of trial type configurations affects delayed matching performances. They found that using two sample/S+ relations per session resulted in lower matching accuracy, while using six samples or trial-unique stimuli (no stimulus is presented more than once in a session) resulted in notably higher accuracy. Williams et al. (2006) demonstrated that the duration of intertrial intervals also affects delayed matching performances. Their results showed that performance improved as a function of increasing the ITI. Future research could continue to manipulate experimental arrangements

such that optimum trial configurations and ITIs for simple and complex stimuli can be established.

In summary, previous research has shown that manipulations of delay interval length, precurrent behavior requirements, complexity of stimuli, across-trial repetition of stimulus presentation, and ITI durations affect delayed matching accuracy. Previous research in the area of delayed matching has not yielded clear guidelines about which of the many experimental manipulations should be used to improve delayed matching performances in children with autism. In order to conduct research in the area of delayed matching, an assessment of intact simultaneous and delayed matching skills is pertinent. The current study addresses this need.

Method

Participants

Participants were 6 preschool students between 3 and 6 years old (four boys, two girls) diagnosed with autism who attended a day school for children with autism in Abu Dhabi, United Arab Emirates. All participants were exposed to match-to-sample training methods in their education plans. Sam, Molly, Oliver, and Andy had demonstrated mastery of simultaneous visual-visual identity matching-to-sample, arbitrary visual-visual matching-to-sample, and auditory-visual matching-to-sample with object and picture stimuli before this project began. Howie and Abby had not. None of the participants had been exposed to delayed matching-to-sample programs before participation in this study. For additional participant characteristics, see Table 1.

Setting and Materials

The study took place in the students' individual cubby areas in the classroom shared by all 6 participants. Materials included an array presentation board and two matching sets of three non-representational picture cards. Example stimuli can be seen in Figure 1. The comparison array presentation board had three 8cm pieces of Velcro placed equidistant along the horizontal midline of the board, on which to affix the drawings. The cards were white, approximately 11-cm square, and each contained one 8-cm arbitrary black-on-white figure, centered on the card (see Figure 1). These arbitrary stimuli, used in all phases of the study, were chosen because participants had no pre-experimental history with them. This decreased the likelihood that participants would provide names for the stimuli, which could facilitate stimulus control across the delay interval. Each of the three stimuli functioned as the sample stimulus for three trials, making a total of nine trials per session. The position of correct and incorrect comparison stimuli in the array was counterbalanced across trials.

Measurement

The dependent variable was selection of the comparison that was physically identical to the sample stimulus (e.g., correct comparison stimulus) from the array, using an isolated index finger point. The experimenter observed and recorded selection responses during experimental sessions. Correct responses were recorded on the data sheet as '+', and resulted in the delivery of a reinforcer as per student-specific guidelines. Incorrect responses were recorded as '-', and resulted in termination of that trial. If the participant did not point to a comparison stimulus within 5 s of array presentation, 'NR' was recorded, indicating no response.

Reliability

Interobserver agreement (IOA) and procedural integrity (PI) data were recorded on a trial-by-trial basis by an observer trained in the experimental methods of the study. IOA was recorded based on observation of the participant response, and was scored as correct “+” or incorrect “-,” or no response “NR.” PI was recorded based on observation of the experimenter’s implementation of the procedures: duration of exposure to sample stimulus before prompting observing response, the prompting of participant’s observing response, duration of delay from sample offset to comparison array onset, arrangement of comparison stimuli as prescribed on a prepared data sheet, and duration of exposure to comparison stimuli. The second observer recorded a “+” for the correct implementation of these procedures, and a “-” if any element of the procedures was not implemented correctly. IOA and PI data were collected for approximately 15% of sessions during Phase 1 and at least 33% of all delay sessions (Phases 2 and 3). IOA was calculated by dividing the number of agreements by the total number of agreements plus disagreements, and multiplying by 100%. IOA scores for all phases for all participants were at least 98.6% (session range, 89% to 100%). PI scores for all phases for all participants were at least 96.3% (session range, 89% to 100%).

Procedure

The participant sat at a table across from the experimenter. The experimenter established the participant’s “ready response” (hands folded on table, eye gaze directed forward). The experimenter presented a sample stimulus on the table surface, approximately 10 cm from the table edge closest to the participant. The participant directed his/her eyes to the sample and engaged in a non-differential observing response (i.e., pointed to sample). If the participant did

not point to the sample within 3 s, the experimenter modeled pointing to and touching it. If the participant still did not point to and touch the sample, the experimenter manually guided the participant's finger to touch the sample stimulus. Depending on the phase, presentation of a three comparison array occurred either simultaneously with or after removal of the sample. The comparison array included one stimulus that was physically identical to the sample (the S+) and two stimuli that were physically dissimilar from the sample (the S- stimuli). For all phases, the comparison array was presented 30-50 cm from the participant (within arm's reach). The array was displayed for 5 s or until the participant pointed to one comparison stimulus. Differential consequences followed correct and incorrect responses; correct responses resulted in the delivery of a reinforcer as per student-specific guidelines, whereas no reinforcer followed incorrect responses. For all phases, sessions consisted of 9 trials and each trial was separated by an intertrial interval of approximately 5 s.

In Phase 1, six or seven sessions were conducted with each participant. Participants for whom the final three sessions of Phase 1 were at least 89% accurate passed to Phase 2. Criterion to pass from Phase 2 to Phase 3 was a minimum of seven sessions, with at least 89% accuracy for the final three consecutive sessions. Within Phase 3, the criterion to increase delay intervals (in 2-s increments) was at least 89% accuracy for one session. Criterion to discontinue the assessment was three consecutive sessions with less than 89% accuracy, or completion of the same number of sessions the participant required to pass Phase 2.

