Teaching Equivalence Relations to Individuals with Minimal Verbal Repertoires: Are Visual and Auditory-Visual Discriminations Predictive of Stimulus Equivalence?

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A thesis submitted to the Department of Psychology in partial fulfillment of the Doctoral Degree at the University of Manitoba

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Abstract

Controversy exists in the literature regarding whether a relationship exists between language and the ability to demonstrate stimulus equivalence. In an attempt to shed some light on this controversy, the present study examined whether individuals with minimal verbal repertoires were able to acquire stimulus equivalence using three 3-member classes. Five adult participants with developmental disabilities took part in the study. Three participants were able to pass up to a visual-visual identity discrimination (Level 4), according to the Assessment of Basic Learning Abilities (ABLA) test (Kerr, Meyerson, & Flora, 1977); and two individuals were able to pass up to ABLA Level 6, an auditory-visual nonidentity discrimination, as well as a prototype visual-visual non-identity discrimination (VVNM) (Goodman, Harapiak, Martin, & Yu, 2001). Language was assessed using three measures: a vocal imitation, tact, and mand assessment (Marion et al., in press); the communication portion of the Vineland Adaptive Behavior Scales (VABS) (Sparrow, Balla, & Cicchetti, 1984); and the Peabody Picture Vocabulary Test – Revised (PPVT-R) (Dunn & Dunn, 1981). All participants failed a test of echoics, tacts, and mands; age-equivalent scores on the VABS and the PPVT-R ranged from 1 year 7 months to 2 years 3 months. Individuals were pretested on their ability to perform all reflexive and symmetric relations with three 3-member classes of pictures, printed words, and symbols. Then, match-to-sample training, with incorporation of antecedent and consequence manipulations, was used to teach three-choice match-to-sample discriminations involving printed words and pictures, and pictures and symbols. Following a minimum of 1808 training trials, 3 participants who passed up to ABLA Level 4 failed to acquire the first relation presented for training. In contrast, 2 participants who were able to perform both ABLA Level 6 and VVNM were able to learn the taught relations. Although these participants did not demonstrate stimulus equivalence as defined by Sidman and Tailby (1982), they did demonstrate positive equivalence test outcomes similar to Carr, Blackman, Wilkinson, and McIlvane (2000). The present study provides support for the notion that well-developed language skills are not necessary to demonstrate equivalence relations. Second, it suggests that visual and auditory-visual nonidentity discriminations, as measured by the ABLA test and a prototype VVNM task, may facilitate the learning of other nonidentity discriminations. Implications of the research findings are discussed.

Introduction

The development of practical repertoires is a key objective in program planning for persons with developmental disabilities. However, persons responsible for developing programs often experience a difficulty in determining appropriate starting points. To date, an abundance of research has supported use of the Assessment of Basic Learning Abilities test (ABLA; formerly called the AVC test) for selecting and sequencing training tasks to enable optimal learning for individuals with developmental disabilities (Martin & Yu, 2000). The ABLA test, originally developed by Kerr, Meyerson, and Flora (1977), assesses an individual's ability to perform a simple imitation task and five two-choice motor, visual, and auditory discriminations of increasing difficulty. A description of the ABLA levels and the types of discriminations required to perform each level are provided in Table 1. Kerr et al. chose these particular discriminations because one or more of them appeared to be required to perform self-care, pre-vocational, and vocational tasks in residential training settings. In addition to using this test for assessment purposes, studies have also examined a series of techniques to effectively teach these discriminations (e.g., Conyers, Martin, Yu, & Vause, 2000; Hazen, Szendrei, & Martin, 1989; Yu & Martin, 1986).

In recent years, research has examined three additional conditional discrimination tasks as potential additions to the ABLA test. These tasks include a prototype visual-visual non-identity matching task (Goodman, Harapiak, Martin, & Yu, 2001) and two prototype auditory matching tasks (Harapiak, Martin, & Yu, 1999; Harapiak, Martin, Yu, & Vause, 2001). Goodman tested the placement of a prototype visual-visual non-identity

Table 1

A Description of the ABLA Levels and the Types of Discriminations Required

ABLA Levels	Types of Discriminations
Level 1, Imitation: A tester puts an object into a container and asks the client to do likewise.	A simple imitation
Level 2, Position Discrimination: When a red box and a yellow can are presented in a fixed position, a client is required to consistently place a piece of foam in the container on the left when the tester says, "Put it in."	A simultaneous visual discrimination with position, color, shape, and size as relevant visual cues
Level 3, Visual Discrimination: When a red box and a yellow can are presented in randomly alternating positions, a client is required to consistently place a piece of foam in the can when the tester says, "Put it in."	A simultaneous visual discrimination with color, shape, and size as relevant visual cues
Level 4, Match-to-Sample: A client demonstrates Level 4 if, when given a yellow can and a red box in randomly alternated left-right positions, and is presented randomly with a yellow cylinder and a red cube, he/she consistently places a yellow cylinder in the yellow can and a red cube in the red box.	A conditional visual-visual quasi-identity discrimination with color, shape, and size as relevant visual cues
Level 5, Auditory Discrimination: When presented with a yellow can and a red box (in fixed positions), a client is required to consistently place a piece of foam in the appropriate container when the tester randomly says, 'red box' or 'yellow can'.	A conditional auditory-visual discrimination with pitch, pronunciation, and duration as relevant auditory cues and position, color, shape, and size as relevant visual cues
Level 6, Auditory-visual Combined Discrimination: Same as Level 5, except the left-right positioning of the containers is randomly alternated.	A conditional auditory-visual discrimination with the same auditory cues as level 5, and with only color, shape, and size as relevant visual cues

Note. Reprinted with permission from Martin and Yu (2000).

matching task with regards to the ABLA test. Results indicated that the task was more difficult than ABLA Level 4, but its relative difficulty to ABLA Level 6 was inconclusive. The two auditory matching tasks were shown to be more difficult than the six ABLA levels (Harapiak, Martin, & Yu; Harapiak, Martin, Yu, & Vause). Research indicates that individuals who are able to perform the ABLA and auditory matching discriminations exhibit a larger verbal repertoire than individuals who are able to perform only the ABLA discriminations (Marion et al., in press; Vause, Martin, & Yu, 2000).

Concurrent with assessing and training of various simple and conditional discriminations, research has focused on the development of equivalence classes among persons with developmental disabilities (Green, 2001). Specific to this topic, researchers have debated whether individuals with minimal verbal repertoires are capable of demonstrating stimulus equivalence. In short, some researchers (e.g., Horne & Lowe, 1996) assert that language is related to an individual's ability to demonstrate equivalence relations. However, other researchers (e.g., Fields, 1996; Saunders & Green, 1996; Sidman, 1996; Sidman, 2000) provide counter-arguments to this view.

Currently, empirical research concerning the relationship between language and stimulus equivalence is minimal. For this reason, the present study attempted to examine whether individuals with minimal receptive and expressive language skills, as measured by various direct and indirect assessments, were able to demonstrate stimulus equivalence with pictures, printed words, and symbols. Second, the study examined the relationship between performance on the ABLA test, arbitrary matching, and the ability to demonstrate stimulus equivalence.

Research Findings on the ABLA Test

Considerable research has demonstrated that the ABLA test is useful for matching the learning ability of persons with developmental disabilities to the difficulty level of training tasks.

Typical training tasks require one or more ABLA levels. To examine the contention by Kerr et al. (1977) that one or more of the ABLA discriminations are needed to perform various training tasks for persons with developmental disabilities, DeWiele and Martin (1996) assessed the basic discriminations required to perform 194 tasks, which were randomly selected from a total of 500 tasks that were taught to individuals in a residential training facility. These tasks were selected from various departments including vocational training, recreation, communication, physiotherapy, and by staff in the home residence of each of the clients. Experts on the ABLA test rated each task to determine whether it could be classified within the levels included in the ABLA test. The experts agreed that 69% of the tasks involved discriminations assessed by the ABLA test.

Hierarchical ordering. Several studies indicate that the ABLA levels are hierarchically ordered in level of difficulty (e.g., Kerr et al., 1977; Martin, Yu, Quinn, & Patterson, 1983; Wacker, 1981). Each level exceeds the previous level in terms of the types of discriminations required. For example, Level 2 (position discrimination) and Level 3 (visual discrimination) both require an individual to perform a simultaneous discrimination, but Level 3 involves one less visual cue (i.e., position). Moreover, if a client passes one level (e.g., Level 3), that client will pass lower levels (i.e., Levels 1 and 2). In contrast, if a client fails a level (e.g., Level 4), that client will also fail higher levels (i.e., Levels 5 and 6).

Predictive validity of the ABLA. In addition to demonstrating a hierarchical ordering among levels included in the ABLA test, research findings suggest that the ABLA test is highly predictive of the ease or difficulty with which an individual is able to perform educational, prevocational, and vocational tasks (Stubbings & Martin, 1995, 1998; Tharinger, Schallert, & Kerr, 1977; Wacker, Kerr, & Carroll, 1983; Wacker, Steil, & Greenbaum, 1983; Witt & Wacker, 1981). For example, Wacker, Kerr, et al. examined whether the ABLA test predicted participants' abilities to perform two-choice and four-choice vocational analogue tasks. Results on the ABLA test predicted performance on the analogue tasks for 11 of 12 participants.

Failed levels are difficult to teach. Failed ABLA levels are very difficult to teach using standard reinforcement and prompting procedures (e.g., Conyers et al., 2000; Meyerson, 1977; Witt & Wacker, 1981; Yu & Martin, 1986). For example, Meyerson attempted to train participants on their first failed ABLA level, and reported that participants needed 100 to 900 training trials before a higher level of discrimination was attained. Similarly, Conyers et al. indicated that, with the use of standard prompting and reinforcement procedures, 3 individuals classified at ABLA Level 4 were not able to learn a prototype Level 6 task, a two-choice auditory-visual discrimination, after 170, 195, and 172 trials, respectively. However, several studies (e.g., Conyers et al.; Hazen et al., 1989; Yu & Martin) have shown that failed ABLA levels and ABLA analogue tasks can be rapidly taught using a training package consisting of many components (e.g. within-stimulus prompting, error interruption, direct-response reinforcement, and presenting a variety of reinforcers). For example, in the Conyers et al. study, the introduction of a multiple-component training package led to successful performance on an auditory-visual conditional discrimination task after 21, 82, and 23 trials, respectively for the three participants mentioned previously.

The ABLA is predictive of communication skills. In addition to examining use of the ABLA test for predicting an individual's ability to perform pre-vocational and vocational tasks, findings suggest that the test is correlated with various measures of receptive and expressive communication (e.g., Barker-Collo, Jamieson, & Boo; Casey & Kerr, 1977; Meyerson, 1977; Vause, Martin, & Yu, 2000; Ward & Yu, 2000). For example, Ward and Yu demonstrated that individuals with developmental disabilities who were unable to pass Levels 5 and 6 on the ABLA test were identified as communicating with single words or less; while, conversely, individuals who passed the auditory levels were able to combine two or more words in phrases and sentences. In a similar vein, researchers (Barker-Collo et al.; Vause et al.) assessed individuals with developmental disabilities on the ABLA test, the communication portion of the Vineland Adaptive Behavioral Scales (VABS) (Sparrow, Balla, & Ciccetti, 1984), and the Communication Status Survey (CSS) (Barker-Collo et al.). Results indicated that ABLA level was significantly correlated with VABS scores on receptive and expressive communication, and aspects of communication measured by items on the CSS. In general, individuals who were able to perform ABLA Levels 5 and 6 had stronger communication skills than individuals who were not able to perform these auditory discriminations.

Additional Two-Choice Conditional Discriminations

In recent years, researchers have developed additional prototype two-choice visual and auditory discrimination tasks, and their placement within the ABLA hierarchy has been examined.

Visual-visual nonidentity matching (VVNM). Goodman et al. (2001) designed a prototype VVNM task that, similar to ABLA Level 4 (a visual-visual quasi-identity discrimination; see Table 1), contained manipulanda that differed on three dimensions (size, shape, and color). On each trial, the red box and yellow can were placed in front of the participant. On randomly alternated trials, the participant was presented with either a green star-shaped piece of wood or an hourglass-shaped piece of wood, and was required to match the green star to the red box and the hourglass-shaped figure to the yellow can. A total of 20 participants were included in the study. The results suggest that the prototype VVNM task is more difficult than ABLA Levels 4, and its relative difficulty in comparison to Level 6 was not definitive. A larger sample is needed to confirm where VVNM fits within the ABLA hierarchy. In this study, the VVNM prototype task was also predictive of performance on everyday visual-visual nonidentity discriminations (e.g., matching a sock to a shoe and a comb to a bag). The term "non-identity matching" is synonymous with "arbitrary matching" and "symbolic matching" (Sidman & Tailby, 1982).

Auditory matching. Other prototype two-choice auditory discrimination tasks have been developed that require discriminations different from ABLA Levels 5 and 6. A visual-auditory non-identity discrimination task involving two objects and two different speech sounds (VANM) was developed by Barker-Collo (1995). In this task, an experimenter would say, "pen, pen, pen" in a high rapid tone on some trials, and "b-l-o-c-k, b-l-o-c-k, b-l-o-c-k" in a slow deep tone on other trials. Across trials, two research assistants would randomly alternate as to who spoke each vocalization. On each trial, the participant is required to place the appropriate object (a block or a pen) in the palm of the assistant who produces the same auditory cue as the experimenter.

An auditory-auditory identity discrimination task (AAIM), based on the VANM task, was also developed by Barker-Collo (1995) with the exception that visual stimuli (i.e., block and pen) are not used. The participant is required to point to the assistant who produces a matching auditory cue to that of the experimenter. An auditory-auditory non-identity discrimination (AANM) was developed by Harapiak et al. (1999). In this task, a testee hears three different speech sounds, and then must indicate which of the two sounds form an arbitrary match. For example, on some trials, an experimenter says, "ball, ball, ball" in a high rapid tone, and on other trials the experimenter says, "i-c-e, i-c-e, i-c-e" in a slow low tone. Across trials, two assistants randomly alternate as to who says "field, field, field" in a high rapid tone and "r-i-n-k, r-i-n-k, r-i-n-k" in a low slow tone. When the experimenter says, "ball, ball, ball," the correct response is for the testee to point to the assistant who said, "field, field, field." When the experimenter says, "i-c-e, i-c-e, i-c-e," the correct response is for the testee to point to the assistant who said, "r-i-n-k, r-i-n-k, r-i-n-k." Three studies (Harapiak et al., 1999; Vause et al., 2000; Harapiak et al., 2001) suggest that these auditory matching tasks are hierarchically ordered in relation to each other and in relation to the ABLA test. The VANM, AAIM, and AANM tasks were positioned higher than ABLA Level 6, with the AAIM being more difficult than VANM, and the AANM task being the most difficult. In other words, auditory-auditory discriminations were more difficult than auditory-visual and visual-auditory discriminations, with the matching of non-identical speech sounds being the most difficult. The types of discriminations required to perform each task are presented in Table 2.

Considering the relationship between pass/fail performance on the auditory discriminations of the ABLA test and communication level (Barker-Collo et al., 1995; Casey & Kerr, 1977; Meyerson, 1977; Vause et al., 2000; Ward & Yu, 2000), Vause et al. examined whether the extension of the ABLA test to include two auditory matching tasks (VANM and AANM) would increase its correlation with communicative ability to a greater extent than the ABLA test alone. Forty individuals with developmental disabilities were included in the study. Participants were assessed on the ABLA levels and auditory matching tasks. In addition, a caregiver of each participant completed the CASS (formerly known as the CSS) (Barker-Collo, 1996) and the communication portion of the VABS (Sparrow et al., 1984). For individuals classified at or above ABLA Level 4, the addition of auditory matching tasks to ABLA Levels 4 and 6 differentiated individual communicative ability to a greater extent than did the ABLA test alone. Concerning predictive validity, Harapiak et al. (2001) conducted a study with 20 individuals with developmental delays and reported that the prototype VANM, AAIM, and AANM tasks were predictive of other VANM, AAIM, and AANM tasks in 96% of cases.

ABLA Test, Auditory Matching, and Verbal Operants

Building on previous research, the relationship between the ABLA test, auditory matching test performances, and performance on a test of echoics, tacts, and mands was examined by Marion et al. (in press). In this study, 38 individuals were first tested on

Table 2

Types of Discriminations Required for the Auditory Discrimination Tasks

Auditory Matching Tasks	Types of Discriminations
Visual-Auditory Non-Identity Matching Task (VANM)	A conditional visual-auditory non-identity discrimination, with color, shape, and size as relevant visual cues and pitch, pronunciation, and duration as relevant auditory cues
Auditory-Auditory Identity Matching Task (AAIM)	A conditional auditory-auditory identity discrimination with pitch, pronunciation, and duration as relevant auditory cues
Auditory-Auditory Non-Identity Matching Task (AANM)	A conditional auditory-auditory nonidentity discrimination with pitch, pronunciation, and duration as relevant auditory cues

levels of the ABLA test and the tests of auditory matching (i.e., AAIM, AANM). Following testing, individuals were directly assessed on a test of vocal imitation, tacting, and manding. To assess vocal imitation, 11 words were presented to each individual, a total of three times each, in the same order. Ten of the eleven words were selected from a list of beginning words suggested by Sundberg and Partington (1998). The participant was given the vocal prompt, "Say (word)." Eleven items were chosen for the tact assessment that represented the words included in the echoic assessment. To assess tacting, the participant was presented with an item and given the vocal prompt, "What's this?" The dependent variable for both assessments was the percentage of correct responses. Correct responses were defined as the pronunciation of all vowels and consonants of a word.

To assess mands, five activities were chosen and were repeated, in the same order, three times each. The activities were as follows: (a) manding for juice in the presence of a cup, (b) pudding in the presence of a spoon, (c) a piece of foam in the presence of ABLA test materials (i.e., box and can), (d) a puzzle piece in the presence of a partially-assembled puzzle, and (e) a pen in the presence of a piece of a paper. To assess a participant's ability to mand, a transitive contrived operation (Shafer, 1994) was used. Shafer discussed a transitive contrived operation as an increase in the value of one stimulus as a result of the presence of another stimulus. To assess an individual's ability to mand for juice, for example, the participant was first given a sip of juice accompanied by the vocal prompt, "Have some." After repeating this twice (and observing the participant consuming the juice), the mand assessment for juice began.

A trial of the mand assessment was broken into four steps. Continuing with the example involving juice, at each step, if the participant said the word correctly or approximated the word (vocalized specific segments of the word), the participant was given the juice and that trial was terminated. If the participant said the word incorrectly, or did not say anything within 10 seconds, the next step was implemented. Step 1 involved providing the prompt "Have some," with the cup present on the table, and the juice hidden underneath the table and out of sight of the participant. Step 2 involved hiding the item underneath the table and giving the participant the vocal prompt, "What do you want?" Step 3 involved presenting the participant with a visual stimulus (the juice), accompanied by the same vocal prompt as in Step 2. Finally, Step 4 involved presenting the visual stimulus, accompanied by the vocal prompt, "Have some. What do you want? Say juice." The dependent variable was the percentage of correct or approximated responses emitted in Step 1 or Step 2.