The above procedures were conducted in all experimental phases. Phases differed in the presence or absence of the sample stimulus with the comparison stimuli, and in Phase 3, by the length of time after the sample was removed before the comparisons were displayed. These procedural differences are described next.

Phase 1: Simultaneous Match to Sample. Immediately following the participant's observing response to the sample, the experimenter presented the array of comparison stimuli. The sample stimulus remained in place.

Phase 2: 0-s Delayed Match to Sample. Immediately following an observing response, the experimenter removed the sample stimulus and simultaneously presented the array of comparison stimuli.

Phase 3: Titrating Delayed Match to Sample (in 2-s increments). Immediately following the observation response, the experimenter removed the sample stimulus. The array of comparison stimuli was presented after a prescribed delay. The delay increased by 2 s across sessions, pending criterion was met.

Results

Two participants' performances in Phase 1 (Abby and Howie) did not meet the criterion of 89% accuracy for three consecutive sessions. Accuracy was well below 89% accuracy in each of the seven sessions of simultaneous identity match-to-sample. Performance was below 40% and 50% accuracy for Abby and Howie, respectively. Figures 2 and 3 show these data.

The remaining four participants' performances met criterion to proceed to Phase 2 (0-s delayed identity matching) and Phase 3 (delayed identity matching with a titrating delay). Results will be discussed individually for each of these four participants.

Sam

Figure 4 depicts the results of Sam's assessment. Sam consistently performed simultaneous identity matching with high accuracy, at 89% accuracy for the first session and

100% accuracy for the remaining six sessions. In Phase 2 (identity matching with a 0-s delay), Sam performed with variable but high accuracy, meeting criterion for passing after the 9th session. In the nine sessions of Phase 2, his performance dropped below 89% accuracy in only three sessions (78% accuracy in sessions 8, 11, and 13). In Phase 3 (identity matching with a titrating delay), Sam demonstrated 100% accuracy in four consecutive sessions in which the delay interval increased by 2 s each session, from a beginning delay of 2 s in Session 17 to 10 s in Session 21. Accuracy dropped to 78% with the introduction of the 10-s delay, then increased to 89% or greater accuracy for two sessions, and then decreased and became variable before termination criterion was met.

Oliver

Figure 5 depicts the results of Oliver's assessment. Oliver performed with variable accuracy (range, 67-100%) during Phase 1, meeting the criterion of three consecutive sessions with at least 89% accuracy after six sessions. Oliver initially maintained high accuracy with the introduction of the 0-s delay between sample offset and comparison array onset; however, this performance was not maintained and variable accuracy scores were obtained in Sessions 10-15. Accuracy again increased and Oliver's performance satisfied the passing criterion after 12 sessions (Session 18). In Phase 3 (2-s incremental increase in delay), Oliver required two sessions with a 2-s delay before meeting criterion to increase to a 4-s delay. High accuracy was maintained at the 4-s delay and, thus, the delay was increased to 6 s. Oliver's performance met criterion to increase to 8 s delay after two sessions but due to a procedural error, another session was administered with a 6-s delay. Performance in the subsequent three sessions with a 6-s delay met criterion to stop.

Molly

Figure 6 depicts the results of Molly's assessment. Molly demonstrated high accuracy throughout Phase 1, with 89% or 100% accuracy in each of the seven sessions of simultaneous identity matching. When a 0-s delay was imposed, an initial disruption in accuracy was observed (Session 8), followed by four sessions with high accuracy, and then variable responding. Criterion was met after 10 sessions in Phase 2. In Phase 3, Molly performed 2-s delayed identity matching with 89% accuracy in the first session of the titrating delay phase, but then performance dropped to 67% accuracy in the next session when a 4-s delay was introduced. In the ensuing three sessions, she met criterion for delay incremental increases to 10 s; however, accuracy declined at this delay value and criterion to terminate sessions was met.

Andy

Figure 7 depicts the results of Andy's assessment. Andy performed with high accuracy during Phase 1. Andy matched the S+ comparison to its simultaneously displayed, physically identical sample with 89-100% accuracy. In Phase 2, with a 0-s delay between the onset of sample and comparison array, his performance accuracy dropped slightly but remained high. Criterion performance was demonstrated after 10 sessions, in which only two were below 89% accuracy (i.e., 78% accuracy in Session 11 and 13). In Phase 3, Andy passed from 2-s delay to 4-s delay after two sessions. He met criterion to stop at 4-s delay with three consecutive sessions below 89% accuracy.

Discussion

In the present study, an assessment procedure was developed to determine delay thresholds for accurate responding in delayed identity matching-to-sample. Participant

performance was tested with increasing delay intervals between the removal of the sample stimulus and presentation of comparison stimuli. When responding dropped below the predetermined passing criterion, the last interval length with passing accuracy was determined to be the threshold for that participant. A threshold was successfully determined for each participant using these methods. Previous research in the area of delayed matching has explored the ways in which manipulations to behavior before and during the delay interval can affect matching performance after the interval ends. This indicates that an assessment tool would be valuable across experimental arrangements to determine appropriate candidates for participation in research related to delayed matching, as well as for skill acquisition in the applied setting. Standardizing the assessment method may aid in the comparison of experimental methods and the generalization of findings.

Manipulations to the assessment method were made throughout the process of administration in order to develop the most effective techniques. During the first phase (simultaneous matching), all participants completed a maximum of seven sessions before passing to the next, regardless of when the criterion to pass was met. This was to ensure similar exposure to simultaneous matching before implementing the delayed matching sessions. Within Phase 2 (0-s delay), participants completed between 9 and 12 sessions even though Oliver, Molly, and Andy met criterion to pass the phase during the first four sessions. Sam's performance repeatedly varied between meeting and falling below this criterion over the course of six sessions before passing after nine sessions. Phase 2 was continued for other participants to ensure similar exposure, but an interesting pattern was noted: those participants who met criterion for passing in the first four sessions all demonstrated variable performance, including accuracy scores below passing criterion in the additional sessions in this phase. Perhaps the

performances were not maintained in extended testing due to the initial novelty of the arrangement; none of the participants had previous exposure to delayed matching. Further research with more participants should include extended assessment of matching with a 0-s delay to determine if similar results are observed. Including extended testing in a standardized assessment may be useful to determine the threshold at which accurate responding is most reliable.

In Phase 3, participants who did not immediately (in one session) pass from one delay interval to the next (2-s to 4-s, 4-s to 6-s, 6-s to 8-s, or 8-s to 10-s), did so in no more than two sessions. With one exception, if a participant did not meet passing criterion after two sessions of exposure to the delay, he or she eventually met criterion to discontinue at that delay interval length. Only Sam met criteria to progress to the maximum delay (10 s). This was also the highest delay at which any participant's performance reached 89% or better. Sam's 10-s delay sessions in Phase 3 were continued for nine sessions to match the number of sessions required for him to meet passing criterion during Phase 2. It should also be noted that again with the exception of Sam, all participants demonstrated decreased performance accuracy immediately or soon after exposure to delays beyond 0-s. After the initial performance disruption upon introduction of delays beyond 0-s (2-s or 4-s), these participants all passed to longer intervals. This indicates that learning occurred during repeated exposures to the delayed-matching paradigm.

There were limitations to the present study. First, the length of delay intervals was tracked only by covert counting by the experimenters administering the assessment. While the training did address methods for counting to ensure consistency, timing with an electronic timer would have been more precise. Second, two of the participants in this study entered without

previous mastery of simultaneous matching. Previous research indicates that participants who can perform accurately on delayed matching tasks are typically able to perform accurately on simultaneous matching tasks (e.g. Constantine & Sidman, 1975). Requiring simultaneous identity matching as a condition of participation would allow for a more homogeneous sample of participants in delayed matching research. Lastly, some modifications to threshold determination may be considered in future research. After a delay threshold is determined by performance decrement at a greater delay interval, performance at the threshold (previous delay interval: 2-s less than where discontinuation occurred) should be reassessed to demonstrate replication of effect. Future research could also address a more specific determination of threshold by including a fourth phase in which to assess with a delay interval length of 1-s less than that which met criterion for discontinuation. Manipulating the delay by 1-s would more accurately determine thresholds.

By first determining delay thresholds empirically, teaching strategies can be better evaluated for efficacy in improving delayed matching performance. Manipulations to naming requirements during sample presentation and delay interval (Constantine & Sidman, 1975; Gutowski & Stromer, 2003), the use of differential physical responses during sample presentation (Dube & McIlvane, 1999) and during the delay interval (Torgrud & Holborn, 1989), manipulation of stimulus complexity (Stromer et al., 1993), and manipulation of the number of stimuli used per session (Williams et al., 1998) are all methods on which curricula might be based for improving this performance.

References

- Allen, K. D., & Fuqua, R. W. (1985). Eliminating selective stimulus control: A comparison of two procedures for teaching mentally retarded children to respond to compound stimuli. *Journal of Experimental Child Psychology, 39*, 55-71.
- Constantine, B., & Sidman, M. (1975). Role of naming in delayed matching-to-sample. *American Journal of Mental Deficiency, 79*, 680-689.
- Dube, W.V. & McIlvane, W. J. (1999). Reduction of stimulus overselectivity with nonverbal differential observing responses. *Journal of Applied Behavior Analysis, 32*, 25-33.
- Gutowski, S. J., & Stromer, R. (2003). Delayed matching to two-picture samples by individuals with and without disabilities: An analysis of the role of naming. *Journal of Applied Behavior Analysis, 36*, 487-505.
- Huguenin, N. H. (1985). Attention to multiple cues by severely mentally retarded adults: Effects of single-component pretraining. *Applied Research in Mental Retardation, 6*, 319-335.
- Huguenin, N.H., & Touchette, P. E. (1980). Visual attention in retarded adults: Combining stimuli which control incompatible behavior. *Journal of the Experimental Analysis of Behavior, 33*, 77-86.
- Koegel, R. L., & Schreibman, L. (1977). Teaching autistic children to respond to simultaneous multiple cues. *Journal of Experimental Child Psychology, 24*, 299-311.
- Schreibman, L., Charlop, M. H., & Koegel, R. L. (1982). Teaching autistic children to use extra-stimulus prompts. *Journal of Experimental Child Psychology, 33*, 475-491.

- Skinner, B. F. (1968). *The technology of teaching*. New York: Appleton-Century-Crofts.
- Stromer, R., McIlvane, W. J., Dube, W. V., & Mackay, H. A. (1993). Assessing control by elements of complex stimuli in delayed matching to sample. *Journal of the Experimental Analysis of Behavior*, *59*, 83-102.
- Torgrud, L. J., & Holburn, S. W. (1989). Effectiveness and persistence of precurrent mediating behavior in delayed matching to sample and oddity matching with children. *Journal of the Experimental Analysis of Behavior*, *52*, 181-191.
- Williams, D. C., Dube, W. V., Johnston, M. D., & Saunders, K. J. (1998). Conditional vs. trial-unique delayed matching to sample. *American Journal on Mental Retardation*, *103*, 186-192.
- Williams, D. C., Johnston, M. D., & Saunders, K. J. (2006). Intertrial sources of stimulus control and delayed matching-to-sample performance in humans. *Journal of the Experimental Analysis of Behavior*, *86*, 253-267.