An 80% correct criterion was used as a pass for vocal imitation, tacting, and manding. Results indicated that: (a) individuals who were only able to pass visual discriminations, Levels 3 and 4 on the ABLA test, passed only 2% of the verbal assessments, (b) individuals who passed up to ABLA Level 6 passed 36% of the verbal assessments, and (c) individuals who passed Level 6, AAIM, and AANM passed 88% of the verbal assessments. Additionally, results showed high test-retest reliability after one month.

When combined with previous research (Vause et al., 2000), these results suggest that an individual's ability to perform ABLA Levels 5 and 6 and the auditory matching tasks are strongly related to communication ability, such that participants who were able to perform more auditory matching discriminations scored higher on the VABS and verbal operant assessments, as compared to individuals who were able to perform fewer auditory matching discriminations.

The present study examined how demonstrating equivalence relates to performance on the ABLA test, and visual-visual non-identity matching.

What is Stimulus Equivalence?

Stimulus equivalence is an efficient and powerful approach for establishing stimulus classes (e.g., Sidman, 1971; Sidman, Kirk, & Willson-Morris, 1985; Sidman & Tailby, 1982; Sidman, Willson-Morris, & Kirk, 1986). In studies conducted by Sidman and colleagues, an equivalence class is defined as a class of at least three members that do not resemble each other but are interchangeable. To achieve equivalence, the relations between members of a stimulus class must possess the following properties: (a) reflexivity, (b) symmetry, and (c) transitivity.

Reflexivity. In a stimulus class of at least three members (A, B, and C), reflexivity is demonstrated if a stimulus is matched to itself (Sidman & Tailby, 1982). Sidman and Tailby discuss reflexivity in terms of generalized identity matching. Generalized identity matching is defined as the matching of a stimulus to itself under conditions in which no reinforcement is provided. For example, given three beverage items (e.g., juice, milk, and water), the individual is demonstrating reflexivity if, in the absence of programmed reinforcement, he or she is able to match the juice to the juice, the milk to the milk, and the water to the water.

Symmetry. Symmetry refers to the reversibility of a conditional relation: If A then B; and if B then A (Sidman & Tailby, 1982). For example, suppose that an individual is taught to match a top hat (sample A) with the printed word HAT (comparison B). If an individual can successfully learn this match, he or she has learned the first relation (If A then B). Subsequent to learning this relation, the individual is now presented with the printed word HAT (now as the sample) and is required to match it, without prior training, to the top hat (now a comparison). If the individual is successful, he or she has demonstrated a symmetric relation (if B, then A). A symmetric relation is typically tested in the absence of direct reinforcement (Devany, Hayes, & Nelson, 1986; Sidman & Tailby).

Transitivity. Transitivity is a conditional relation that emerges as a result of the learning of two prior relations. The two prior relations are: if A, then B; and if B, then C. If the relation, if A then C, emerges in the absence of prior training or differential reinforcement, then transitivity has been demonstrated (Sidman & Tailby, 1982). For example, suppose that an individual is taught two relations: (a) matching a hat (A) to the printed word HAT (B), and (b) matching the printed word HAT (B) to the printed word CLOTHING (C). If an individual is then able to match the hat (A) to the printed word CLOTHING (C), without training, a transitive relation has emerged. Testing the symmetry of the transitive relation, which, in this case involves matching the printed word CLOTHING (C) to the hat (A), has been referred to as simultaneous testing (Sidman & Tailby) or equivalence testing (Sidman, Wynne, Maguire, & Barnes, 1989).

Fields, Verhave, and Fath (1984) commented that in order to establish an equivalence class, N-1 training pairs are required, with N being the total number of stimuli in a class. The equation used to determine the possible number of transitive relations is (N-2) (N-1) / 2. For example, in order to establish a three-member class, two training pairs are needed, and the possible number of transitive or derived relations is one. Osborne and Gatch (1989) comment on the efficiency of these procedures when additional stimuli are trained. For example, in order to establish a six member stimulus class, five training pairs are required, and the possible number of transitive relations is ten.

Conditional discriminations and stimulus equivalence. It is clear that certain prerequisite discriminations must be present in an individual's repertoire in order to establish an equivalence class. For example, matching a top hat with the printed word HAT requires an individual to perform a VVNM discrimination. A question thus arises: are individuals who are unable to pass VVNM discriminations or auditory-visual discriminations, as determined by performance on the ABLA test and a prototype matching task, able to form stimulus equivalence classes involving visual non-identity stimuli?

Research on Stimulus Equivalence

Establishing equivalence classes with abstract and nonsense stimuli. To a large extent, abstract syllables and drawings have been used to teach equivalence relations (e.g., Devany et al., 1986; Dube, Green, & Serna, 1993; Fields, Adams, Verhave, & Newman, 1990; Fields, Newman, Adams, & Verhave, 1992; Lazar, Davis-Lang, & Sanchez, 1984; Sidman & Tailby, 1982; Sigurdardottir, Green, & Saunders, 1990). For example, Sidman and Tailby (1982) studied stimulus equivalence with 8 typically developing children (7 males and 1 female), ranging in age from 5 to 7 years. In this study, each child was explicitly taught three 3-member conditional relations (AB, AC, and DC) involving Greek letters that were presented in a visual or auditory manner.

Results indicated that 6 of the 8 children were able to perform three 4-member stimulus classes. In all, nine relations were taught (i.e., three sample-comparison relations for AB, AC, and DC) and, as a result, six symmetric and transitive relations emerged (i.e., three sample-comparison relations for BC, CB, AD, DB, BD, and CD). Specifically, the authors reported the emergence of three transitive or derived relations (i.e., BC, AD, and DB). Without explicit training, nine oral naming relations also emerged. Therefore, the ratio of emergent to directly trained relations was 27:9.

Establishing equivalence classes with practical stimuli. Abstract symbols and drawings have been widely used in teaching equivalence relations to persons with developmental disabilities (e.g., Barnes, McCullagh & Keenan, 1990; Carr, Wilkinson, Blackman, & McIlvane, 2000; Devany et al., 1986; Dixon & Spradlin, 1976; Eikeseth & Smith, 1992; Saunders, Wachter, & Spradlin, 1988; Vyse & Rapport, 1989). However, a small but growing number of studies have used stimulus equivalence procedures to teach practical repertoires to individuals with developmental disabilities. For example, Sidman (1971), in his first stimulus equivalence study, attempted to teach reading skills to a 17-year-old boy with mental retardation. Prior to the study, the boy demonstrated auditory-visual comprehension (matching visual pictures, names, and colors to dictated words spoken by the experimenter) and visual-auditory comprehension (picture naming), but was unable to comprehend printed words or read them aloud. The participant was explicitly taught to match auditory words spoken by the experimenter to visual words. The teaching of this relation led to emergence of matching visual pictures to visual words (and vice versa) as well as the oral naming of printed words. In the absence of direct training, the individual demonstrated 40 new relations. The participant demonstrated the formation of equivalence classes each consisting of a word, a picture, a dictated word, and the oral name. In an attempt to replicate this study, Sidman and Cresson (1973) used match-to-sample training to teach simple reading skills to 2 boys, 18 and 19 years of age, with Down's syndrome. Unlike the participant in Sidman (1971), both boys had to be explicitly taught to perform generalized identity matching (matching identical printed words) and auditory-visual comprehension (matching dictated words to pictures). Similar to the participant in Sidman, teaching the relation of matching dictated words to visual words led to the automatic emergence of reading comprehension and oral reading.

Over the years, several studies have used a stimulus equivalence paradigm to teach simple reading skills (Sidman, Cresson, & Willson-Morris, 1974) as well as a variety of other practical skills to individuals with disabilities including manual signing (Osborne & Gatch, 1989; VanBiervliet, 1977), pre-arithmetic skills (Gast, Vanbiervliet, & Spradlin, 1979), spelling skills (Stromer & Mackay, 1992, 1993; Mackay, 1985), name-face matching (Cowley, Green, and Braunling-McMorrow, 1992), shopping skills (Taylor & O'Reilly, 2000), monetary skills (Crozier, 1991; McDonagh, McIlvane, & Stoddard, 1984) and relations among consonants, words, and pictures (Carr et al., 2000). The present study added to this literature by attempting to teach relations between pictures, printed words, and symbols to individuals with developmental disabilities.

Stimulus equivalence and language. Among researchers, one area of debate concerns the relationship between stimulus equivalence and language. For example, some researchers (e.g., Dugdale & Lowe, 1990; Horne & Lowe, 1996) argued that the emergence of stimulus equivalence can be accounted for by an individual's language or "naming" skills. Simply stated, individuals who do not possess naming skills will not be able to demonstrate equivalence relations. It was proposed that it is the speaker-listener relationship that accounts for the emergence of naming, whereby symmetrical stimulus-name relations occur when the speaker attends (says) his or her own words as well as comprehends the same words that are spoken to him or her (Dugdale & Lowe). In Sidman's (1996) commentary to the Horne and Lowe article, he provides an example of this statement: "True naming is demonstrated when a child not only says "boy" upon seeing a boy but, having said (or heard) "boy," then points to a boy" (p. 262).

The notion that stimulus equivalence is related to an individual's language ability was also supported by Hayes (1991). In an attempt to empirically support this notion, Horne and Lowe (1996) cite a number of research studies (e.g., Barnes et al. 1990; Devany et al., 1986; Dugdale & Lowe, 1990; Eikeseth & Smith, 1992). For example, Devany et al. (1986) conducted a study with 12 children, with mental ages ranging from 14 to 36 months; chronological ages ranged from 2 years 1 month to 4 years 4 months. The group consisted of 4 normally developing children, 4 children with mental retardation who had some speech skills, and 4 children with mental retardation who had no speech skills. No formal assessment was used to measure speech skills. Results suggested that children who had typical or some language skills were able to demonstrate equivalence classes. However, individuals with mental retardation and no language skills required more trials to learn conditional discriminations and failed to form equivalence classes.

Similarly, Barnes et al. (1990) conducted a study with 6 children who were 3 to 8 years of age. The study included typically-developing children with verbal skills that, according to informant assessment, were appropriate to age level, and hearing-impaired children with verbal skills that were below or above 2 years of age. The authors indicated that verbal ages of the hearing-impaired children were assessed using the Reynell Developmental Language Scales (Reynell & Huntley, 1985). In addition, direct assessment was used to assess tacting skills, whereby an experimenter touched an object and gave the vocal prompt, "What is this?" or emitted a vocal prompt, "Where is the (object)?" With the exception of 1 participant whose verbal skills were determined as below 2 years of age, participants demonstrated an object-word and a word-object tact repertoire. Subsequent to preliminary assessments, participants were taught conditional discriminations involving abstract stimuli. Results indicated that participants acquired the conditional discriminations in about the same number of trials and 5 of 6 participants were able to form equivalence classes. The 1 participant who failed to demonstrate the formation of equivalence classes had the poorest verbal skills and was not able to reliably perform word-object and object-word tacting. Further, in accordance with their argument that a linkage exists between language and stimulus equivalence, Horne and Lowe (1996) cite a series of studies conducted with pigeons, monkeys, baboons, and chimpanzees, whereby stimulus equivalence was not established (e.g., Rodewald, 1974; Hogan & Zentall, 1977; Holmes, 1979; Sidman et al., 1982; Kendall, 1983; D'Amato, Salmon, Loukas, & Tomie, 1985; Lipkens, Kop, & Matthijs, 1988). Lastly, Horne and Lowe offer several criticisms concerning one recent study (Schusterman & Kastak, 1993) in which stimulus equivalence was claimed to be demonstrated, via a match-to-sample procedure, with a sea lion.

In response to Horne and Lowe (1996), researchers (e.g., McIlvane & Dube, 1996; Saunders & Green, 1996) offer several points of criticism. Among their points, they assert that previously cited studies (e.g., Barnes et al., 1990; Devany et al., 1986) present a number of confounds. For example, Saunders and Green suggest that, rather than an inadequate naming repertoire, "an initial history of simple discriminations, fragile baselines, and confounding effects related to instructional control" (p. 313) may have accounted for the inability of some individuals to establish equivalence relations. Further, researchers (e.g., Fields, 1996; McIlvane & Dube; Saunders & Green) comment that criticisms regarding the Schusterman and Kastak (1993) study are unfounded. Sidman (2000) cites additional studies conducted with animals that demonstrate equivalence (e.g., Reichmuth, 1997; Schusterman & Kastak, 1998).

On a related note, some studies (e.g., Dugdale & Lowe, 1990; Eikeseth & Smith, 1992) have reported that teaching individuals to name stimuli can facilitate the learning of equivalence relations. However, a recent study conducted by Carr and Blackman (2001) provided data that does not support this statement. In Sidman's (1996) commentary, he argues, in response to the Dugdale et al. study, that it is unclear whether naming or some other variable is responsible for the emergence of equivalence relations. In his commentary, he refers to his book published in 1994 entitled "Equivalence Relations and Behavior: A Research Story," where he attempts to address the question of how equivalence relations may be formed. He states one possible explanation, "the reinforcement contingency creates the unit and with it, the equivalence relation. The establishment of equivalence relations is, then, one of the outcomes of reinforcement contingencies" (p. 387; Sidman, 1994). When speaking of units of analysis, Sidman (2000) mentions two-term units, three-term units, four-term units, and so on. The two-term unit is synonymous with operant reinforcement, whereby engaging in a particular behavior is followed by a consequence, but engaging in any other behavior is not. A three-term unit, referred to as a simple discrimination, is when a response is followed by a reinforcer in the presence of a particular discriminative stimulus. Building on a three-term unit, a four-term unit is generally referred to as a conditional discrimination in which a reinforcer is provided in the presence of one of two discriminative stimuli whereby a correct response is dependent on the conditional stimulus offered to the participant. When equivalence relations emerge, Sidman asserts that we are speaking of the formation of new analytic units. Further addressing statements made by researchers (Dugdale & Lowe; Horne & Lowe, 1996) concerning the role of naming in the establishment of equivalence classes, Sidman concludes that a name is simply another member of a given class, and is considered equal to all members in the class.

Although Sidman (1996) provides a theoretically sound basis for the formation of stimulus equivalence classes, he states, "if I have any position, it is that data rather than debate will show the way" (p. 258). To date, there are few studies that have examined the relationship between naming and stimulus equivalence, using methodologically sound procedures. Recently, Carr et al. (2000) examined whether adolescents and adults with limited verbal repertoires and severe mental retardation were able to form equivalence relations with visual and auditory stimuli. In Experiment 1, 3 individuals with mental retardation participated in the study. To assess verbal repertoire, each participant was assessed on two direct assessment measures: the Peabody Picture Vocabulary test (PPVT-R; Dunn & Dunn, 1981) and the Gardner Expressive One-Word Picture Vocabulary Test-Revised (EOWPVT-R; Gardner, 1990; as cited in Carr et al.). On these assessments, all participants scored slightly above or below an age-equivalent score of 2 years. None of the participants possessed oral naming skills. Prior to training, participants were able to match dictated words to visual stimuli (an auditory-visual discrimination). Three-choice match-to-sample training, with incorporation of within-stimulus prompting, was used. In this procedure, the participant matched stimuli based on identical stimulus features, and stimuli were gradually transformed over trials until the participant was matching the required non-identical stimuli. Matching dictated words to pictures was an entry skill; participants were explicitly taught to match consonants to their corresponding pictures and abstract forms to pictures. Posttests indicated that participants successfully demonstrated stimulus equivalence, including all symmetric and transitive relations.

Two adolescent males with mental retardation and autism participated in Experiment 2 of Carr et al. (2000). The study reported that 1 participant had a verbal repertoire similar to participants in Experiment 1, and the other had higher oral skills, including an extensive echoic repertoire. The authors indicated that the former participant was assessed on the Derbyshire Language Scheme Assessment (Knowles & Maridlover, 1982), placing him at 2 years of age, and the latter was assessed with the Reynell Developmental Language Scales (Reynell & Huntley, 1985) with a score of 3 years 2 months. The study employed two-choice match-to-sample training with abstract stimuli. Results indicated that the former participant demonstrated one symmetric relation and gradual emergence of the transitive relation and the symmetry of the transitive. The latter participant showed no emergence of symmetric and transitive relations.

Statement of the Problem

Similar to Carr et al. (2000), the present study examined whether individuals with minimal verbal repertoires were able to learn equivalence relations with functional stimuli. Three-choice match-to-sample training, with the incorporation of a within-stimulus prompt fading procedure, was used to attempt to teach an AB relation (matching printed words to pictures) and a BC relation (matching pictures to symbols) to 5 adults with developmental disabilities. For participants who learned the AB and BC relations, they were then tested for stimulus equivalence.

The present study adds to the literature in the following ways: (a) it determined whether individuals with minimal verbal repertoires could learn stimulus equivalence using a more precise measure of "minimal verbal repertoires" than in past studies; and (b) it assessed whether individuals who were able to perform visual non-identity discriminations and auditory-visual discriminations, as measured by the ABLA test, could learn the prerequisite (baseline) discriminations more rapidly, and demonstrate more emergent relations, than individuals who passed only visual identity discriminations, also as measured by the ABLA test.

Three individuals who passed ABLA Level 4, but failed ABLA Level 6 and VVNM, and 2 individuals who passed ABLA Level 6 and VVNM were included in the study. All participants failed VANM, AAIM, and AANM. Participants were matched, as closely as possible, on language, using the assessment of echoics, tacts, and mands, specified by Marion et al. (in press), and two global assessment measures (i.e., PPVT-R; Dunn & Dunn, 1981; VABS, Sparrow et al., 1984). In general, previous studies of a similar nature (e.g., Barnes et al., 1990; Carr et al., 2000; Devany et al., 1986) reported that participants were deficient in language skills when they scored between 1 year of age and 3 years of age on receptive and expressive language assessments. All participants in the present study fell within this range.

The present study provided a test of Horne and Lowe's (1996) naming hypothesis, which suggests that individuals who do not possess prerequisite naming skills should not acquire equivalence relations. Based on several arguments presented by researchers (e.g., Fields, 1996; McIlvane & Dube, 1996; Saunders & Green, 1996; Sidman, 1996; Sidman, 2000), it was hypothesized that individuals with minimal verbal repertoires would be able to demonstrate equivalence relations. Second, considering that the ability to perform arbitrary or symbolic relations is necessary for the testing of equivalence relations, it was hypothesized that individuals who were able to perform these discriminations, as measured by ABLA Level 6 and the prototype VVNM task, would learn AB and BC relations quicker and demonstrate a greater emergence of equivalence relations than individuals who failed ABLA Level 6 and the VVNM prototype task.

Method

Setting and Participants

Assessment and training sessions were conducted in the testing room of the Psychology Department of the St. Amant Centre. The St. Amant Centre is a residential and community training facility for persons with developmental disabilities. The testing room contained a rectangular table with chairs located on each side. During sessions, the tester was seated directly across from the participant. Additional observers, who conducted reliability checks, were seated beside or behind the experimenter.