Table 1

Participant Information

Participant	Age	Mand	Tact	Directions
Molly	4y- 11m	Multiple-word utterances: Mostly English	None	Some 2-step directions: English or Arabic
Oliver	5y-8m	Multiple-word utterances: English or Arabic	Multiple word utterances: English or Arabic	2-step directions: English or Arabic
Andy	5y-1m	PECS with vocal approximations: Mostly English	None	2-step directions: English or Arabic
Howie	4y-3m	One-word utterances: Arabic or English	None	Some 1-step directions: English or Arabic
Sam	4y-4m	One-word utterances: Arabic or English	Some one-word utterances: Mostly English	1-step directions: English or Arabic
Abby	3y-9m	PECS only: No vocal utterances	None	Some 1-step directions: English

Figure Captions

Figure 1. Stimuli used in delayed matching assessment.

Figure 2. Responding during assessment Phase 1 (simultaneous matching) for Abby.

Figure 3. Responding during assessment Phase 1 (simultaneous matching) for Howie.

Figure 4. Responding during assessment Phase 1 (simultaneous matching), Phase 2 (0-s delayed matching), and Phase 3 (titrating delay in 2-s increments) for Sam.

Figure 5. Responding during assessment Phase 1 (simultaneous matching), Phase 2 (0-s delayed matching), and Phase 3 (titrating delay in 2-s increments) for Oliver.

Figure 6. Responding during assessment Phase 1 (simultaneous matching), Phase 2 (0-s delayed matching), and Phase 3 (titrating delay in 2-s increments) for Molly.

Figure 7. Responding during assessment Phase 1 (simultaneous matching), Phase 2 (0-s delayed matching), and Phase 3 (titrating delay in 2-s increments) for Andy.

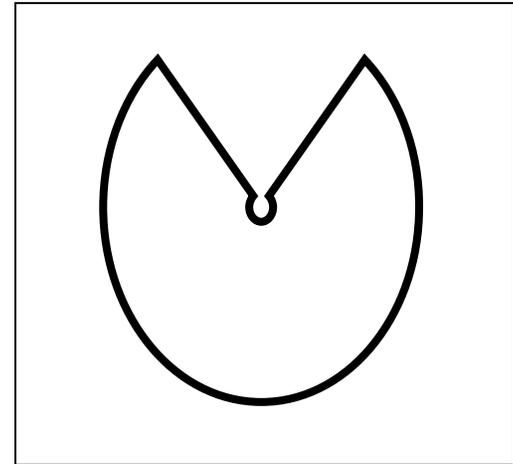
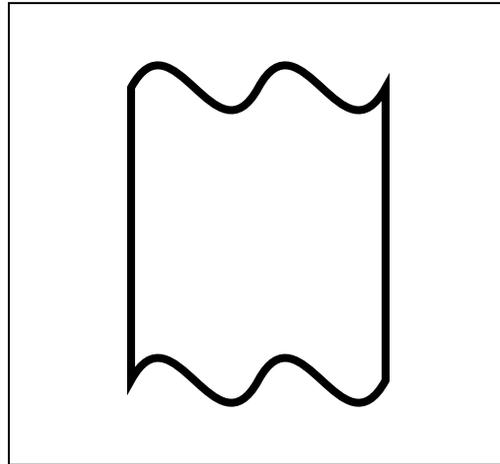
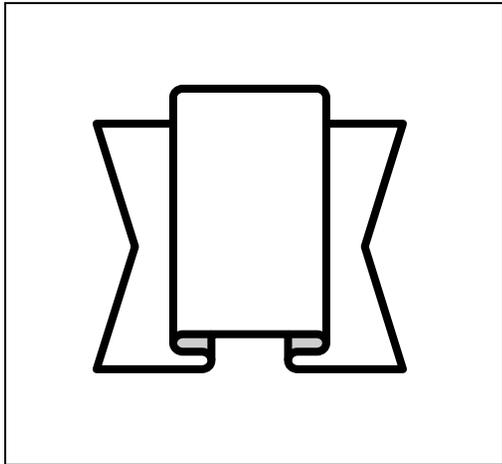


Figure 1

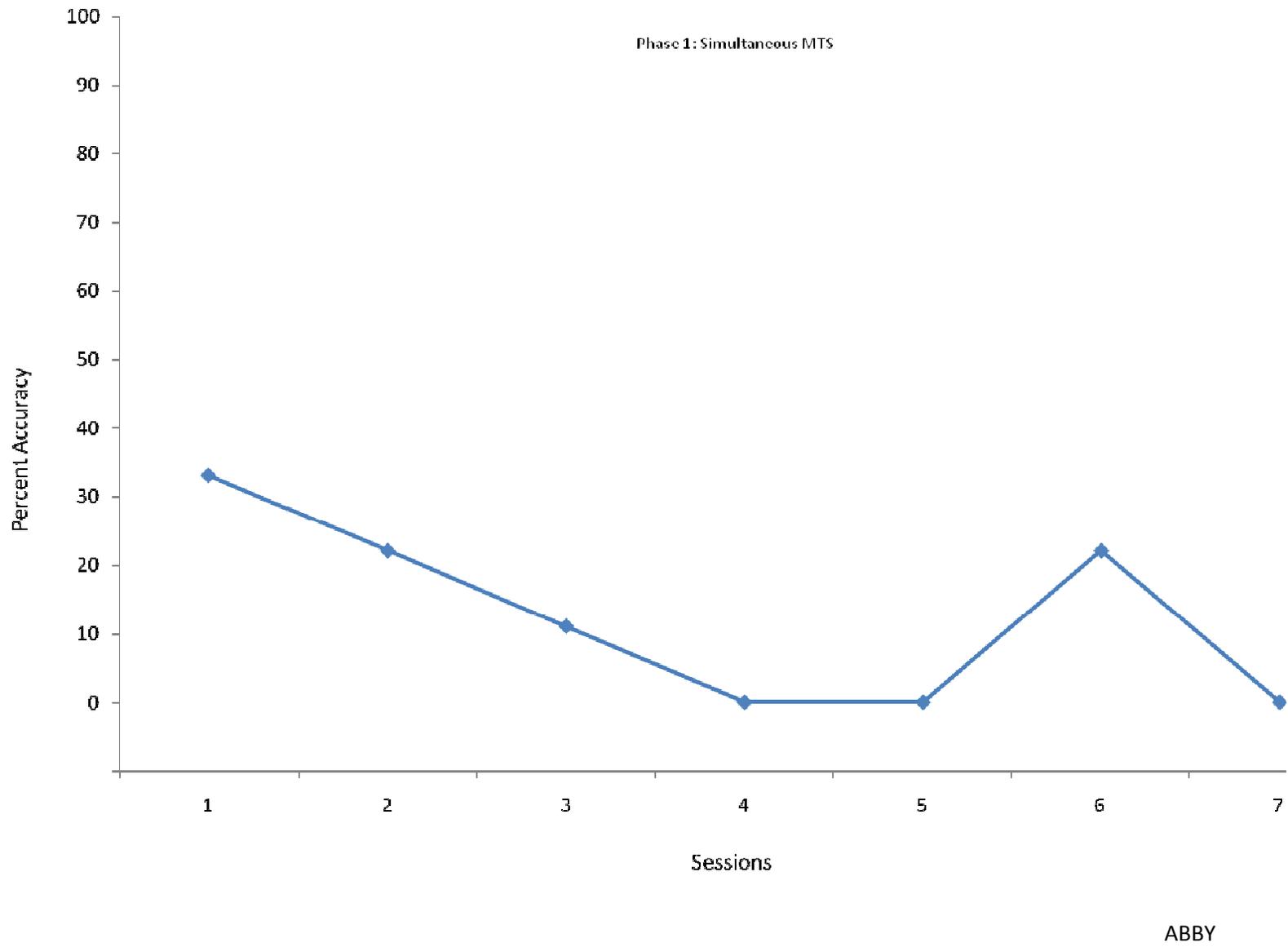


Figure 2