Five male participants with developmental disabilities participated in the study. They were selected based on their scores on the ABLA test, and because they had minimal language skills (discussed below). Of the 5 participants, 4 individuals resided at the St. Amant Centre, and 1 individual resided at a community home that is affiliated with the Centre. Ages of Participants 1 through 5 were 36, 44, 28, 33, and 27, at the beginning of the study. On the Wechsler Adult Intelligence Scale (WISC-III) (Wechsler, 1997), all participants had a Full Scale IQ score of 45, indicating moderate mental retardation (American Psychiatric Association, 1994). However, considering that performance was "extremely low" (Wechsler), it is likely that the test was insensitive for this population. In the study conducted by Marion et al. (in press), the five participants were assessed on the Scales of Independent Behavior-Short Form (Buininks, Woodcock, Weatherman, & Hill, 1984), which is a measure of adaptive behavior. All participants scored in the severe range. Also, according to agency records, Participant 3 had a diagnosis of autism. Pre-training assessments of the participants, and the assessment results, are discussed in a later section.

Ethical approval for the present study was obtained from the Psychology/Sociology Research Ethics Board (PSREB) of the University of Manitoba. Written consent for participation in the study was obtained according to the following steps. First, families of potential participants were contacted by mail and asked to complete a consent form (for a copy of the project description and consent form, see Appendix A). If a family member completed the consent form and was the legal guardian for the individual, the individual was asked, in a vocal manner, if he or she would like to participate in the study. During this interaction, a staff member was present to witness whether the individual provided his or her assent. For individuals at a low functioning level who had no functional speech, various gestures were observed (e.g., nodding head, smiling). For individuals who did not perform gestures that reliably indicated their willingness to participate in the study, assent was considered if the individual continued to transport to the testing room and participated in assessment and training trials. If the family member was not the legal guardian for the individual, a second step was implemented whereby the legal guardian (i.e., the Public Trustee) was contacted by mail to obtain consent (see Appendix A). If the legal guardian provided consent, the same process concerning obtaining the individual's assent occurred.

Materials

The ABLA tasks. The materials for the ABLA test consisted of a red box with black stripes, a yellow can, a small red block with black stripes, a small yellow cylinder, and a small piece of irregularly-shaped beige foam. Copies of the ABLA data sheets are included in Appendix B.

The VVNM task and auditory matching tasks. Materials for the VVNM task consisted of ABLA test materials (i.e., the red box and yellow can), a green star-shaped piece of wood, and a blue hourglass-shaped piece of wood. Materials for the VANM task consisted of a blue pen and a red block (used in the ABLA test). AAIM and AANM required no materials. Copies of the VVNM and auditory matching data sheets are included in Appendix C.

Verbal operant assessment materials. With the exception of data sheets, no materials were required for the vocal imitation assessment. Materials for the tact assessment included 11 tangible items: a red box and yellow can (ABLA test materials), a piece of beige foam, a blue pen, orange or apple juice in a plastic container, a small Styrofoam cup, a container of chocolate or vanilla pudding, a metal spoon, a round brown bowl, a small puzzle in the shape of a bear that was embedded on a 25 X 38 cm platform, and a sheet of 22 X 28 cm (8 ½ X 11 inch) white bond paper. Materials for the tact assessment were also used to assess manding, with the exception of the round brown bowl. All materials, with the exception of the foam, were selected from a list of beginning words suggested by Sundberg and Partington (1998). Vocal imitation, tact, and mand data sheets are included in Appendix D.

Vineland Adaptive Behavior Scales (VABS). The VABS (Sparrow et al., 1984) is a standardized test and has been used to assess the personal and social sufficiency of individuals from birth to adulthood. The communication portion of the Interview Edition, Expanded Form of the VABS was administered to a care-worker of each participant. Three communication subdomains of the VABS were administered: (a) Receptive, (b) Expressive, and (c) Written subdomains. The Receptive, Expressive, and Written communication subdomains are represented by 23 items, 76 items and 34 items, respectively. These items were rated on a scale ranging from 0 (no, never) to 2 (yes, usually). The Communication domain was reported to have good internal consistency reliability, which ranged from .84 to .97 across the 15 age groups. Test-retest reliability and construct validity were not computed for the Expanded Form, but were computed for the Survey Form. It is possible to make reasonable estimates based on the Survey Form (Sparrow et al.). For the Survey form, test re-test reliability ranged from .95 to .99 for all domains. The Communication Domain is correlated with intelligence tests, hearing vocabulary, and achievement tests.

Peabody Picture Vocabulary Test (PPVT-R). The PPVT-R (Dunn & Dunn, 1981) is a standardized test used to directly assess receptive vocabulary for individuals ranging from 2 years 6 months to 40 years 11 months. More specifically, the test assesses an individual's "listening repertoire" whereby he was asked to match spoken words to corresponding line drawings of objects or events in everyday life (Carr et al., 2000). The test contains a total of 175 items. Regarding retest reliability of one year or less, the PPVT-R has a median correlation of .75 for raw scores. Further, it is acknowledged that "stability of PPVT scores decreases as the length of time between testings increases" (Dunn & Dunn). The PPVT-R is correlated with intelligence tests, vocabulary tests, and achievement tests.

Wechsler Adult Intelligence Scale (WAIS-III). The Wechsler Adult Intelligence Scale-III (Wechsler, 1987) is a standardized assessment of intelligence that provides three composite scores (Verbal, Performance, and Full Scale). It contains 14 subtests with an equal number of Verbal and Performance subtests.

Stimuli required for pretesting and posttesting relations. The same materials were used for pretesting, training, and posttesting of match-to-sample relations. The materials included nine 10 X 15 cm white plasticized cards that each contained a picture, a printed word, or a symbol. Refer to Figure 1 for a copy of the stimuli, in black-and-white, indicating three 3-member stimulus classes. Printed words included (a) the word DISK (A1), with letters filled with blue and white polka-dots, located in the center of the card,

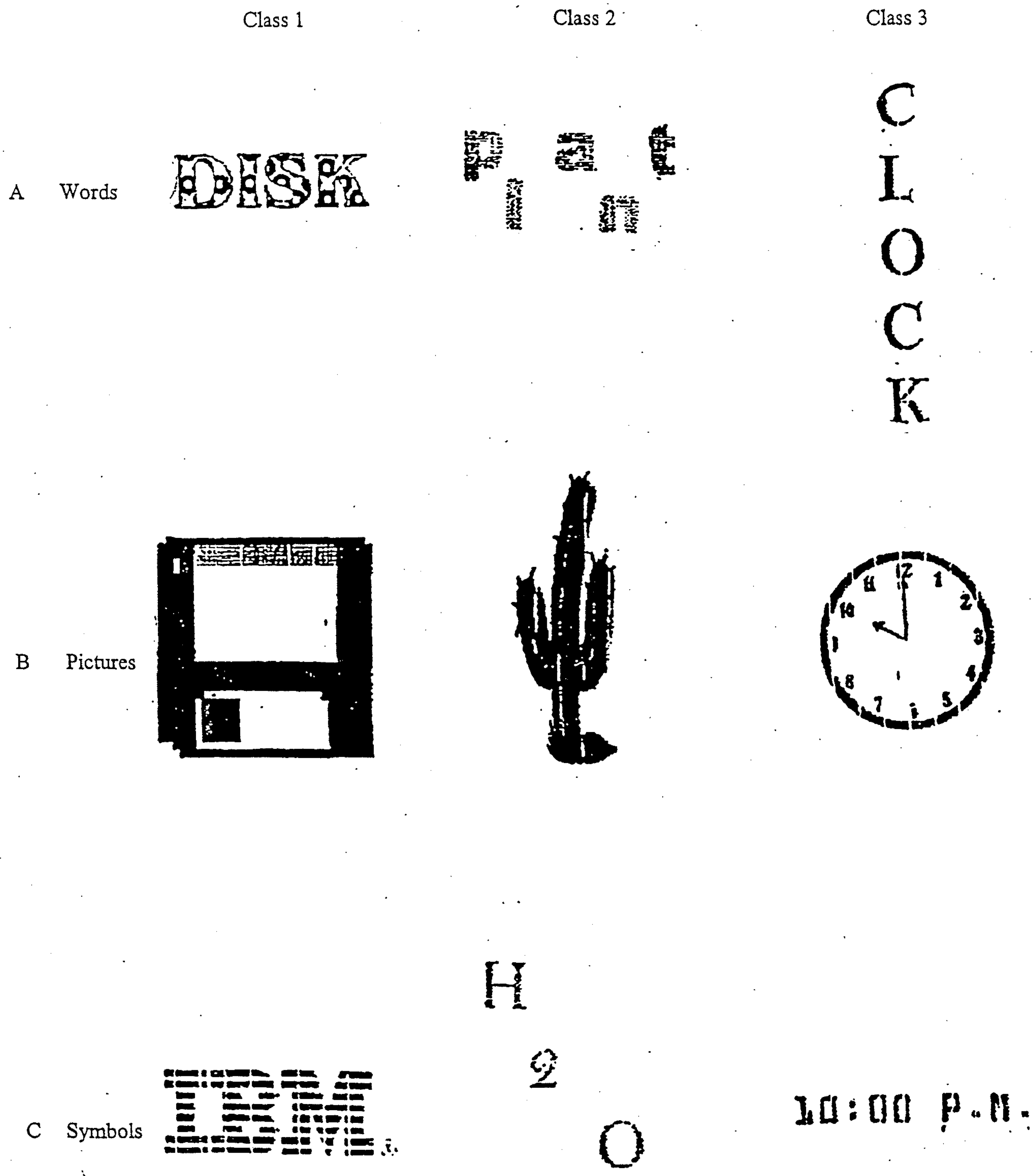


Figure 1. Three 3-member stimulus classes.

(b) the word plant (A2), alternating lowercase letters in light blue and pink, in the center of the card with the "l" and "n" positioned lower than the other letters, and (c) the word CLOCK (A3), with the respective letters positioned down the card. Pictures were (a) a black computer disk in the center of the card (B1), (b) a green cactus with a black outline displayed on the left side of the card (B2), and (c) a clock consisting of a red outline and black numbers and hands and displayed at the bottom right of the card (B3). Symbols included (a) the printed symbol IBM (C1), in black stripes, positioned at the bottom of the card, (b) the printed symbol H20 (C2), in yellow, running diagonally from left to right, and (c) the symbol 10:00 pm (C3) written, in brown, at the top of the card. The different colors, orientations of letters, and placements of the stimuli on the card were used to exaggerate the differences between stimuli and to facilitate discriminations for individuals with developmental disabilities. Stimuli were placed on a brown wooden board that was 46 cm by 42 cm and divided, by two thin wooden bars, into three 15 cm sections (see Figure 2). Additional materials used for training purposes are presented in Appendix E. See Appendix F for pretest, training and posttest data sheets.

Pretraining Assessments and Assessment Results

ABLA assessments, VVNM assessment, and tests of auditory matching. Each ABLA level is described in Table 1. The VVNM task and the tests of auditory matching are described in the Introduction. According to procedures specified by Kerr et al. (1977), each participant was assessed on the ABLA tasks and additional visual (VVNM) and auditory tasks (VANM, AAIM, and AANM). Throughout all testing sessions, a continuous reinforcement schedule (CRF) was used whereby each correct response was immediately followed by verbal praise (e.g., "Good job!"). An incorrect response was

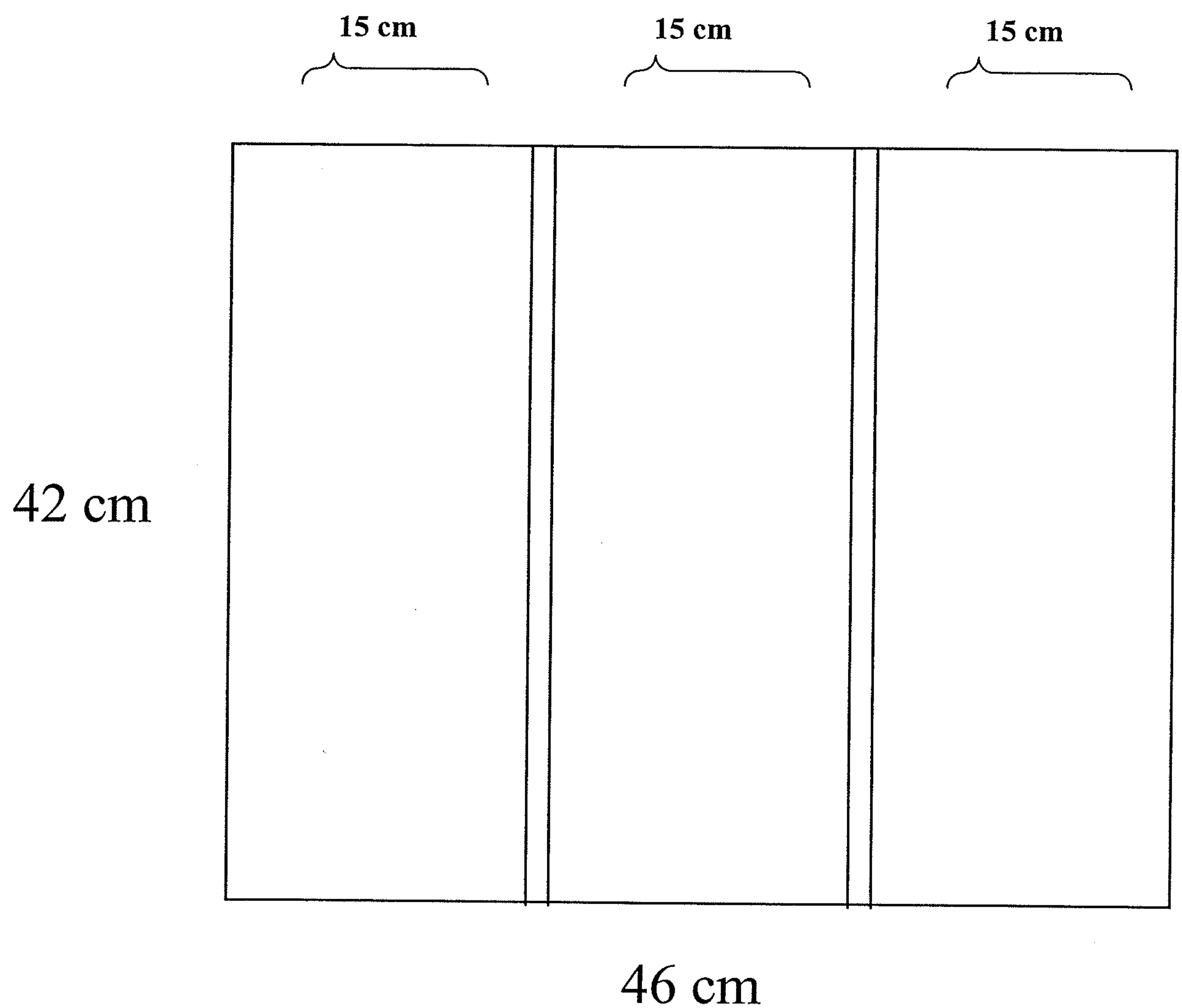


Figure 2. Wooden board that the stimuli were placed on.

followed by a correction procedure that consisted of a demonstration, a guided trial, and an opportunity for an independent response. Testing continued for each task until either eight consecutive correct responses (passing criterion) or eight cumulative errors (failing criterion) occurred.

Prior to testing, in accordance with the ABLA procedure, a demonstration, a guided trial, and an opportunity for an independent response were provided. Individuals did not advance to test trials until they were able to perform one independent correct response with each sample stimulus. If, after a number of trials, the individual was not able to demonstrate an independent correct response, the experimenter used his or her discretion to discontinue. If trials on any level were discontinued, the individual was classified at the previous level. Participants 1 through 3 passed ABLA Level 4, but failed Levels 5 and 6, VVNM, VANM, AAIM, and AANM. Participants 4 and 5 passed all six ABLA levels and the VVNM prototype task but failed the prototype tasks for VANM, AAIM, and AANM.

Assessment of vocal imitation, tacts, and mands. Subsequent to ABLA and auditory matching assessments, participants were assessed on vocal imitation, tacting, and manding according to procedures specified by Marion et al. (in press), and as summarized in the introduction. Briefly, to assess vocal imitation, the participant was presented with 11 words in a predetermined sequence. The same sequence was repeated three times. For each word, the experimenter presented a vocal cue, "Say (word)." Items used for the tact assessment represented the words used to test vocal imitation. In the tact assessment, the participant was presented with the item and vocally asked, "What's this?" For vocal imitation and tact assessments, differential reinforcement was provided.

Correct responses, which were defined as the pronunciation of all vowels and consonants of a word, were reinforced with verbal praise (e.g., "Good job!"). When an individual approximated a response or made no response, after a duration of 10 seconds, the experimenter said, "Thank-you" in a neutral voice. After every third trial, in an attempt to maintain responding of the participant, an activity was presented which consisted of rolling a small blue ball across the table and reinforcing the participant with verbal praise for catching it and/or rolling it back to the experimenter.

The mand assessment consisted of five activities: (a) manding for juice in the presence of a cup, (b) pudding in the presence of a spoon, (c) a piece of foam in the presence of ABLA test materials (i.e., box and can), (d) a puzzle piece in the presence of a partially assembled puzzle, and (e) a piece of paper in the presence of a pen. Each activity was repeated three times, for a total of 15 trials. Before each test trial began, the participant was presented with the item accompanied by a vocal prompt indicating that the participant should consume the item (e.g., for the pudding, the prompt was, "Have some."), or engage in the activity (e.g., for the puzzle, the vocal prompt was, "Put it together."). Before each test trial, the action was repeated twice. Then, depending on the trial, the item to be manded (e.g., juice) was hidden underneath the table, and another item (e.g., cup) was placed on top of the table. The participant was provided with verbal praise and access to the item if he said the word correctly, or approximated the word. If the participant did not say the word correctly or approximate the word, after a duration of 10 seconds, the experimenter said, "Thank-you" in a neutral voice. Then, the experimenter said, "Have some. What do you want?" while the item to be manded was still hidden. Criterion for access to the item was the same as Step 1. In the Marion et al.

(in press) study, the pass criterion for each verbal operant assessment was 80%. None of the participants reached this criterion. Specific scores of participants on the vocal imitation, tact, and mand assessments are presented in Table 3.

Standardized language assessment measures. The experimenter administered the communication portion of the VABS (Sparrow et al., 1984) to a primary caregiver of each participant. Concurrently, participants were directly assessed on the PPVT-R (Dunn & Dunn, 1981). At the end of the study, participants who met mastery criterion for the two trained discriminations and tested for stimulus equivalence were posttested on the VABS (Sparrow et al.) and the PPVT-R (Dunn & Dunn). Posttest results on the standardized language assessments are presented in Table 3, and reviewed in the Results section (refer to p. 64).