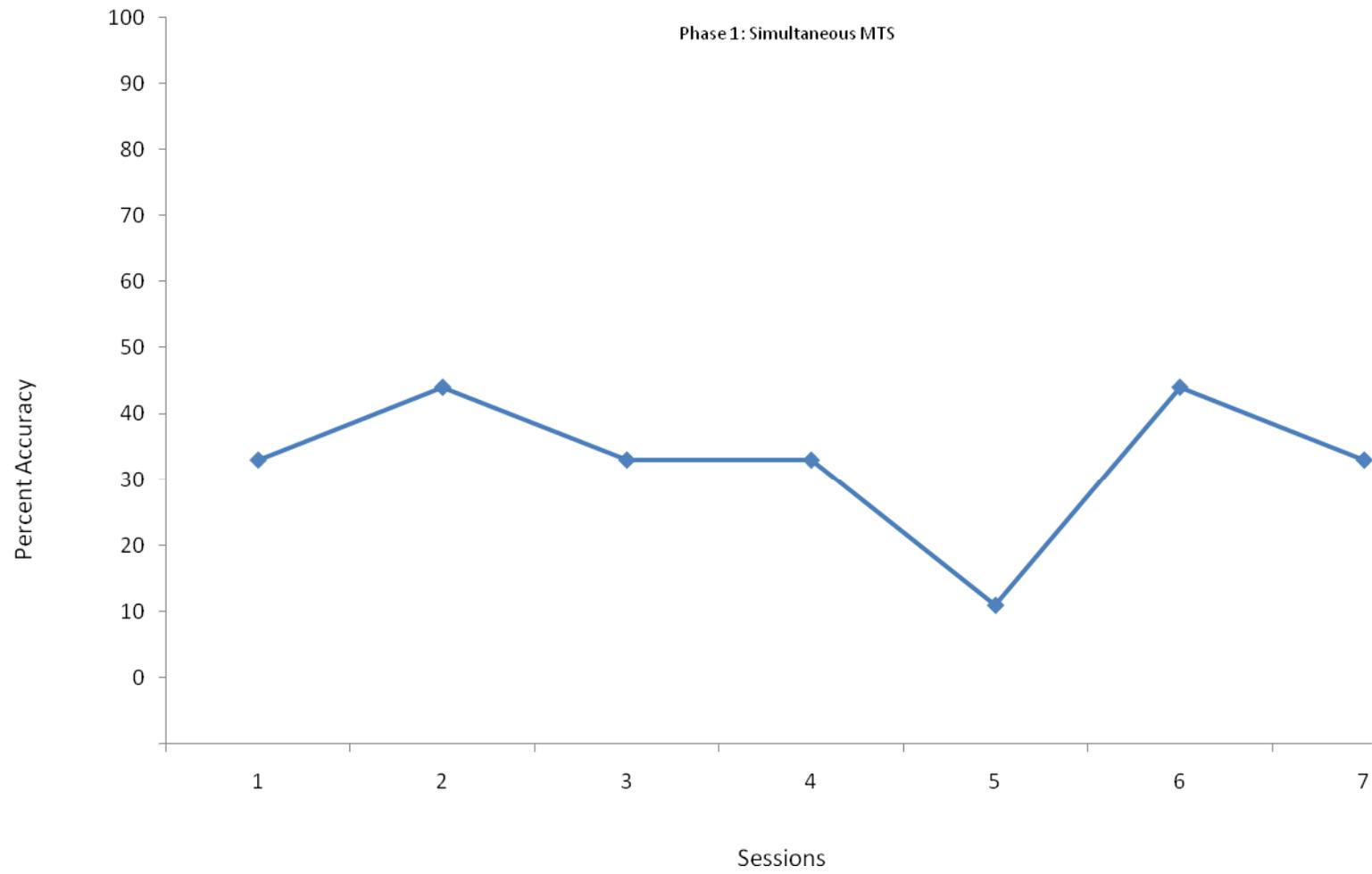
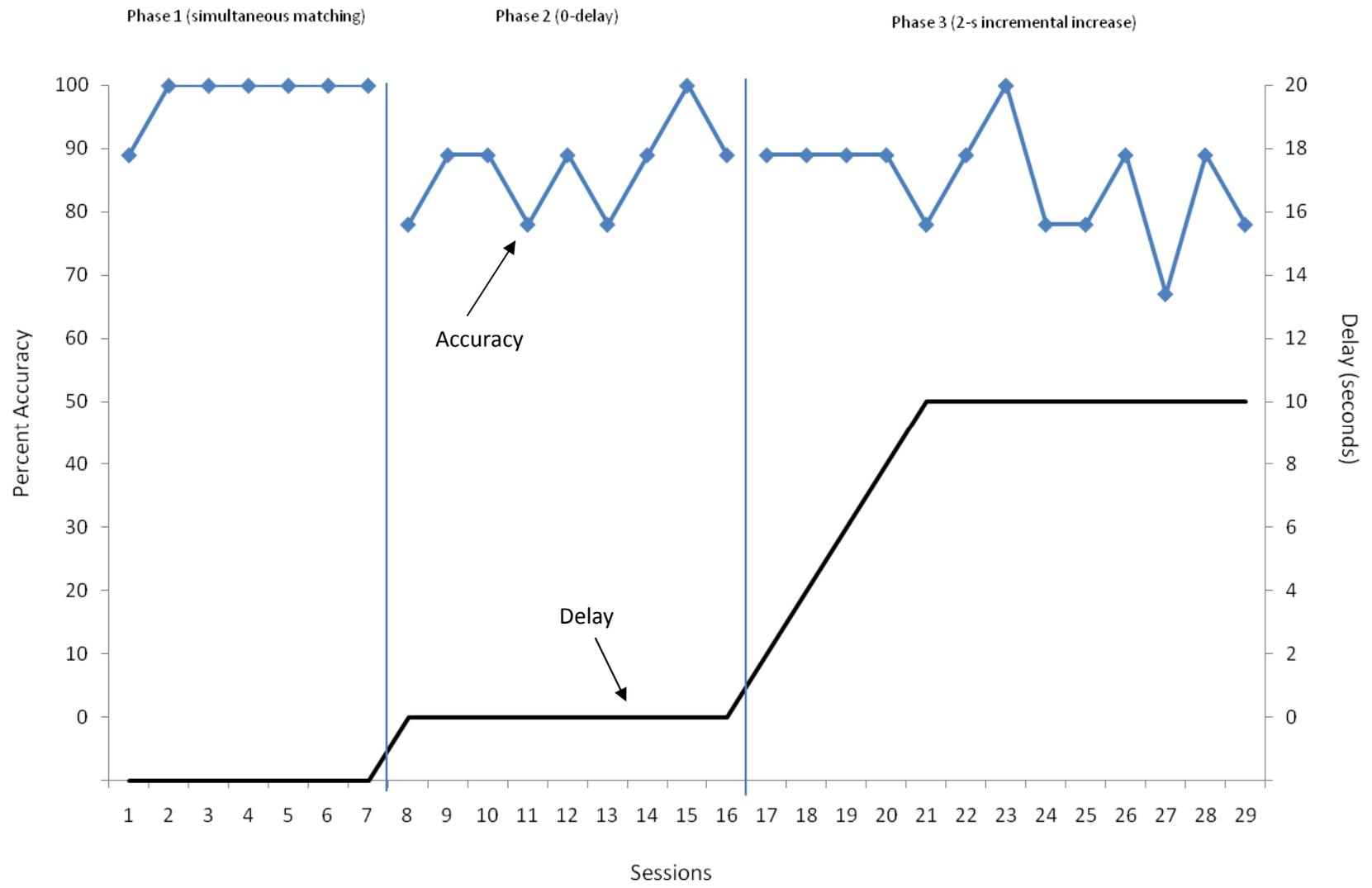
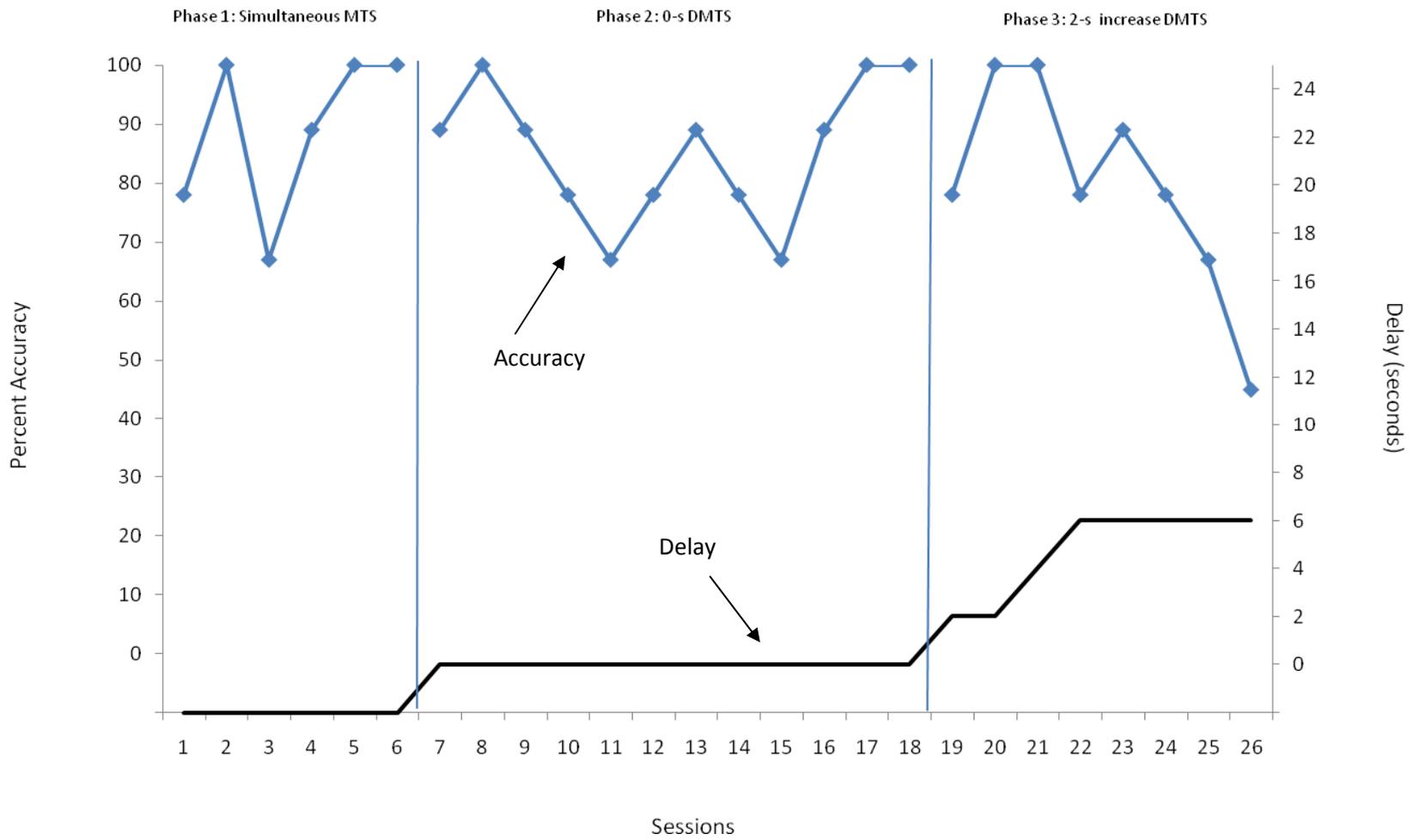