Pretesting stimulus equivalence relations. For the three 3-member stimulus classes presented in Figure 1 (see p. 31), nine relations (AA, BB, CC, AB, BA, AC, CA, BC, CB) were tested, with 18 trials per relation, for a total of 162 test trials. See Table 4 for a detailed description of relations that were pretested. In a set of 18 trials, each stimulus served as the sample an equal number of times, and the same sample did not appear on more than two consecutive trials. Also, the correct comparison did not appear in the same position on more than two consecutive trials (Green, 2001; Green & Saunders, 1998). A three-choice match-to-sample format was used. Three comparison stimuli (one correct comparison stimulus and two incorrect comparison stimuli) were placed at the top of the wooden board that was centered with the participant's shoulders. The stimuli were placed on the board from the participant's left to right. The participant was presented, at his eye level, with the sample stimulus. The correct response was to

Table 3

Results on Tests of Language for the Five Participants

Participant	ABLA Level	Vocal Imitation (pretest; posttest)	Tacts (pretest; posttest)	Mands (pretest; posttest)	Age-Equivalent on the Communication Domain of the VABS (pretest; posttest)	Age-Equivalent on the PPVT-R (pretest; posttest)
1	4	0%	0%	0%	1 year, 3 months	1 year, 10 months (untestable)
2	4	0%	0%	0%	1 year, 5 months	2 years, 0 months
3	4	73%	18%	0%	2 years, 2 months	2 years, 0 months
4	6	39%; 18%	30%; 27%	67%; 67%	1 year 6 months; 1 year 6 months	2 years, 7 months; 2 years 5 months
5	6	33%; 27%	3%; 6%	6%; 0%	1 year 8 months; 1 year 6 months	2 years, 3 months; 3 years, 3 months

Note. ABLA tests were administered as specified by Kerr et al., 1977; tests of Vocal Imitation, Tacts, and Mands were administered as described by Marion et al. (in press); the VABS was developed by Sparrow et al. (1984); and the PPVT-R by Dunn and Dunn (1981).

Table 4

Relations That Were Pretested

Relations	Sets of Stimuli
AA	A1 to A1, with A1, A2, and A3 as comparisons
	A2 to A2, with A1, A2 and A3 as comparisons
	A3 to A3, with A1, A2 and A3 as comparisons
BB	B1 to B1, with B1, B2, and B3 as comparisons
	B2 to B2, with B1, B2, and B3 as comparisons
	B3 to B3, with B1, B2, and B3 as comparisons
CC	C1 to C1, with C1, C2, and C3 as comparisons
	C2 to C2, with C1, C2, and C3 as comparisons
	C3 to C3, with C1, C2, and C3 as comparisons
AB	A1 to B1, with B1, B2, and B3 as comparisons
	A2 to B2, with B1, B2, and B3 as comparisons
	A3 to B3, with B1, B2, and B3 as comparisons
BC	B1 to C1, with C1, C2, and C3 as comparisons
	B2 to C2, with C1, C2, and C3 as comparisons
	B3 to C3, with C1, C2, and C3 as comparisons
BA	B1 to A1, with A1, A2, and A3 as comparisons
	B2 to A2, with A1, A2, and A3 as comparisons
	B3 to A3, with A1, A2, and A3 as comparisons
CB	C1 to B1, with B1, B2, and B3 as comparisons
	C2 to B2, with B1, B2, and B3 as comparisons
	C3 to B3, with B1, B2, and B3 as comparisons
AC	A1 to C1, with C1, C2, and C3 as comparisons
	A2 to C2, with C1, C2, and C3 as comparisons
	A3 to C3, with C1, C2, and C3 as comparisons
CA	C1 to A1, with A1, A2, and A3 as comparisons
	C2 to A2, with A1, A2, and A3 as comparisons
	C3 to A3, with A1, A2, and A3 as comparisons

place the sample stimulus on top of or behind the correct comparison. Placing the sample behind the comparison stimulus was defined as placing the sample on the bottom of the brown wooden board (from the participant's view) in the section on the board that contained the correct comparison (refer to description of brown wooden board; see Figure 2). During pretesting, differential reinforcement was not provided. All responses were followed by the experimenter saying, "Thank-you." However, considering the reinforcement history of participants for correct responding on tabletop tasks (e.g., the ABLA test), an edible was presented immediately before each trial began. It was assumed that this would maintain participants' responding during pretesting, without influencing the results. Pretest results of the 5 participants for reflexive relations (AA, BB, and CC) and six non-identity relations (AB, BC, BA, CB, AC, CA) are presented in Figure 3. For Participants 1 through 3, who passed up to ABLA Level 4, pretesting scores for reflexive relations AA, BB, and CC were 39%, 61%, and 55%, respectively; 28%, 100%, and 50%, respectively; and 94%, 100%, and 89%, respectively. Results for the six non-identity relations ranged from 28% to 44% (mean = 34%) for Participant 1; 33% to 50% (mean = 37%) for Participant 2; and 17% to 44% (mean = 28%) for Participant 3. Participant 4, who passed up to ABLA Level 6, scored 100% on all reflexive relations; Participant 5 scored 100%, 94%, and 100%, on the reflexive relations, respectively. Results for the six non-identity relations ranged from 22% to 33% (mean = 31%) for Participant 4; and 28% to 72% (mean = 46%) for Participant 5.

Training Procedure to Teach the Match-to-Sample Relations, AB and BC, Prior to Testing For Stimulus Equivalence

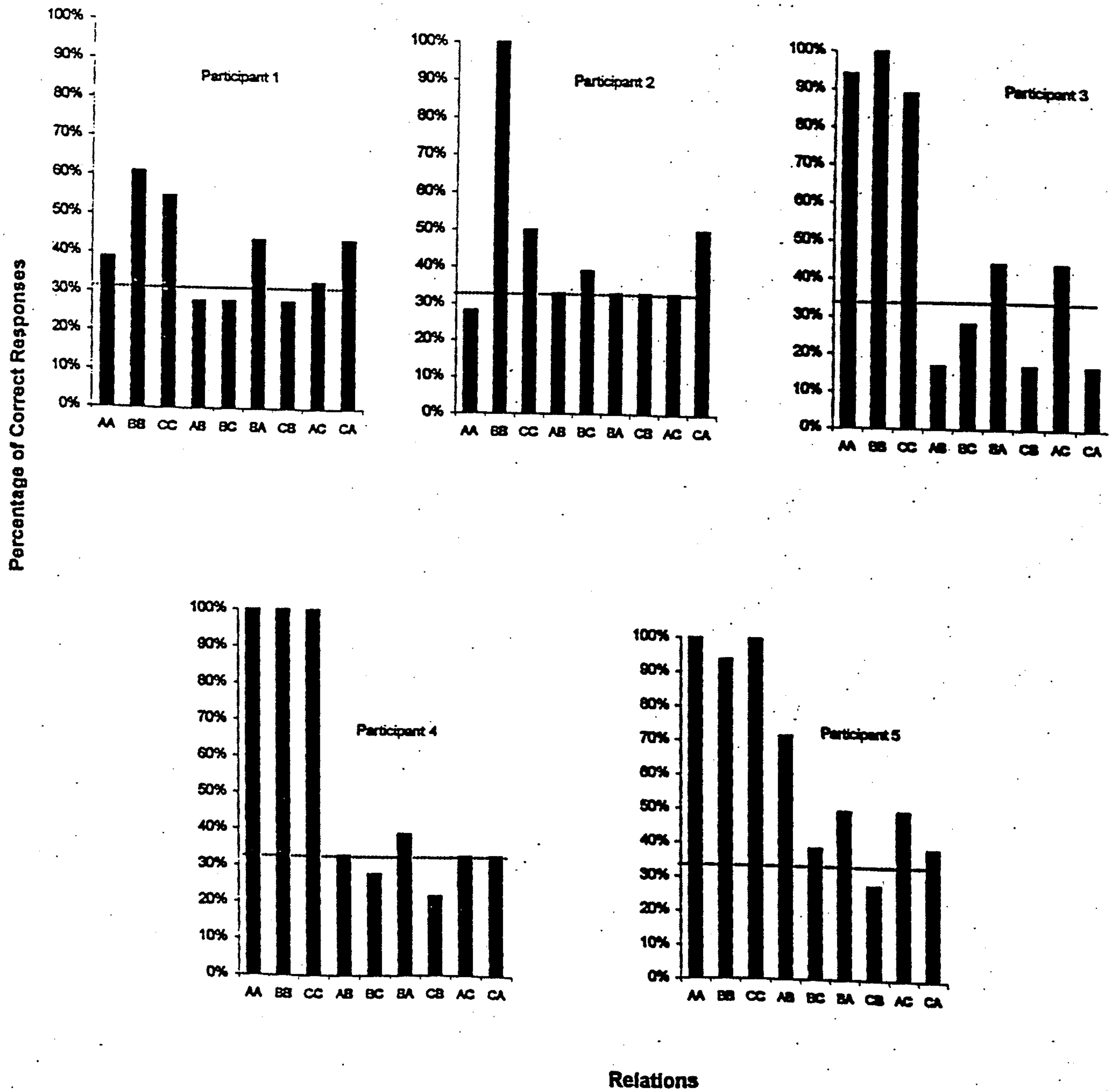


Figure 3. Pretest Results for the Five Participants. The dashed lines represent chance performance (i.e., 33%).

The general goal of many stimulus equivalence studies is to teach participants to match A stimuli to B stimuli, and B stimuli to C stimuli, so that participants can be tested to see if they are able to demonstrate stimulus equivalence. While the goal of some studies of stimulus equivalence has been to focus on the extent to which different training procedures impact the degree to which stimulus equivalence can be demonstrated, this was not a concern of the present study. Rather, the goal of this research was to attempt to use training procedures that have been shown to be effective, to teach Participants 1, 2, and 3, who had minimal language skills and passed ABLA Level 4, and Participants 4 and 5, who had minimal language skills and passed ABLA Level 6, to master AB and BC relations so that tests of stimulus equivalence could be given and the performances compared. For this study, mastery criterion for advancing to the posttest was two consecutive sessions, for both AB and BC, of at least 15 out of 18 correct responses, with no more than one incorrect response per relation. Throughout training, multiple components were used. If minimal or no progress was observed after a number of trials with certain components, they were deleted and additional components were added. The various training components used are briefly described below. A detailed description of the training components and procedures is presented in Appendix E.

a. Reinforcer preference was assessed at the beginning of each session in order to identify effective reinforcers;

b. A procedure was used to ensure that participants were attending to stimuli at the beginning of each trial;

c. Guidelines outlined by Green and Saunders (1998) concerning trial presentation were followed as closely as possible, see p. 36;

d. Social and edible reinforcers were provided contingent upon correct responding;

e. An correction procedure was implemented following errors;

f. Initially, training with a three-choice match-to-sample task (one sample and three comparisons; refer to items g and h) was implemented; when this proved to be unsuccessful, mastery of a two-choice task (one sample and two comparisons) was taught before progressing to a three-choice match-to-sample task;

g. *Position fading* of the incorrect comparison stimulus, in a three-choice match-to-sample task, was implemented whereby, across trials, the correct comparison stimulus was maintained in its target location, and incorrect comparison stimuli (i.e., blank cards) were initially out of reach of the participant, and were gradually faded toward their target position contingent upon correct responses. When this occurred, the blank cards were replaced by picture stimuli;

h. Because position fading was unsuccessful, *size fading of the incorrect comparison stimuli*, in a three-choice match-to-sample task, was used. Across trials, the correct comparison stimulus was presented at its target size, and the incorrect stimuli were initially presented at a very small size, and then were gradually increased to their target size across steps;

i. Because size fading of the incorrect stimuli was unsuccessful, *size fading of one comparison stimulus*, in a two-choice match-to-sample task, that, across trials, served as both the correct and incorrect comparison was used. The sample stimuli and the other comparison stimulus remained at their target size. The comparison stimulus was initially presented at a very small size, and then was gradually increased to its target size across steps;

j. When mastery criterion was achieved with size fading of one comparison stimulus, in a two-choice match-to-sample task, size fading occurred with a third comparison stimulus, during which the third stimulus was presented at a very small size, and then gradually increased to its target size across steps;

k. For Participants 1, 2, and 3, the blocking procedure of Saunders and Spradlin (1989, 1990) was also used in blocks of ten trials and blocks of five trials, whereby the same sample stimulus was presented across blocks;

l. For Participants 1, 2, and 3, in addition to the size fading of one comparison stimulus described in item g, one sample stimulus was initially presented at a very large size, and then was decreased in size across steps;

m. For Participants 1, 2, and 3, direct-response reinforcement (Thompson & Iwata, 2000) was used, whereby the experimenter placed a preferred edible directly under the correct comparison stimulus;

n. For Participants 4 and 5, who mastered some of the tasks but showed consistent errors with a particular stimulus, position fading (as described in item g) was used;

o. For Participant 5, because position fading was unsuccessful, one comparison stimulus that was initially faded from a small size to its target size (see item i) was presented at a very large size and gradually decreased in size across steps. *Color fading* was also used whereby the clock face was on a white background, and the color of the face was initially dark gray, and was faded to light gray, and, finally, to white.

Periodic review of AB while training BC. After participants mastered the AB relationship, they were trained, using a combination of procedures that were successful in teaching AB, on the BC relationship. During training of BC, participants were given a periodic review of, and reinforcement for responding correctly on AB trials. For Participant 5, due to behavioral problems, AB trials were interspersed among BC trials in a 1:3 ratio. Details of the review are described in a later section.

Bridge Between Training and Testing of Equivalence Relations with Respect to Reinforcement Delivery

Before advancing to Posttest for Participants 4 and 5, they were required to meet the same criterion, set for mastery of AB and BC, on one session of 18 trials (i.e., at least 15 out of 18 with no more than one error per stimulus class) with no differential reinforcement. This was conducted to ensure that performance was maintained, on taught relations, in the absence of differential reinforcement. As in pretesting, a reinforcer was presented before each trial began, and correct and incorrect responses were followed by the vocal response, "Thank-you."

Testing for Equivalence

Figure 4 provides a diagram outlining relations tested, and potential emergent relations. Similar to pretesting, all test relations were conducted in the absence of differential reinforcement. In an attempt to maintain responding, immediately before each trial began, the participant was presented with a preferred consumable item. Due to

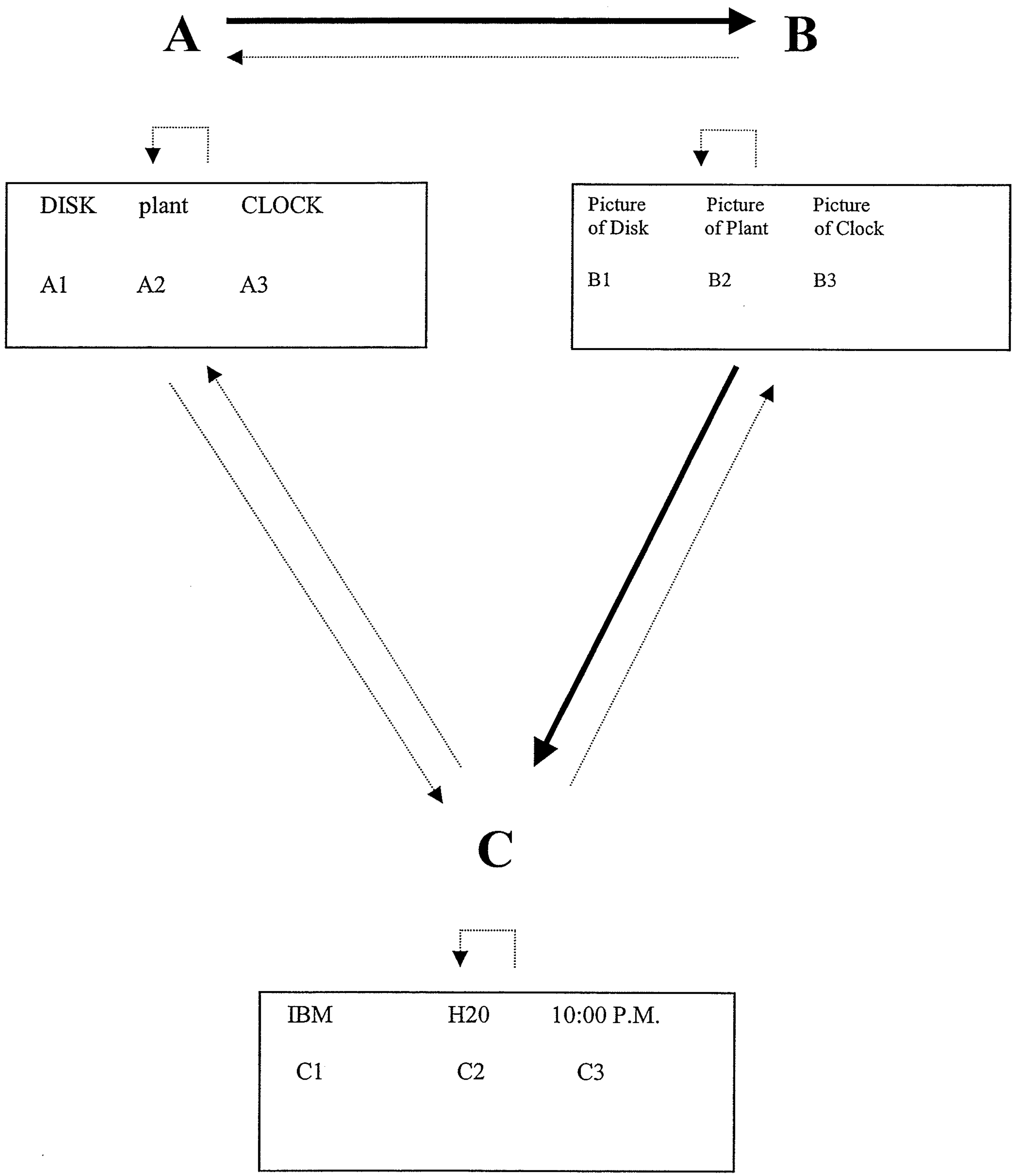


Figure 4. The straight dark arrows represent ***trained*** relations and the straight dotted arrows represent the possible ***emergent*** relations. Reflexive relations are indicated by the curved arrows.

performance on posttesting for both participants (see Results section), additional training was implemented, and repeated posttests were conducted, as summarized below.

Variations in posttesting for Participants 4 and 5.

Participant 4. See Table 5 for the sequence of training, posttesting, and re-training for Participant 4. Posttest 1 began with the testing of the transitive relation and symmetry of the transitive, followed by the testing of symmetric and reflexive relations. Posttest 2, on the other hand, involved testing the symmetric relations first, followed by testing of the transitive relation, the symmetry of the transitive, and, finally, the reflexive relations (see Table 5). Also, in Posttest 2, taught relations were interspersed, in massed trial blocks, with test relations (i.e., AB preceded BA; BC preceded CB). The rationale for these changes is explained in the Discussion section.

Participant 5. See Table 6 for the sequence of training, posttesting, and re-training for Participant 5. Posttests for Participant 5 involved testing symmetric relations, followed by the transitive relation, the symmetry of the transitive, and, finally, reflexive relations. Also, following the training procedure for taught relations AB and BC, all posttests involved interspersing taught relations with test relations, using a 1: 1 ratio, with taught relations preceding all test relations (refer to Table 6). Also, during Posttests 3 and 4, taught relations were reinforced. The rationale for this change is explained in the Discussion. In an attempt to maintain responding and eliminate behavioral problems during posttests and retraining, after approximately 9 to 24 trials, the participant was presented with an activity (e.g., drawing) for approximately 1 to 2 minutes. Due to

Table 5

Sequence of Training, Posttesting, and Re-training for Participant 4

Type	Differential Reinforcement	Order of Relations Trained/Tested	# Of Trials
Train AB	Yes		Mastery Criterion for AB: 2 sets of 18 trials (at least 15/18 correct with no more than one error per stimulus class)
Train BC (while reviewing AB)	Yes	AB, BC	Same as criterion for AB
Continue training AB and BC	Yes		Criterion to Advance to Posttest: 2 consecutive sessions of 18 trials for AB and BC (at least 15/18 correct with no more than one error per stimulus class) in one session
Posttest #1	No	AC, CA (transitive and symmetry of transitive); CB, BA (symmetric); AA, BB, CC (reflexive)	18 trials per relation
Re-train AB and BC	Yes		Same as Criterion to Advance to Posttest #1
Bridge Training of AB and BC	No		18 trials per relation
Posttest #2	No	AB, BA (trained and symmetric); BC, CB (trained and symmetric); AC, CA (transitive and symmetry of transitive); AA, BB, CC (reflexive)	18 trials per relation
Retention (1 month after Posttest #2)	Same as Posttest #2		

Table 6

Sequence of Training, Posttesting, and Re-training for Participant 5

Type	Differential Reinforcement	Order of Relations Trained/Tested	Interspersed Training Ratio	# Of Trials
Train AB	Yes			Mastery Criterion for AB: 2 sets of 18 trials (at least 15/18 correct with no more than one error per stimulus class)
Train BC (while reviewing AB)	Yes	BC: AB	3:1	Same as criterion for AB
Continue training AB and BC	Yes			Criterion to Advance to Posttest: 2 consecutive sets of 18 trials for AB and BC (at least 15/18 correct with no more than one error per stimulus class) in one session
Bridge Training of AB and BC	No			18 trials per relation
Posttest #1	No	BC: CB (trained and symmetric); AB: BC: AC (trained and transitive); AB: BC: CA (trained and symmetry of transitive); AA, BB, CC (reflexive); AB: BA (trained and symmetric)	1:1	18 trials per relation

Table 6 cont'd (Participant 5)

Type	Differential Reinforcement	Order of Relations Trained/Tested	Interspersed Training Ratio	# Of Trials
Retrain BC	Yes			Same as criterion for Train BC
Posttest #2	No	AB: BA (trained and symmetric) BC: CB (trained and symmetric); AB: BC: AC (trained and transitive); AB: BC: CA (trained and symmetry of transitive); AA, BB, CC (reflexive)	Same as Posttest #1	
Retrain AB and BC	Yes			Same as criterion for Continue training AB and BC
Posttest #3	Yes; for trained relations (AB and BC)	Same as Posttest # 2, with no testing of reflexive relations		
Retrain AB and BC with two-choice match-to-sample (eliminated clock stimuli)	Yes			Same as criterion for Retrain AB and BC (with the exception of 12 trials per relation rather than 18)
Posttest #4, 2-choice	Same as Posttest # 3			12 trials per relation

Table 6 cont'd (Participant 5)

Type	Differential Reinforcement	Order of Relations Trained/Tested	Interspersed Training Ratio	# Of Trials
Retention, 2-choice (1 month after Posttest 4)	Same as Posttest #3			
Retention, 3-choice (1 month after Posttest 4)	Yes; for trained relations (AB and BC)	Same as Posttest # 3, with testing of reflexive relations		

extraneous stimulus control (see Results section) that was evident in Posttests 1, 2, and 3 for Participant 5, the clock stimuli (A3, B3, and C3) were removed in Posttest 4.

Retention

Approximately one month after the final posttest, retention of performance was tested (see Tables 5 and 6).

Reliability Assessments

For inter-observer reliability (IOR) checks, an observer and a tester independently recorded the responses of each participant. An agreement was scored if both persons recorded the same response (i.e., correct or incorrect) on a given trial. In contrast, a disagreement was scored if both persons recorded different responses on a given trial. Agreement scores were calculated across trials for each participant by dividing the number of agreements by the number of agreements plus disagreements and then multiplying by 100%. IOR checks for trial outcome were conducted on 86% of ABLA testing and auditory matching tests, 81% of verbal operant tests, 71% of pretest sessions, 47% of training sessions, and 79% of posttest sessions. Across participants, IOR scores for ABLA and auditory matching tests ranged from 93% to 100% (mean = 100%). On verbal operant tests, IORs ranged from 67% to 100% (mean = 82%). For pretesting, training, and posttesting sessions, IORs ranged from 99% to 100% (mean = 100%), 93% to 100% (mean = 100%), and 94% to 100% (mean = 100%), respectively. All reliability checks are rounded off to the nearest whole number.

Procedural reliability (POR) checks were conducted to ensure that key treatment components (e.g., proper set-up of materials, appropriate consequences for correct and incorrect responses) were implemented by the tester. During POR checks, an observer recorded whether steps were carried out correctly by the experimenter on each trial according to procedural checklists (see Appendix section). In addition, a reliability check of the POR was conducted by a second observer for many of the POR checks. An agreement was scored if both persons agreed that a procedural component was implemented on a given trial. In contrast, a disagreement was scored if both observers did not agree that a procedural component was implemented on a given trial. Reliability of POR checks was calculated in the same manner as IOR assessments.

POR checks for trial outcome were conducted on 61% of ABLA testing and auditory matching tests, 86% of verbal operant tests, 53% of pretest sessions, 36% of training sessions, and 77% of posttesting. Across participants, POR scores for ABLA and auditory matching tests ranged from 93% to 100% (mean = 100%). For verbal operant tests, PORs ranged from 86% to 100% (mean = 98%). For pretesting, training, and posttesting sessions, PORs ranged from 95% to 100% (mean =100%), 90% to 100% (mean = 100%), and 90% to 100% (mean = 94%), respectively. Numbers were rounded off to the nearest whole number.

Reliability checks for POR scores were conducted on 61% of ABLA testing and auditory matching tests, 67% of verbal operant tests, 51% of pretest sessions, 34% of training sessions, and 77% of posttest sessions. Reliability of POR scores for ABLA and auditory matching tests ranged from 70% to 100% (mean = 96%). For verbal operant tests, IORs ranged from 93% to 100% (mean = 99%). For pretesting, training, and posttesting sessions, IORs ranged from 95% to 100% (mean = 100%), 85% to 100% (mean = 99%), and 95% to 100% (mean = 100%), respectively. Numbers were rounded to the nearest whole number. For a copy of procedural reliability data sheets, see Appendix section.

Results

Despite attempts to use several stimulus control techniques and consequence manipulations, Participants 1 through 3 were not able to meet mastery criterion for relation AB with only two comparison stimuli. Visual inspection of the data indicated that position biases and stimulus preferences occurred throughout training. Combining all procedures for Participants 1 through 3, the total number of training trials for AB were 1808, 2158, and 1995, respectively.

Participant 4

Combining all procedures for Participant 4, who passed up to ABLA Level 6, the total number of training trials to reach mastery criterion for the AB and BC relations were 1375 and 756, respectively. Results of pretesting and posttesting for Participant 4 are presented in Figure 5.

Pretest. As shown in Figure 5, Participant 4 scored 100% on the pretests for reflexive relations (AA, BB, and CC). Pretest scores for the six non-identity relations ranged from 22% to 33% (mean = 31%).

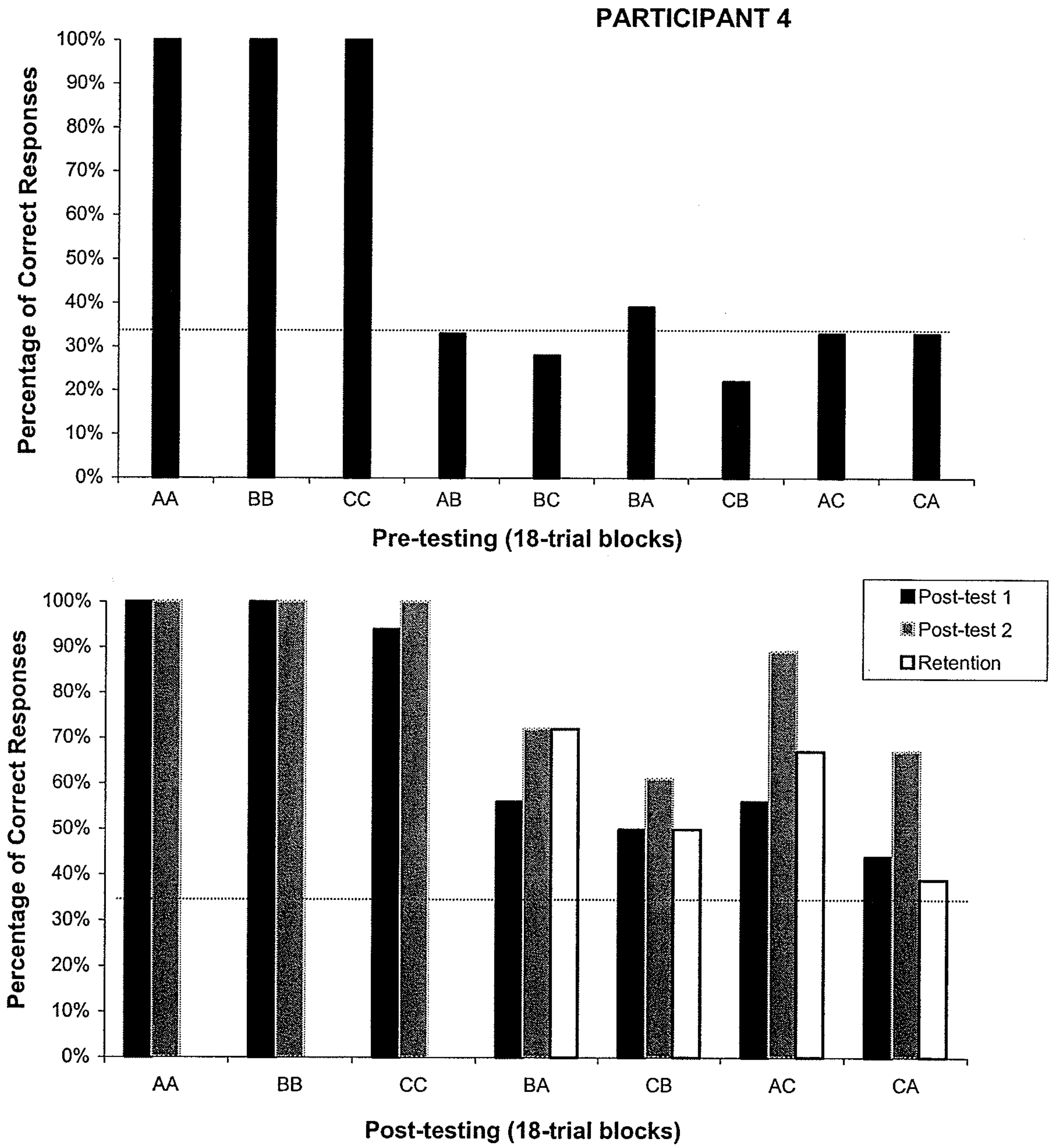


Figure 5. Pretest and posttest results for Participant 4. The dashed line indicates chance performance.

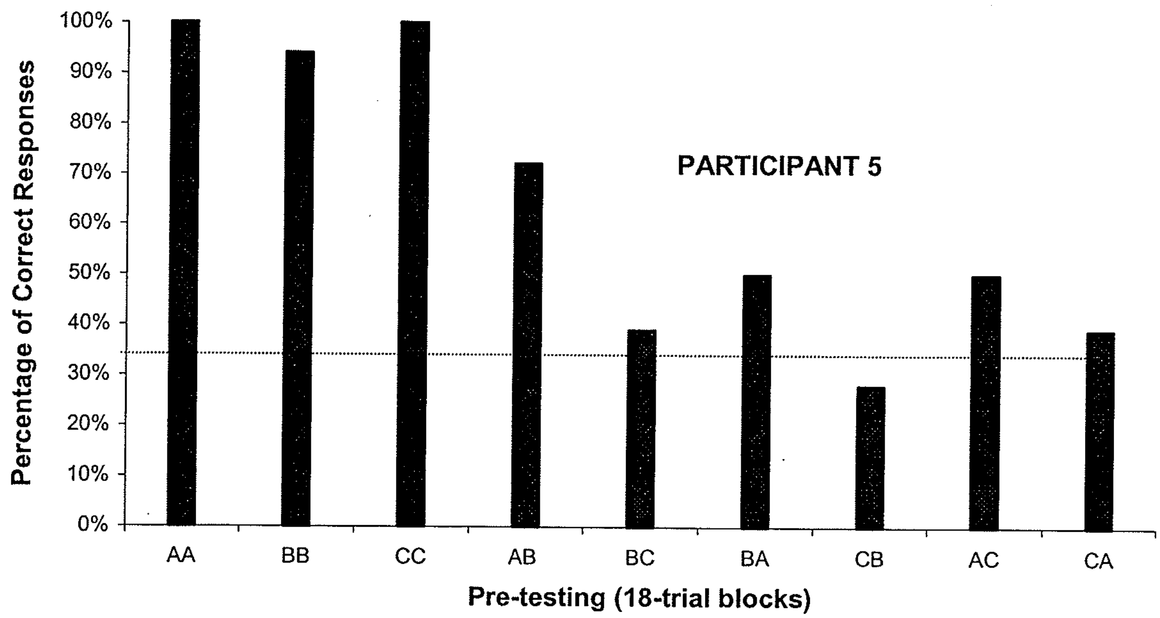
Posttest 1. After demonstrating mastery on the AB and BC relations, Posttest 1 scores for reflexive relations (AA, BB, CC) remained high (see Figure 5). The taught relations, AB and BC, were not tested, but their symmetric relations, BA and CB, rose to 56% and 50%, respectively. The transitive relation, AC, rose to 56%, and the symmetry of the transitive relation, CA, rose to 44%.

Posttest 2 with AB and BC interspersed. On Posttest 2, subsequent to retraining AB and BC relations to mastery criterion, the reflexive relations remained high. AB and BC, the taught relations that were interspersed with the test relations, remained intact at 100% and 94%, respectively (not shown in Figure 5). Their symmetric relations, BA and CB, rose to 72% and 61%, respectively. The transitive relation, AC, rose to 89%, and the symmetry of the transitive relations, CA, rose to 67%.

One-month retention. One month following Posttest 2, the taught relations, AB and BC, were 100% and 67%, respectively. Retention scores of the symmetric and transitive relations all showed a decrease, reverting to Posttest 1 levels except for BA, which remained at 72% (see Figure 5).

Participant 5

Combining all procedures for Participant 5, who passed up to ABLA Level 6, the total number of training trials to reach mastery criterion for the taught relations, AB and BC, were 1382 and 2243, respectively. Results of pretests and posttests 1, 2, and 3 for Participant 5 are presented in Figure 6.



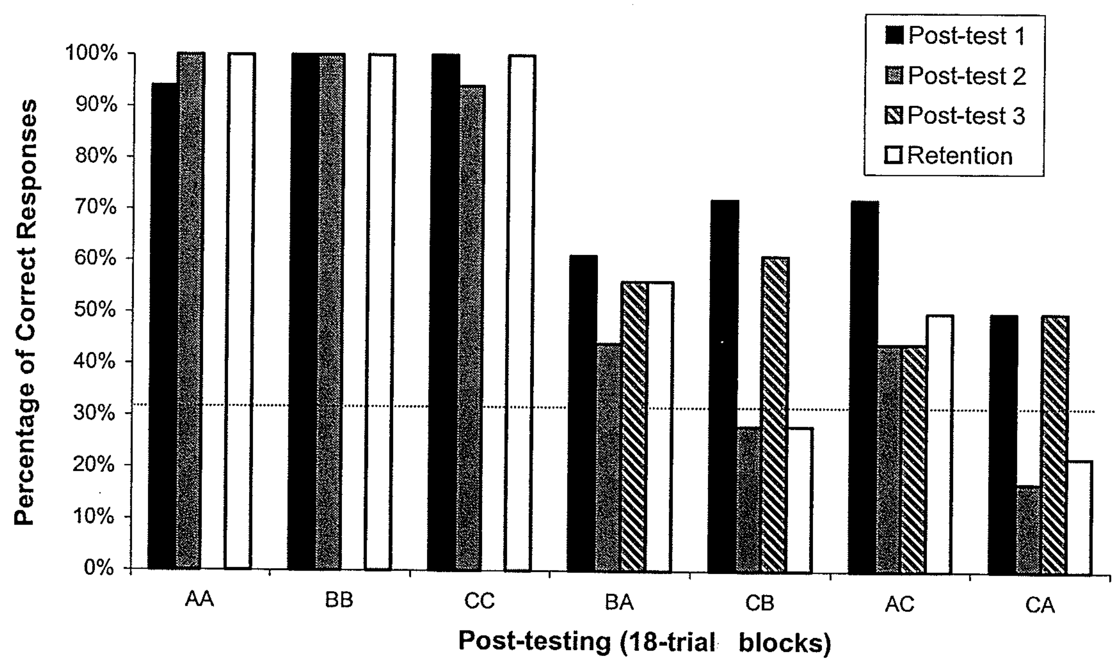


Figure 6. Pretest and posttests 1, 2, and 3 results for Participant 5. The dashed line indicates chance performance.

Pretest. As shown in Figure 6, Participant 5 scored 100%, 94%, and 100%, on the pretests for reflexive relations (AA, BB, and CC). For the six non-identity relations, pretest scores ranged from 28% to 72% (mean = 46%).

Posttest 1 with AB and BC interspersed. After demonstrating mastery criterion on AB and BC relations, Posttest 1 scores for reflexive relations (AA, BB, CC) remained high (see Figure 6). As shown in Table 5 (see p. 47), test relations were interspersed with taught relations in a 1:1 ratio. Relevant taught relations were administered with each symmetric relation, the transitive relation, and the symmetry of the transitive relation. Therefore, as shown in Table 5, AB and BC were administered three times each (i.e., AB: BA; BC:CB; AB:BC:AC; AB:BC:CA). The taught relations AB and BC averaged 96% and 74% (not shown in Figure 6). Symmetric relations, BA and CB, rose to 61% and 72%, respectively. The transitive relation, AC, rose to 72%, and the symmetry of the transitive relation, CA, rose to 50%.

Posttest 2 with AB and BC interspersed. On Posttest 2, following retraining on the BC relation, all reflexive relations remained high. AB and BC, the taught relations averaged 89% and 74%, respectively (not shown in Figure 6), and their symmetric relations, BA and CB, dropped to 44% and 28%. The transitive relation, AC, dropped to 44%, and the symmetry of the transitive relation, CA, dropped to 17%.

Posttest 3 with AB and BC interspersed and reinforced. On Posttest 3, reflexive relations were not tested. Subsequent to retraining on AB and BC, during Posttest 3, the taught relations averaged 96% and 82%, respectively (not shown in Figure 6), and their symmetric relations, BA and CB, rose to 56% and 61%, respectively. The transitive relation, AC, remained at 44%, and the symmetry of the transitive, CA, was 50%, which was similar to that of Posttest 1.

One-month retention. One month retention scores (see Figure 6) for reflexive relations were 100%. The taught relations, AB and BC averaged 94% and 65%, respectively. Symmetric relation, BA, remained at 56%, and CB dropped to 28%. The transitive relation, AC, was 50%, which was similar to that of Posttests 2 and 3, and the symmetry of the transitive dropped to 22%.