Figure 3



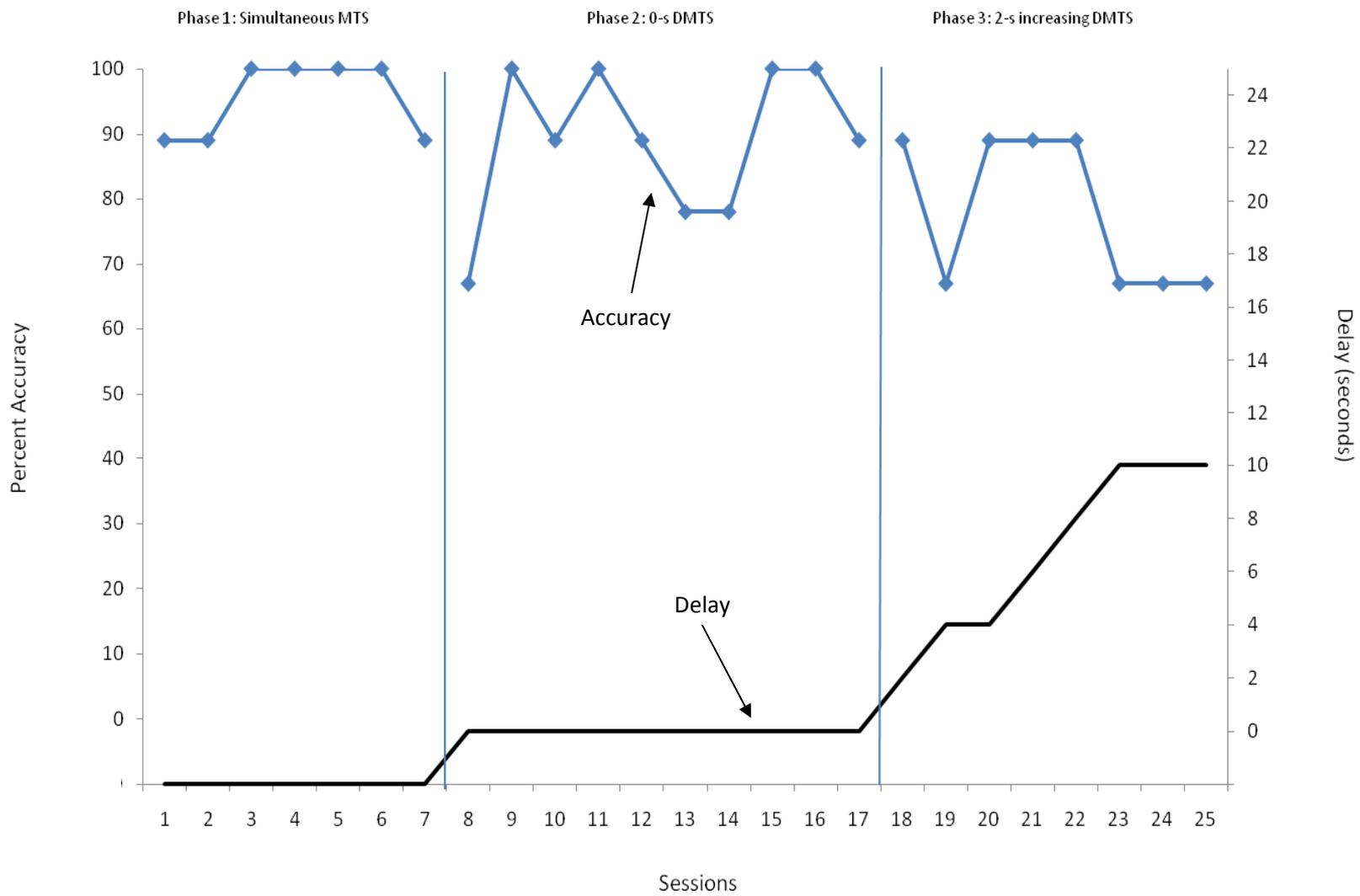
SAM

Figure 4



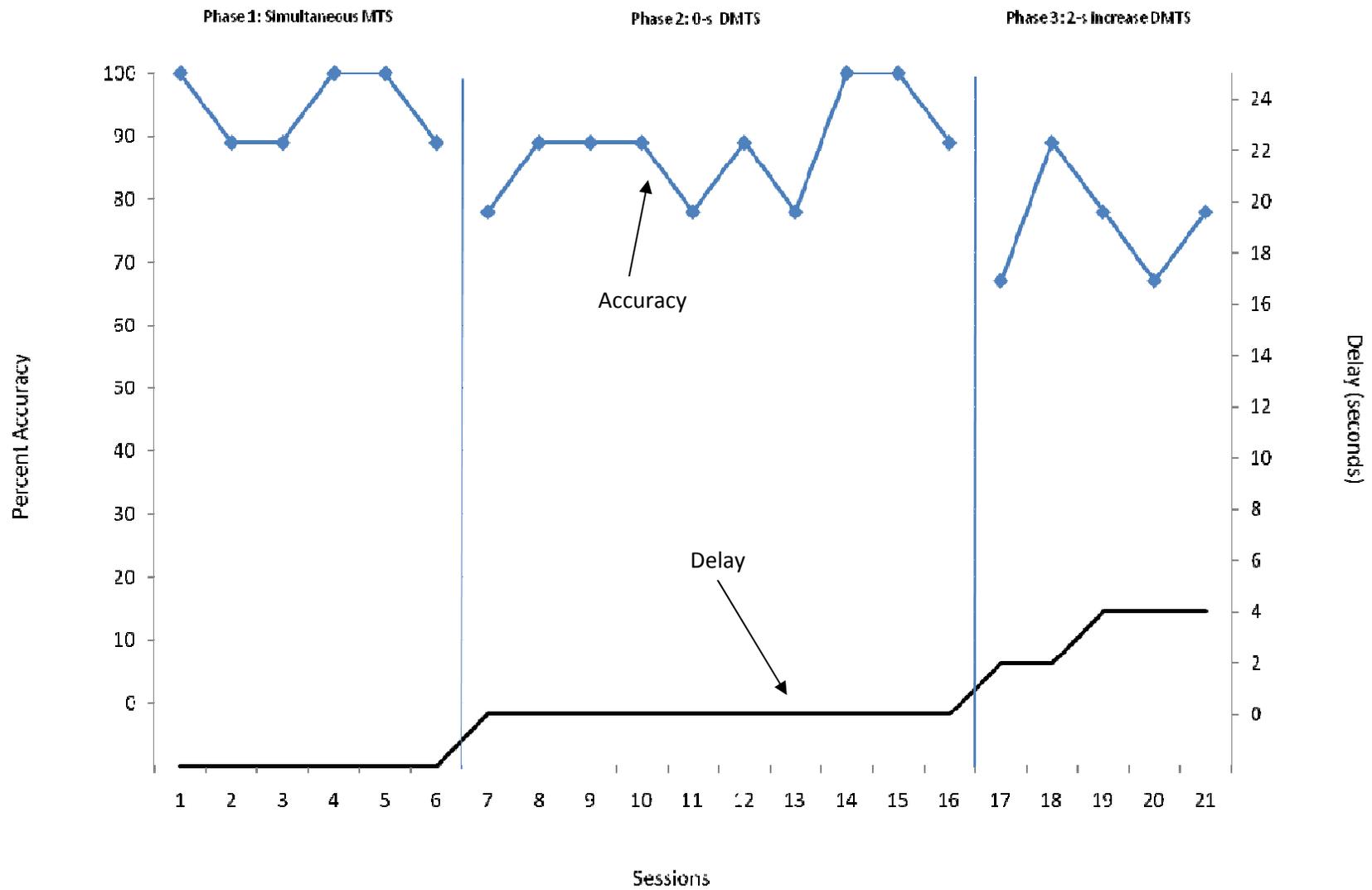
OLIVER

Figure 5



MOLLY

Figure 6



ANDY

Figure 7