Error analysis 1. Table 7 shows an error analysis of Posttests 1 through 3 for Participant 5. As indicated in the Table, the taught relations, AB and BC, included 162 trials (i.e., 3 sets of 18 trials of AB and BC for each Posttest). Symmetric and transitive relations (i.e., BA, CB, AC, and CA) included 54 trials (i.e., 1 set of 18 trials for each Posttest). Errors, indicated by a "-" , show trials in which a participant did not place the sample stimulus on or behind the correct comparison. Conversely, a "+" indicates that the participant placed the sample stimulus on or behind the correct comparison. As indicated in Table 7, it appears that, across relations, a large number of errors occurred when the clock stimuli, word CLOCK (A3), picture of the clock (B3), and symbol 10:00 P.M. (C3), served as sample stimuli. Additionally, it was observed that Participant 5 reliably matched the word CLOCK (A3) to the picture of the clock (B3); however, instead of correctly matching the picture of the clock (B3) to the symbol 10:00 p.m. (C3), quite a few errors occurred, during BC tests, whereby the picture of the clock (B3) was matched to the symbol H20 (C2). Not surprisingly, during the CB test, there were errors in matching the symbol H20 (C2) to the picture of the clock (B3); during the AC test, the

Table 7

Error Analysis of Posttests 1, 2, and 3 for Participant 5

AB

	DISK (A1)	Plant (A2)	CLOCK (A3)
Picture of Disk (B1)	53+	1-	
Picture of Cactus (B2)	1-	47+	1-
Picture of Clock (B3)		6-	53+

BC

	Picture of Disk (B1)	Picture of Cactus (B2)	Picture of Clock (B3)
IBM (C1)	51+	1-	15-
H20 (C2)	2-	52+	17-
10:00 p.m. (C3)	1-	1-	22+

BA

	Picture of Disk (B1)	Picture of Cactus (B2)	Picture of Clock (B3)
DISK (A1)	18+	12-	3-
Plant (A2)		2+	6-
CLOCK (A3)		4-	9+

CB

	IBM (C1)	H20 (C2)	10:00 p.m. (C3)
Picture of Disk (B1)	10+		6-
Picture of Cactus (B2)	5-	13+	6-
Picture of Clock (B3)	3-	5-	6+

AC

	DISK (A1)	Plant (A2)	CLOCK (A3)
IBM (C1)	15+	1-	
H20 (C2)	2-	12+	16-
10:00 p.m. (C3)	1-	5-	2+

CA

	IBM (C1)	H20 (C2)	10:00 p.m. (C3)
DISK (A1)	10+	4-	7-
plant (A2)	4-	3+	3-
CLOCK (A3)	4-	11-	8+

Note. Stimuli displayed horizontally are sample stimuli, and stimuli displayed vertically are comparison stimuli.

word CLOCK (A3) was erroneously matched to the symbol H20 (C2); and during the CA test, the symbol H20 (C2) was erroneously matched to the word CLOCK (A3). Considering the extraneous stimulus control concerning the taught BC relation during all three Post-tests, it is possible that the participant was demonstrating, to some degree, the emergence of unintended stimulus-stimulus relations. As shown in Table 7, on several occasions, Participant 5 also erroneously matched the picture of the clock (B3) to the symbol IBM (C1), and the symbol 10:00 P.M. (C3) to the word "DISK" (A1). Refer to Figure 7 for a diagram that illustrates these relationships.

Posttest 4 (2-choice) with AB and BC interspersed and reinforced. Considering the results of the error analysis, the three clock stimuli were excluded in Posttest 4, which changed the task from three-choice match-to-sample to two-choice match-to-sample (See Figure 8). For trained relations, AB and BC, scores averaged 97% and 94%, respectively (not shown in Figure 8). Their symmetric relations, BA and CB, were 58% and 83%. The transitive relation, AC, was 92%, and the symmetry of the transitive relation was 80%.

Error analysis #2. Table 8 shows an error analysis for Posttest 4 for Participant 5. As shown in the Table, the taught relations, AB and BC, included 36 trials (i.e., 3 sets of 12 trials for each relation). Symmetric and transitive relations (i.e., BA, CB, AC, and CA) each included 12 trials. Correct and incorrect responses were recorded in the same manner as the error analysis of Posttests 1 through 3 (see p. 59). When the clock stimuli were eliminated, the number of erroneous matches decreased. However, the participant continued to make the same erroneous matches with the remaining stimuli as had been made with three-choice tasks, such as the picture of the cactus (B2) to the word DISK (A1).

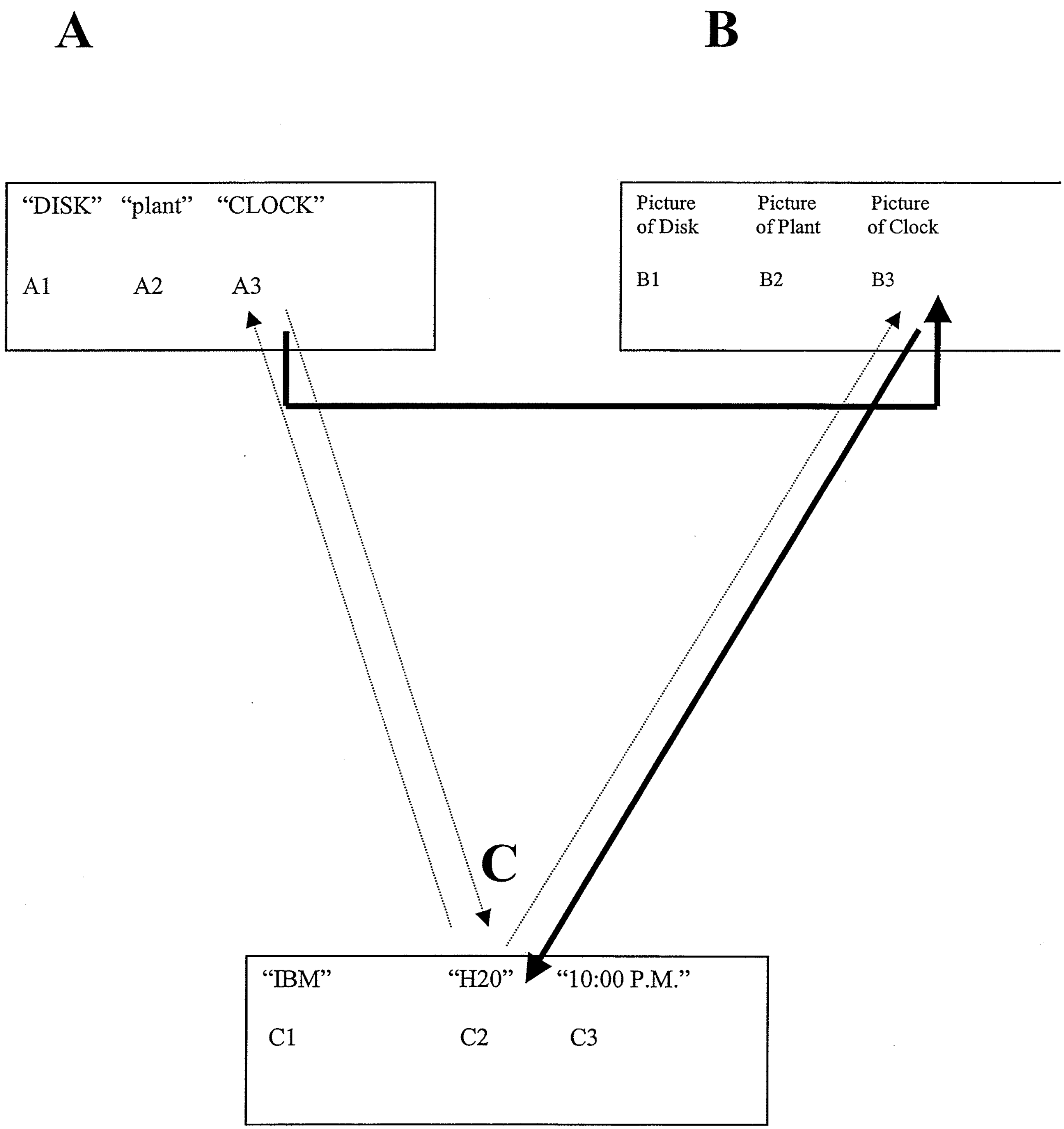


Figure 7. The dark lines represent trained relations AB and BC and the dashed lines represent unintended stimulus-stimulus relations.

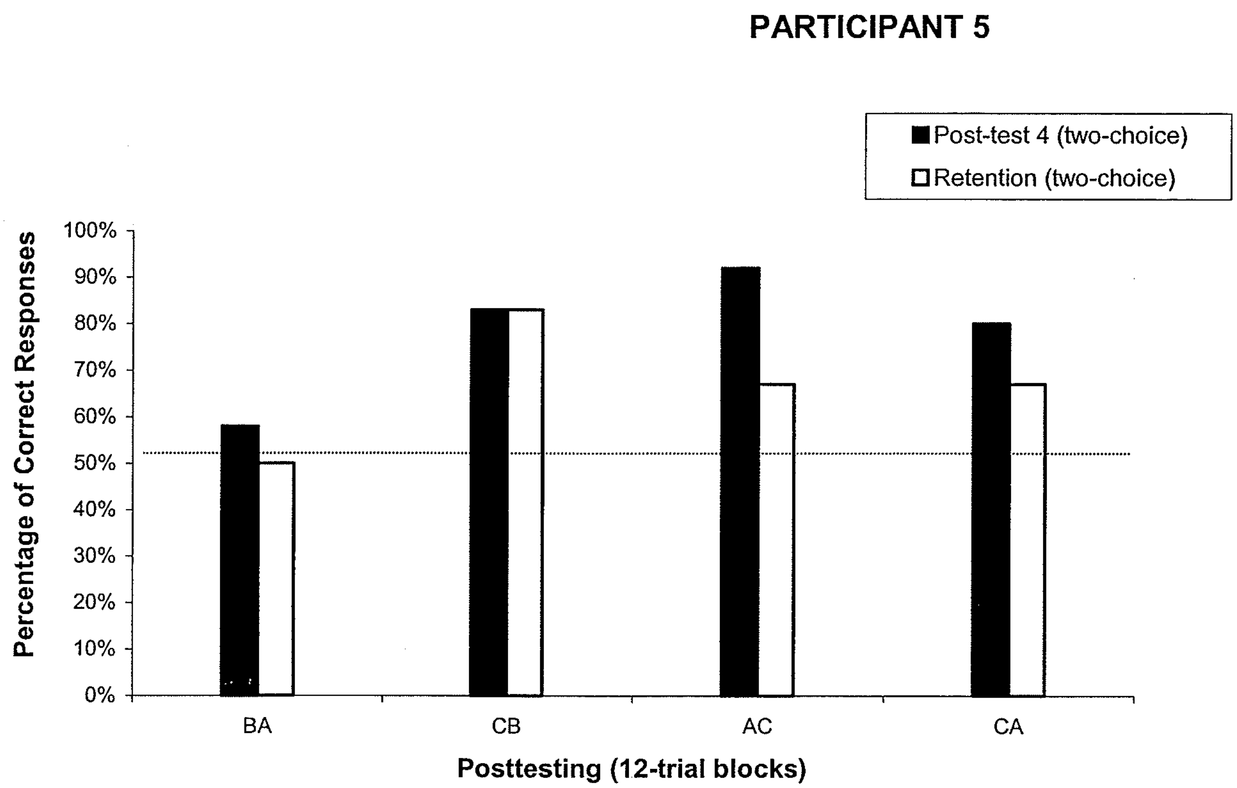


Figure 8. Posttest 4 results for Participant 5. The dashed line indicates chance performance.

Table 8

Error Analysis of Posttest 4 for Participant 5

AB	DISK (A1)	Plant (A2)
Picture of Disk (B1)	18+	1-
Picture of Cactus (B2)		17+

BC	Picture of Disk (B1)	Picture of Cactus (B2)
IBM (C1)	16+	
H20 (C2)	2-	18+

BA	Picture of Disk (B1)	Picture of Cactus (B2)
DISK (A1)	6+	5-
Plant (A2)		1+

CB	IBM (C1)	H20 (C2)
Picture of Disk (B1)	4+	
Picture of Cactus (B2)	2-	6+

AC	DISK (A1)	plant (A2)
IBM (C1)	5+	
H20 (C2)	1-	6+

CA	IBM (C1)	H20 (C2)
DISK (A1)	5+	2-
plant (A2)	1-	4+

Note. Stimuli displayed horizontally are sample stimuli, and stimuli displayed vertically are comparison stimuli.

One-month retention (2-choice). Reflexive relations were not tested. One month retention scores for the taught relations, AB and BC averaged 89% and 92%, respectively (not shown in Figure 8). Symmetric relation, BA, dropped to 50%, and CB remained at 83% (see Figure 8). The transitive relation and the symmetry of the transitive relation both dropped to 67%. A complete summary of Pretest, training, and Posttest results for Participants 4 and 5 is shown in Table 9.

Posttests for language assessments. Subsequent to testing for stimulus equivalence, Participants 4 and 5 were posttested on language assessments (refer to Table 3, p. 37). Comparing pretest scores to posttest scores on tests of verbal operants, Participant 4's scores on vocal imitation and tacting dropped by 21% and 3%, respectively; his manding score remained the same. Participant 5's vocal imitation and manding scores dropped by 6%; his tacting score increased by 3%. On the VABS (Sparrow et al., 1984), there were no differences for Participant 4, and Participant 5's age equivalent score, at posttest, dropped by two months, in comparison to pretest. Age-equivalent scores on the PPVT-R (Dunn & Dunn, 1981) were 2 years 5 months and 3 years 3 months for Participants 4 and 5, respectively. Participant 4's age-equivalent remained the same. For Participant 5, since time of pretesting, his age-equivalent increased by 12 months.

Discussion

After approximately 2000 training trials, Participants 1, 2, and 3 were not able to learn the first taught relation, AB, that was prerequisite to test for stimulus equivalence. Therefore, no attempt was made to teach the BC relation to these participants. In contrast,

Table 9

Percent Correct During Pretests, Training, and Posttests for Participants 4 and 5

	AA	BB	CC	AB	BC	BA	CB	AC	CA
Participant 4									
Pretest (Baseline)	100%	100%	100%	33%	28%	39%	22%	33%	33%
Train AB & BC to criterion				97%	97%				
Posttest 1	100%	100%	94%			56%	50%	56%	44%
Retrain AB and BC to criterion				100%	100%				
Posttest 2 with AB & BC interspersed	100%	100%	100%	100%	94%	72%	61%	89%	67%
Retention (1 month after Posttest 2)	89%	100%	100%	100%	67%	72%	50%	67%	39%
Participant 5									
Pretest (Baseline)	100%	94%	100%	72%	39%	50%	28%	50%	39%
Train AB & BC to criterion				100%	100%				
Posttest 1 with AB & BC interspersed	94%	100%	100%	96%	74%	61%	72%	72%	50%
Retrain BC to criterion					100%				
Posttest 2 with AB & BC interspersed	100%	100%	94%	89%	74%	44%	28%	44%	17%
Retrain AB and BC to criterion				94%	94%				
Posttest 3 with AB & BC interspersed and reinforced				96%	82%	56%	61%	44%	50%
Retrain AB & BC to criterion in 2-choice				100%	100%				
Posttest 4 (2-choice) with AB & BC interspersed and reinforced				97%	94%	58%	83%	92%	80%
Retention 2-choice (1 month after Posttest 4)				89%	92%	50%	83%	67%	67%
Retention 3-choice (1 month after Posttest 4)	100%	100%	100%	94%	65%	56%	28%	50%	22%

Participants 4 and 5 were able to learn the AB relation in approximately two-thirds of the amount of training trials implemented with Participants 1 through 3. Participants 4 and 5 also learned the BC relation.

Furthermore, in replication of Carr et al. (2000), results of Participants 4 and 5 provided some support for the hypothesis that, contrary to Horne and Lowe (1996), individuals with minimal verbal repertoires were capable of showing positive outcomes on equivalence tests. Equivalence results that were considered "positive" were comparable to those reported by Devany et al. (1986) and Study 2 of Carr et al., although two-choice rather than three-choice tasks were used. According to Saunders and Green (1992), a positive outcome on a test indicates that: (a) conditional relations are demonstrated between sample and comparison stimuli used in the test; and (b) the taught relations possess that particular property. However, like Study 1 of Carr et al., in the present study, both participants did not demonstrate stimulus equivalence, as it is defined by Sidman and Tailby (1982), in that positive results did not occur on all tests of reflexivity, symmetry, and transitivity.

Extending the Results of Past Studies

The present study extended the results of Carr et al. and other researchers (e.g., Barnes et al., 1990; Carr et al., 2000; Devany et al., 1986; Eikeseth & Smith, 1992) by using a more precise measure of language skills, rather than relying solely on informal observation of language skills or global measures of language assessment (e.g., PPVT-R, Dunn & Dunn, 1981). Similar to Barnes et al., the present study attempted to examine participants' abilities to demonstrate basic verbal operants. In the Barnes et al. study, however, only tacting skills were examined. In the present study, in addition to assessing tacting, participants were also assessed on their ability to perform echoics and mands. Evaluating an individual's performance on basic verbal operants, as compared to performance on standardized tests, allows for the measurement of basic behavioral processes, in the presence of differential reinforcement. As Sidman (1986) states, "to some extent, standard intelligence and achievement tests do probe the behavioral sequences of which one is currently capable. They do so by sampling arbitrarily selected instances, based on cultural standards. No test, however, goes so far as to probe the quantity and quality of reinforcers that serve to maintain a particular person's behavioral repertoire" (p. 49). In the present study, it was reported that Participant 5's PPVT-R score (Dunn & Dunn, 1981) increased by 12 months from the pretest to the posttest, which took place one year later (see Table 3). This result may not be surprising considering that it was reported that scores on the PPVT-R tend to increase over time (Dunn & Dunn). Considering the variability in performance on this one measure, it is difficult to determine whether these scores accurately represent his receptive language. Results on standardized tests, combined with an inability of participants to pass tests of echoics, tacts, and mands, provides stronger evidence that they did not possess well-developed speaker and listener repertoires.

The relationship between performance on the ABLA test, performance on visual and auditory nonidentity matching tasks (i.e., VVNM and ABLA Level 6), and the ability to learn prerequisite relations that are necessary to test for stimulus equivalence was also examined. As mentioned above, after approximately 2000 training trials, Participants 1, 2, and 3, who passed up to ABLA Level 4 and failed ABLA Level 6 and the VVNM prototype task, were not able to master the first taught relation, AB. However, Participants 4 and 5, who passed these tasks, were able to master both AB and BC. This finding supports the hypothesis that individuals who are able to perform arbitrary relations, as measured by performance on ABLA Level 6 and the prototype VVNM task, are better able to learn the relations necessary to test for stimulus equivalence than are individuals who are not able to perform ABLA Level 6 and the VVNM prototype task.

Finally, in contrast to past studies (e.g., Barnes et al., 1990; Carr et al., 2000; Devany et al., 1986), the present study collected one-month retention data on test relations. As indicated in the Results section, with a few exceptions, performance on tests of one-month retention for Participants 4 and 5 was lower or the same as Posttest scores. Also, there were instances where faulty matches made during training were "retained" during posttest. One example, identified in a previous section, was Participant 5's difficulty with the trained BC relation whereby the same faulty match (i.e., B3C2) exhibited during training carried over to Posttests. Considering the lack of retention data collected in past studies regarding individuals with minimal verbal repertoires, it is not possible to make comparisons across studies.

Alternative Explanations of Findings

Participant 4. Results for Participant 4 indicate performance above chance level (i.e., 33%) on symmetric relations, BA and CB, with an improvement in performance from Posttest 1 to Posttest 2. Through repeated testing, and retraining of taught relations between tests, the participant demonstrated high performance on the transitive relation, AC, and performance above chance level on the symmetry of the transitive relation, CA. Similar to results of Carr et al., these data may support the gradual emergence phenomenon (Sidman, 1994) that is commonly reported in equivalence studies. However, there are possible alternative explanations for an improvement in performance from Posttest 1 to Posttest 2. It is possible that an increase in performance may have been due to changes in test trial order (Green & Saunders, 1998). Specifically, Posttest 1 began with test trials for the transitive relation and symmetry of the transitive relation, AC and CA, followed by test trials for symmetric relations, BA and CB. In contrast, Posttest 2 began with symmetric relations, followed by blocks of test trials for the transitive relation and symmetry of the transitive relation. Additionally, in Posttest 2, blocks of symmetric test trials were preceded by blocks of corresponding training trials (e.g., AB training trials followed by BA test trials). Green and Saunders suggest that exposure to tests of symmetry, whereby participants are exposed to trials of matching comparison stimuli to sample stimuli, may foster performance on tests for transitivity, where relations between sample stimuli and comparison stimuli are novel. It is therefore possible that changes in test trial order, combined with incorporation of taught relations, may have led to improvements in equivalence test results. However, it is also possible that repeated testing functioned as training. Referring to a situation in which repeated testing is conducted and all properties are not demonstrated, Saunders and Green (1992) state that "one possibility is that the tests do not affect the trained relation but serve as instructional events that train specific conditional relations among the stimuli that make up the test trial configuration" (p. 238). Finally, it is important to note erroneous matching such as the matching of the symbol 10:00 P.M. (C3) to the picture of the cactus (B2) and the symbol 10:00 P.M. (C3) to the picture of the plant (A2) may have been carried over from training (see Appendix G).

Participant 5. Posttest 1 results for Participant 5 indicated high scores on reflexive relations, and performance above chance level (i.e., 33%) on all symmetric and transitive relations. Following retraining on the taught relation, BC, a marked drop in performance in symmetric and transitive relations was evident in Posttest 2, followed by an increase in performance in Posttest 3, that was similar to results of Posttest 1. The taught BC relation ranged between 74% and 82% on the three Posttests. One possible explanation for lower performance on the BC relation and a failure to demonstrate equivalence relations, despite the meeting of mastery criterion for the taught relations, AB and BC, prior to each posttest, was the change in reinforcement density between training and testing. It is suggested by several researchers (e.g., Carr et al., 2000; McIlvane & Stoddard, 1985; Sidman, 1986) that individuals with learning difficulties may be especially sensitive to changes in reinforcement parameters, and it, in fact, may be necessary to adjust the reinforcement schedule in order to maintain an individual's motivation to respond. Specifically, considering that test trials are novel to the participant, he or she may learn to quickly discriminate test trials from training trials, and responses may come under the control of extraneous variables (e.g., stimulus preference) during test trials. In an attempt to prevent this problem, researchers (e.g., Carr et al.; McIlvane & Stoddard) designed posttests such that training trials were interspersed with test trials, and reinforcement was provided during a certain percentage of training trials and test trials. Considering that the present study included no differential reinforcement on Posttests 1 and 2, and differential reinforcement for only taught relations in Posttest 3, a sudden change in the density of reinforcement between training and testing is a possible contributor to the findings.

However, as mentioned in the Results section, extraneous stimulus control was indicated by the large number of erroneous matches that occurred when the clock stimuli (i.e., C1, C2, and C3) were presented as samples, as well as when other stimuli appeared as samples. These errors may be only partially explained by a change in the reinforcement schedule during Posttests. It is suggested, therefore, that other variables, such as the history of errors made during training, may be responsible for the participant's drop in performance on the taught relation, BC, and the possible development of an unintended equivalence relations (i.e., A3C2; see Figure 7). However, the emergence of A3C2 could also have developed based on similar features between the sample and comparison stimuli (see section below on limitations). When the clock stimuli were removed, and posttests were conducted with only two comparisons, the taught relations remained intact, the symmetric relations, BA and CB, and the symmetry of the transitive, CA, were above chance level, and the transitive relation, AC, was demonstrated. It is not possible, however, to rule out the possibility that repeated testing may have functioned as training for that individual (Saunders & Green, 1992).

Limitations

The present study has several limitations. First, it is possible that the stimuli chosen for the present study may have led to the development of faulty stimulus control. In the procedural section, it is stated that "the use of different colors, orientations of letters, and placements of stimuli on the card was to exaggerate differences between stimuli and to facilitate discriminations for individuals with developmental disabilities" (p. 30). However, in choosing the stimuli, the researcher did not take into account the possibility of participants matching by identical features between stimuli in different classes. For example, as shown in Table 7, Participant 5 made quite a few errors in matching the picture of the clock (B3) to the symbol IBM (C1) or the symbol H20 (C2). In the former case, the participant may have been matching based on similar size; in the latter case, the participant may have been matching based on the shape of the clock (i.e., circle) to the "0" in H20. Similarly, Participant 5 matched the word CLOCK (A3) to the symbol H20 (C2). In this example, the participant could have been matching the "0's" or the similar alignment of the stimuli. A slightly different way to conceptualize the faulty matching that occurred in this study is that the use of compound stimuli may have led to stimulus overselectivity. To rule out this problem, it was suggested by G. Green (personal communication, June, 2002) that visual stimuli within a stimulus set should be approximately the same shape, color, and size.

Several limitations regarding the tests of echoics, tacts, and mands need to be acknowledged. One is the limited number of words that were used. The echoic and tact assessment each consisted of 11 words, and the mand assessment consisted of 5 words. Future studies should attempt to expand the test by including a larger number of words from the list of beginning words suggested by Sundberg and Partington (1998). A second limitation is the focus on only spoken words as acceptable responses. The test does not take into account other modes of communication such as picture-based communication, signing, or gesturing. Expansion of the test to include other forms of communication is needed. Lastly, in the mand assessment, prior to each trial, the participant was presented with the item and asked to consume it, in order to provide him or her with a brief history of reinforcement. It was assumed that subsequent presentation of the task with the missing component would create an establishing operation. An establishing operation involves a change in an environmental event that (a) temporarily alters the effectiveness of consequences as reinforcers (or punishers), and (b) influences behavior that normally leads to those reinforcers (or punishers) (Michael, 1982). Moreover, the experimenter assumed that, prior to each mand trial, consuming an item or using the item to complete an activity indicated that the item was reinforcing to the individual. To ensure that this is the case, a preference assessment should be conducted and items chosen for the mand assessment should be individualized to the participant.

Implications For Future Research

The results of this study have several implications for future research. First, considering the vagueness of the phrase "minimally verbal," future studies in this area might capitalize or expand on the test of echoics, tacts, and mands in order to more precisely describe the language repertoire of participants.

Second, as suggested by Carr et al. (2000), future researchers may want to consider participants that are completely nonverbal, but may have the ability to learn the entry level skills (i.e., conditional discriminations). Specifically, they suggest that young children with autism who are nonverbal, or preverbal infants may fit this criterion. Future studies should examine this possibility and should use ABLA and VVNM assessments to describe the entry repertoires of participants.

Third, the results suggest that performance on Level 6 and VVNM may be prerequisite to the learning of other arbitrary relations that are necessary to test for stimulus equivalence. Additional research is needed to confirm this possibility.

Conclusions

In summary, the present study yielded two main findings. First, it provided evidence against Horne and Lowe's hypothesis that language is necessary for the formation of equivalence relations. In the present study, Participants 4 and 5 demonstrated positive outcomes on some equivalence tests, even though both participants failed a test of echoics, tacts, and mands. Second, in contrast to Participants 4 and 5, who passed ABLA Level 6 and the prototype VVNM task, Participants 1, 2, and 3, who only passed up to ABLA Level 4, were not able to learn the first taught relation, AB, even after approximately 2000 training trials. This suggests that the ability to perform Level 6 and a VVNM prototype task may facilitate the learning of relations necessary to demonstrate positive results on a test for stimulus equivalence.

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Appendix A

Consent Form

Research Project: Teaching Relations Among Corresponding Pictures, Words, and Symbols to Individuals with Developmental Disabilities

The project will be conducted by Tricia Vause, a doctoral student at the University of Manitoba, and supervised by Dr. Garry Martin, Professor at the University of Manitoba, and Dr. Dickie Yu, Research Director at St. Amant Centre.

What is the study about?
The development of practical skills is a key objective for persons with developmental disabilities. We want to find out whether a procedure designed to assess an individual's basic skills can help us determine which skills an individual needs to work on. In particular, we are interested in teaching relationships among pictures, words, and symbols to individuals with developmental disabilities.

What will the project involve?

Participation in the project will include the following:

1. An assessment to find out the individual's basic learning abilities (e.g., matching skills).
2. An assessment to find out what types of matching skills an individual needs to work on.
3. Provide a series of training sessions in order to teach matching skills.
4. Test to determine what skills the individual has learned.

The entire project will be completed over a period of approximately one year. The duration for each individual, however, will be approximately six months.

Is participation voluntary?
Yes. Participation is voluntary. Whether or not an individual participates will not affect any services the participant may be receiving now or in the future from the St. Amant Centre or from the University of Manitoba.

Can the sessions be stopped at any time?
Yes. Sessions will be stopped if a participant indicates that he or she wishes to leave or stop the session.

What personal information will be obtained?
Demographics (e.g., age), diagnostic information (e.g., adaptive functioning level) and relevant medical information will be obtained from the individual's records. This information will be collected for research purposes only, to examine how it relates to the individual's performance.

Will personal information be kept confidential?
Yes. The identities of all participants will be kept strictly confidential. All data collected during the study and information from clinical records will be kept in a locked office and will be accessible only to the researchers. Any presentations, reports, or publications as a result of this project will not contain any identifying information.

What are the risks in taking part in the study?
The assessment and training procedures present no risks to participants.

What are the benefits in taking part in the study?
There are several direct benefits for a participant. First, the participant will be taught basic matching skills that are relevant to everyday situations. Second, we will determine the learning abilities of each participant. Front-line staff will be informed of relevant information (e.g., matching skills) that may be generalized to everyday situations, with the permission of the legal guardian. This information will be provided verbally to a staff member.

Will participating cost anything?
No.

Will there be compensation for participating?
No. There is no financial compensation for participating.

Who should I call if I have any questions or concerns about the project?
If you have any questions or concerns about the project, please call either Tricia Vause, 256-4301 (ext. 328) , Dr. Dickie Yu, 256-4301, ext. 399, or Dr. Garry Martin, 474-8589.

What should I do if I am interested?

If you are a family member or an advocate, but are not the legal guardian, we would like your support for the participant to take part in this project. Please sign the next section, *Support of Family/Advocate*, to indicate your support. The person(s) with legal authority to give consent should sign in the section, *Signature of Person Legally Authorized to Give Consent,* at the bottom of the page.

Support of Family/Advocate (if family member is not the legal guardian)

I support the participation of (print name of participant) ______________________________ in this project.

______________________	______________________	______________________
Print Name of Parent/Advocate	Signature of Parent/Advocate	Date

Signature of Person Legally Authorized to Give Consent

By signing this form, I give consent for (print name of participant) ________________________ to participate in the above named research project. I am aware that I may stop at any time with no impact on the services that the participant is receiving or may receive in the future. I agree to allow the project staff to:

- **Gather demographics and diagnostic information about the participant from the clinical/agency records.**
- **Assess the participant to find out his/her learning abilities.**
- **Assess the participant on his or her matching skills.**
- **Train the participant on matching skills.**
- **Include participant's results in publications, reports, talks, so that others may learn from this project. The identity of the participant, however, will not be disclosed.**

______________________	______________________	______________________
Print Name of Person Legally Authorized to Give Consent	Signature of Person Legally Authorized to Give Consent	Date

Appendix B

Data Sheets and POR Sheets for ABLA Levels 4 and 6

ABLA Level 4 Data Sheet

Subject___________ **Tester**___________ **Observer**___________ **Date**____________

Level 4 (Matching) 'L' and 'R' indicate correct placement of can
'b' indicates to present little red cube
'c' indicates to present small cylinder.
Ask, "Where does it go?"

R	L	R	L	R	R	L	L	R	R	L	L	R	R
c	c	b	b	c	b	c	b	b	c	b	c	c	b
1	2	3	4	5	6	7	8	9	10	11	12	13	14
___	___	___	___	___	___	___	___	___	___	___	___	___	___
___	___	___	___	___	___	___	___	___	___	___	___	___	___
___	___	___	___	___	___	___	___	___	___	___	___	___	___
___	___	___	___	___	___	___	___	___	___	___	___	___	___
___	___	___	___	___	___	___	___	___	___	___	___	___	___
___	___	___	___	___	___	___	___	___	___	___	___	___	___
___	___	___	___	___	___	___	___	___	___	___	___	___	___

L	L	R	L	R	L	R	R	L	L	R	L	R	L
c	b	b	b	c	c	b	c	b	c	c	b	b	c
15	16	17	18	19	20	21	22	23	24	25	26	27	28
___	___	___	___	___	___	___	___	___	___	___	___	___	___
___	___	___	___	___	___	___	___	___	___	___	___	___	___
___	___	___	___	___	___	___	___	___	___	___	___	___	___
___	___	___	___	___	___	___	___	___	___	___	___	___	___
___	___	___	___	___	___	___	___	___	___	___	___	___	___
___	___	___	___	___	___	___	___	___	___	___	___	___	___
___	___	___	___	___	___	___	___	___	___	___	___	___	___

L	R	L	R	L	L	R	R	R	L	R	L
b	c	c	b	b	c	c	b	c	b	b	c
29	30	31	32	33	34	35	36	37	38	39	40
___	___	___	___	___	___	___	___	___	___	___	___
___	___	___	___	___	___	___	___	___	___	___	___
___	___	___	___	___	___	___	___	___	___	___	___
___	___	___	___	___	___	___	___	___	___	___	___
___	___	___	___	___	___	___	___	___	___	___	___
___	___	___	___	___	___	___	___	___	___	___	___
___	___	___	___	___	___	___	___	___	___	___	___

ABLA Level 6 Data Sheet

Subject___________ **Tester**___________ **Observer**___________ **Date**____________

Level 6 (Auditory-Visual) 'L' and 'R' indicate correct placement of can

Say, "Red Box" (RB) or "Yellow Can" (YC)

R	R	L	L	L	R	R	L	R	R	R	R	L	L
YC	RB	YC	RB	YC	YC	RB	RB	YC	RB	YC	YC	RB	RB
1	2	3	4	5	6	7	8	9	10	11	12	13	14
___	___	___	___	___	___	___	___	___	___	___	___	___	___
___	___	___	___	___	___	___	___	___	___	___	___	___	___
___	___	___	___	___	___	___	___	___	___	___	___	___	___
___	___	___	___	___	___	___	___	___	___	___	___	___	___
___	___	___	___	___	___	___	___	___	___	___	___	___	___
___	___	___	___	___	___	___	___	___	___	___	___	___	___
___	___	___	___	___	___	___	___	___	___	___	___	___	___

L	R	L	L	L	R	L	R	L	R	R	L	L	R
YC	RB	RB	YC	RB	YC	YC	RB	RB	RB	YC	YC	RB	YC
15	16	17	18	19	20	21	22	23	24	25	26	27	28
___	___	___	___	___	___	___	___	___	___	___	___	___	___
___	___	___	___	___	___	___	___	___	___	___	___	___	___
___	___	___	___	___	___	___	___	___	___	___	___	___	___
___	___	___	___	___	___	___	___	___	___	___	___	___	___
___	___	___	___	___	___	___	___	___	___	___	___	___	___
___	___	___	___	___	___	___	___	___	___	___	___	___	___
___	___	___	___	___	___	___	___	___	___	___	___	___	___

R	L	R	L	L	R	L	R	L	R	L	R
RB	YC	YC	RB	YC	RB	RB	YC	YC	YC	RB	RB
29	30	31	32	33	34	35	36	37	38	39	40
___	___	___	___	___	___	___	___	___	___	___	___
___	___	___	___	___	___	___	___	___	___	___	___
___	___	___	___	___	___	___	___	___	___	___	___
___	___	___	___	___	___	___	___	___	___	___	___
___	___	___	___	___	___	___	___	___	___	___	___
___	___	___	___	___	___	___	___	___	___	___	___
___	___	___	___	___	___	___	___	___	___	___	___

Procedural Reliability Checklist – Level 4 and Level 6

Name: ______________________________

Tester:______________________________

POR:_______________________________

Date:_______________________________

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Set up (correct position of apparatus; correct manipulandum)																				
Demonstration																				
Guided Trial																				
Correct Auditory Cue from experimenter (Independent Response)																				
If participant does not respond after 10s, verbal/physical prompt is provided																				
If Correct…Praise and an edible																				
If Incorrect…"No…" Then go back to demonstration																				

Appendix C

Data Sheets and POR Sheets for VVNM and Auditory Matching

VVNM Data Sheet

Subject___________ **Tester**___________ **Observer**___________ **Date**___________

VVNM

'L' and 'R' indicate correct placement of can
'h' indicates to present hourglass figure
(matched to can)
's' indicates to present star.
(matched to box)
Ask, "Where does it go?"

R	L	R	L	R	R	L	L	R	R	L	L	R	R
s	s	h	h	s	h	s	h	h	s	h	s	s	h
1	2	3	4	5	6	7	8	9	10	11	12	13	14
___	___	___	___	___	___	___	___	___	___	___	___	___	___
___	___	___	___	___	___	___	___	___	___	___	___	___	___
___	___	___	___	___	___	___	___	___	___	___	___	___	___
___	___	___	___	___	___	___	___	___	___	___	___	___	___
___	___	___	___	___	___	___	___	___	___	___	___	___	___
___	___	___	___	___	___	___	___	___	___	___	___	___	___
___	___	___	___	___	___	___	___	___	___	___	___	___	___

L	L	R	L	R	L	R	R	L	L	R	L	R	L
s	h	h	h	s	s	h	s	h	s	s	h	h	s
15	16	17	18	19	20	21	22	23	24	25	26	27	28
___	___	___	___	___	___	___	___	___	___	___	___	___	___
___	___	___	___	___	___	___	___	___	___	___	___	___	___
___	___	___	___	___	___	___	___	___	___	___	___	___	___
___	___	___	___	___	___	___	___	___	___	___	___	___	___
___	___	___	___	___	___	___	___	___	___	___	___	___	___
___	___	___	___	___	___	___	___	___	___	___	___	___	___
___	___	___	___	___	___	___	___	___	___	___	___	___	___

L	R	L	R	L	L	R	R	R	L	R	L
h	s	s	h	h	s	s	h	s	h	h	s
29	30	31	32	33	34	35	36	37	38	39	40
___	___	___	___	___	___	___	___	___	___	___	___
___	___	___	___	___	___	___	___	___	___	___	___
___	___	___	___	___	___	___	___	___	___	___	___
___	___	___	___	___	___	___	___	___	___	___	___
___	___	___	___	___	___	___	___	___	___	___	___
___	___	___	___	___	___	___	___	___	___	___	___
___	___	___	___	___	___	___	___	___	___	___	___

VANM and AAIM Data Sheet

Participant:____________________ Residence: ____________________ Date:__________

"Pen"-P "Block"-B. The number in parentheses indicates which assistant speaks first. Circle VANM or AAIM

T:	P	B	B	P	P	B
A:	(1)P	(1)B	(1)P	(2)B	(2)P	(2)B
B:	(2)B	(2)P	(2)B	(1)P	(1)B	(1)P
	1	2	3	4	5	6
	—	—	—	—	—	—
	—	—	—	—	—	—
	—	—	—	—	—	—
	—	—	—	—	—	—
	—	—	—	—	—	—
	—	—	—	—	—	—
	—	—	—	—	—	—

T:	P	B	B	B	P	B
A:	(1)B	(2)P	(2)B	(1)P	(2)B	(1)B
B:	(2)P	(1)B	(1)P	(2)B	(1)P	(2)P
	7	8	9	10	11	12
	—	—	—	—	—	—
	—	—	—	—	—	—
	—	—	—	—	—	—
	—	—	—	—	—	—
	—	—	—	—	—	—
	—	—	—	—	—	—
	—	—	—	—	—	—

T:	P	P	B	P	B	B
A:	(1)B	(2)P	(2)P	(1)P	(1)B	(1)P
B:	(2)P	(1)B	(1)B	(2)B	(2)P	(2)B
	13	14	15	16	17	18
	—	—	—	—	—	—
	—	—	—	—	—	—
	—	—	—	—	—	—
	—	—	—	—	—	—
	—	—	—	—	—	—
	—	—	—	—	—	—
	—	—	—	—	—	—

T:	P	B	P	P	B	P
A:	(2)B	(2)B	(2)P	(1)P	(2)P	(1)B
B:	(1)P	(1)P	(1)B	(2)B	(1)B	(2)P
	19	20	21	22	23	24
	—	—	—	—	—	—
	—	—	—	—	—	—
	—	—	—	—	—	—
	—	—	—	—	—	—
	—	—	—	—	—	—
	—	—	—	—	—	—

AANM Data Sheet

Participant:____________________ Residence: ____________________ Date:____________

"Ball"-B and "Field"-F "Ice"-I and "Rink"-R. The number in parentheses indicates which assistant speaks first.
Trials: correct response is to point to assistant.

T:	I	B	B	I	I	B
A:	(1)R	(1)F	(1)R	(2)F	(2)R	(2)F
B:	(2)F	(2)R	(2)F	(1)R	(1)F	(1)R
	1	2	3	4	5	6
	___	___	___	___	___	___
	___	___	___	___	___	___
	___	___	___	___	___	___
	___	___	___	___	___	___
	___	___	___	___	___	___
	___	___	___	___	___	___
	___	___	___	___	___	___

T:	I	B	B	B	I	B
A:	(1)F	(2)R	(2)F	(1)R	(2)R	(1)F
B:	(2)R	(1)F	(1)R	(2)F	(1)F	(2)R
	7	8	9	10	11	12
	___	___	___	___	___	___
	___	___	___	___	___	___
	___	___	___	___	___	___
	___	___	___	___	___	___
	___	___	___	___	___	___
	___	___	___	___	___	___
	___	___	___	___	___	___

T:	I	I	B	B	B	I
A:	(1)F	(2)F	(2)R	(1)F	(1)R	(1)R
B:	(2)R	(1)R	(1)F	(2)R	(2)F	(2)F
	13	14	15	16	17	18
	___	___	___	___	___	___
	___	___	___	___	___	___
	___	___	___	___	___	___
	___	___	___	___	___	___
	___	___	___	___	___	___
	___	___	___	___	___	___
	___	___	___	___	___	___

T:	I	B	I	I	I	B
A:	(2)R	(2)F	(2)R	(1)R	(2)R	(1)R
B:	(1)F	(1)R	(1)F	(2)F	(1)F	(2)F
	19	20	21	22	23	24
	___	___	___	___	___	___
	___	___	___	___	___	___
	___	___	___	___	___	___
	___	___	___	___	___	___
	___	___	___	___	___	___

Procedural Reliability Checklist – VVNM

Name: ______________________________

Tester:______________________________

POR:________________________________

Date:_______________________________

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Set up (correct position of apparatus; correct manipulandum)																				
Demonstration																				
Guided Trial																				
Correct Auditory Cue from experimenter (Independent Response)																				
If participant does not respond after 10s, verbal/physical prompt is provided																				
If Correct…Praise and an edible																				
If Incorrect…"No…" Then go back to demonstration																				

Procedural Reliability Checklist – VANM, AAIM, AANM

Name: ____________________________

Tester: ____________________________

POR: ____________________________

Date: ____________________________

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Set up (correct position of apparatus (if applicable); correct position of assistants (hands palms-up on table)																				
Demonstration																				
Guided Trial																				
Correct Auditory Cues from assistants and experimenter (independent response)																				
If participant does not respond in 10s, verbal/physical cue is provided																				
If Correct…Praise and an edible																				
If Incorrect…"No…" Then go back to demonstration																				

Appendix D

Data sheets and POR sheets for Verbal Operant Tests

Vocal Imitation and Tacting Data Sheet

Participant:____________________Residence:__________________________
Tester: _______________________IOR: ______________________
Date:_________________________
Circle: Echoics or Tacts

WORD	CORRECT	APPROXIMATION (indicate in the same box)	INCORRECT	OMISSION
1. box		boh, ox		
2. can/tin		cah, ann/tii, inn		
3. pen		en, peh		
4. juice		juu, uice		
5. cup		cuh, up		
6. pudding		pudd, puh, ding		
7. spoon		spoo, oonh		
8. bowl		boh, oohl		
9. foam/sponge		foo, ooam/sponn, onge		
10. puzzle/bear		puzz, zzle/beaa, air		
11. paper		paah, perr, pape		
12. box		boh, ox		
13. can/tin		cah, ann/tii, inn		
14. pen		en, peh		
15. juice		juu, uice		
16. cup		cuh, up		
17. pudding		pudd, puh, ding		
18. spoon		spoo, oonh		
19. bowl		boh, oohl		
20. foam/sponge		foo, ooam/sponn, onge		
21. puzzle/bear		puzz, zzle/beaa, air		
22. paper		paah, perr, pape		
23. box		boh, ox		
24. can/tin		cah, ann/tii, inn		
25. pen		en, peh		
26. juice		juu, uice		
27. cup		cuh, up		
28. pudding		pudd, puh, ding		
29. spoon		spoo, oonh		
30. bowl		boh, oohl		
31. foam/sponge		foo, ooam/sponn, onge		
32. puzzle/bear		puzz, zzle/beaa, air		
33. paper		paah, perr, pape		

Manding Data Sheet

Participant:____________________ Residence:___________________________
Tester: ________________________ IOR: _______________________
Date:__________________________

TASK:

Verbal	Correct	Approximation	Incorrect	Omission		Nonverbal	
					Ges	Search	Reach
Step 1 (CEO)							
Step 2 (IV; Prompted Mand)							
Step 3 (IV; Prompted Mand, Tact)							
Step 4 (IV; Prompted Mand; Tact; Echoic)							

TASK:

Verbal	Correct	Approximation	Incorrect	Omission		Nonverbal	
					Ges	Search	Reach
Step 1 (CEO)							
Step 2 (IV; Prompted Mand)							
Step 3 (IV; Prompted Mand, Tact)							
Step 4 (IV; Prompted Mand; Tact; Echoic)							

TASK:

Verbal	Correct	Approximation	Incorrect	Omission		Nonverbal	
					Ges	Search	Reach
Step 1 (CEO)							
Step 2 (IV; Prompted Mand)							
Step 3 (IV; Prompted Mand, Tact)							
Step 4 (IV; Prompted Mand; Tact; Echoic)							

Place a check mark in the appropriate column.

Procedural Reliability Checklist – Echoics and Tacts

Participant: ____________________
Residence: ____________________
Tester: ____________________
POR: ____________________
Date: ____________________

Circle: Echoics or Tacts

	Set up	Demonstration for echoics / "What's this?" for tacts	"Pick it up." (Every third trial)	If correct… verbal praise	If incorrect, approximation, or omission, Thank-you
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					

Use checkmark if correct, X if incorrect, leave blank if N/A

Procedural Reliability Checklist – Mands

Participant: ____________________
Residence: ____________________
Tester: ____________________
POR: ____________________
Date: ____________________

	Demo	Set up (explained in handout)	Correct Prompt	"Pick it up" (ball) after the completion of each task	If correct or approximation... Verbal praise	If incorrect... Thank-you
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						
22						
23						
24						
25						
26						
27						
28						
29						
30						

Use checkmark if correct, X if incorrect, leave blank when N/A

Appendix E

Detailed Description of Training Materials and Components

As mentioned in the procedural section, this study used training procedures that have been shown to be effective, to teach participants to match A stimuli to B stimuli, and B stimuli to C stimuli, in order to test for stimulus equivalence. This section provides a detailed description of additional training materials, besides those used during pretest, as well as training components used in the study. As indicated in the procedural section, components were added and dropped contingent upon whether progress was made. Each training component addressed in the procedural section is listed, and expanded upon as appropriate.

Additional Materials For Training Match-to-Sample Relations

In an attempt to teach relations AB and BC, additional materials were needed to implement a series of antecedent and consequence manipulations. Materials included the following: (a) two blank 10 X 15 inch white plasticized cards, (b) nine cards displayed in Figure 1, each cut into five increments, with each increment containing a larger portion of the card and the respective stimulus, (c) four additional cards containing the picture of the cactus (B2), the picture of the clock (B3), the word DISK (A1), the symbol H20 (C2), and the symbol 10:00 P.M. (C3), whereby the respective stimuli were 12.5%, 25%, 50%, and 75% the size of the original card, and (d) four additional cards containing the picture of the clock whereby the clock was 175%, 150%, 125%, and 112.5% the size of the original card. Also, with respect to the clock, the face was gradually faded over trials from a dark shade of gray to a lighter shade of gray to white. In addition to the wooden board described in the procedural section, a white wooden board that was 114 cm by 64 cm and contained three circular indentations was used. Data sheets used for pretesting and posttesting relations AB and BC were also used in training (see Appendix F).

Reinforcer Preference

Prior to training, staff members were asked to identity preferred consumable items (e.g., edibles, liquids) for each participant. These items were presented in one of two ways. In some instances, subsequent to a correct response, the participant was presented with an array of six items, accompanied by the vocal cue, "Pick one." The chosen edible was immediately replaced by the experimenter. In other instances, the participant was presented with six items, at the beginning of the session, and was vocally asked, "Pick three." Throughout that session, correct responses were followed by the presentation of one of three items presented in the same sequence.

Attending To Stimuli At The Beginning of Each Trial

Initially, the experimenter began each trial by holding a comparison stimulus at the participant's eye level and vocally said, "Look at this one." The experimenter then waited until the participant's face oriented toward the card and said, "Take it." The participant placed the card in the participant's hand, and then pointed to the left, middle, and right section on the board and said, "Now put it here." The cards were placed on the board from the participant's left to right. The experimenter then presented a sample stimulus at the participant's face level and asked, "Where does it go?" During the first few sessions, it was difficult to determine whether participants' faces were oriented to the sections on the board that contained the samples and the correct comparison stimuli. Therefore, during subsequent sessions, the experimenter placed the comparison stimuli directly on the board. The experimenter continued to present the sample stimulus at the participant's face level and asked, "Where does it go?"

Trial Presentation

During training, guidelines outlined by Green and Saunders (1998) concerning trial presentation were followed as closely as possible. However, due to a number of variables (e.g., use of prompt fading, criteria for advancing and backing up steps), some exceptions were made. Guidelines included the following: (a) each stimulus should serve as the sample an equal number of times; (b) the sample should not appear on more than two consecutive trials; and (c) the correct comparison should not appear in the same position on more than two consecutive trials.

Differential Reinforcement For Correct and Incorrect Responding

Correct responses were followed by praise and a consumable item that were both delivered on a CRF schedule. During the first few sessions, incorrect responses were followed by the experimenter placing the sample behind the correct comparison stimulus, pointing to the sample and comparison, and saying, "See this one, it goes here. These two go together." However, because it was difficult to determine whether participants' faces were oriented to the section on the board with the sample and correct comparison, and considering the participants' minimal verbal repertoires, the procedure was changed so that incorrect responses were followed by the experimenter placing the sample with the correct comparison, and making a short statement, "This one goes here."

Match-To-Sample Training Procedures

Training on the AB relation began with procedures being implemented within a three-choice match-to-sample task. Due to limited success in teaching the AB relation, two-choice match-to-sample training was implemented, and then followed by three-choice match-to-sample training. A description of the training procedures is described below.

Position Fading Within A Three-Choice Match-to-Sample Task

In this procedure, the correct comparison stimulus was placed on the board, and the participant was presented with the sample at his eye level, accompanied by the vocal prompt, "Where does it go?" A correct response was defined as placing the sample on top or behind the correct comparison stimulus. Criterion for advancing to the next step was 10 consecutive correct responses. Step 2 involved three substeps: (a) placing the correct comparison on the board and two blank cards off the board, but touching the two sections on the board where the correct comparison was not placed; (b) placing the two blank cards halfway on the board; and (c) placing all cards (1 correct comparison and 2 blanks) on the board. A correct response on a substep was required to advance to the next substep, and an incorrect response resulted in backing up a substep. Step 3 consisted of placing the correct comparison and two blank cards on the board, and then presenting the sample with the vocal prompt, "Where does it go?" Criterion for advancing to the next step (i.e., Step 4) was 10 correct consecutive responses. If the participant obtained less than 5 correct responses, he moved back to Step 2. In Step 4, the correct comparison, a blank comparison, and a picture comparison were placed on the board. Finally, Step 5 involved presenting the correct comparison, and the two incorrect comparisons. Criterion for advancing and backing up a step for Steps 4 and 5 was the same as for Step 3. Participants 1 through 5 completed 184, 108, 265, 318, and 225 trials, respectively. Across participants, the number of trials completed per session ranged from 10 trials to

78 trials. After completing these trials, Participant 1 met criterion for Step 2, and Participants 2 through 5 met criterion for Step 3. Due to learning difficulties, an attempt was made to incorporate other fading techniques.

Size Fading of The Incorrect Comparison Stimuli

The correct comparison was made as distinguishable as possible, while gradually fading in portions of the two incorrect comparisons. Each comparison was represented by five pieces, with all comparisons consisting of pieces approximately equal in size. Each piece consisted of a larger part of the card (and the comparison stimulus). Over trials, the correct comparison remained at its initial size, and the incorrect comparison stimuli were gradually faded in, using five steps, and beginning with the smallest pieces. The final step consisted of all stimuli at their initial size. On Steps 1 through 3, the participant had to obtain 9 correct consecutive responses in order to advance a step. Five or less responses resulted in backing up a step. On Steps 4 and 5, the participant had to obtain 18 correct responses to pass the step. The backing up criterion was the same for Step 1 through 3. This procedure was only implemented for one session with Participants 4 and 5. In one session, participants' completed 72 and 144 trials, respectively. After advancing through Steps 1 thorough 4 with 100% accuracy, on Step 5, mean performance for Participants 4 and 5 was 33% and 67%. It was hypothesized that participants' responding was controlled by an antecedent other than the size of the correct comparison stimulus. Therefore, a second size fading procedure was implemented.

Size Fading Involving One Comparison Stimulus

Initially, two-choice match-to-sample training was used. To teach relation AB, the words plant (A2) and DISK (A1) were sample stimuli, and the pictures of the cactus (B2) and disk (A1) were comparison stimuli. Three stimuli (i.e., words plant, DISK and picture of disk) remained at their initial size, with the picture of the cactus increasing in size across steps from 12.5% (Step 1) to 25% (Step 2) to 50% (Step 3) to 75% (Step 4), and, finally, 100% (Step 5). Across trials, during all steps, the cactus served as both the incorrect and correct comparison. The criterion for advancing through Steps 1 through 5 was 10 consecutive correct responses; the criterion for backing up a step was three cumulative errors. When the participant advanced to Step 6, the word CLOCK (A3), as sample, and the picture of the clock (B3), as comparison, were added in. In Steps 6 through 10, all stimuli remained at their initial size, with the picture of the clock increasing in size in the same manner as the picture of the cactus. Two-choice match-to-sample training was used, whereby a trial consisted of the clock stimuli, and either the disk or plant stimuli. For Steps 6 through 8, criterion for advancing and backing up a step was the same as for Steps 1 through 5. For Steps 9 and 10, criterion for advancing a step was 18 consecutive correct responses; criterion for backing up a step was 3 cumulative errors. In Step 11, three-choice match-to-sample training was used, with all stimuli at their initial size. Mastery criterion was two consecutive sessions of at least 15 out of 18 correct responses, with no more than one incorrect response per relation. Across participants, the number of trials completed per session ranged from 16 trials to 171 trials. Using this procedure, Participants 1 and 3 remained at Step 1, and Participant 2 was only able to advance to Step 2 after 1624 trials, 1893 trials, and 1887 trials, respectively. Participants 4 and 5 reached mastery criterion for AB and BC after 859 and 756 trials, and 833 and 2243 trials, respectively.

Procedural additions for Participants 1, 2, and 3. For Participants 1 to 3, due to difficulties in passing the beginning Steps (i.e., Steps 1 and 2) of the size fading procedure, involving two comparison stimuli (see paragraph directly above), additional antecedent and consequence manipulations were attempted. A blocked-trial procedure was introduced which was similar to Saunders and Spradlin (1989; 1990). Five and ten-trial blocks were used. Across Participants 1, 2, and 3, this procedure was implemented for 176 trials, 80 trials, and 110 trials, respectively. Percent correct was 60%, 43%, and 45%, respectively. Due to relatively poor performance, the blocking procedure was discontinued.

In addition to gradually increasing the size of the cactus (B2), the size of a sample stimulus (the disk; A1) was gradually decreased across steps. Also, a white wooden board containing three circular indentations was used to implement direct response reinforcement (Thompson & Iwata, 2000). Before each trial, the experimenter placed an edible in the indentation that was under the correct comparison. If the participant made a correct response, he was able to remove the sample and comparison, and retrieve the reinforcer. To prevent completion of errors, the experimenter put her hand on top of the incorrect comparison to block an incorrect response and immediately removed the board.

Procedural additions for Participants 4 and 5. At one point in training the AB relation, Participant 4 was fluctuating between Steps 5 and 6 of the size fading procedure. Visual inspection indicated that the word CLOCK (A3) was not reliably controlling his response. A position fading procedure was introduced whereby each time the sample was the word CLOCK (A3), the picture of one of two incorrect comparisons (i.e., B1 or B2) was gradually faded toward and away from the picture of the clock (B3) that was placed on the board. The incorrect comparison was faded on and off the board in ¼ increments. A correct response was required to advance an increment (e.g., fading from ½ of card on the board to ¾ of card on the board); an incorrect response resulted in backing up an increment. After two sessions of advancing and backing up increments on Step 6, Participant 4 was able to achieve 10 consecutive correct responses at Step 6 and proceeded through the remaining steps.

The same difficulty was exhibited by Participant 5. A similar fading procedure to that of Participant 4 was introduced, with the exception that each time the sample was the word plant (A2), the picture of the clock (B3; incorrect comparison) was gradually faded toward and away from the cactus (B2; correct comparison) that was placed on the board. Visual inspection of the data indicated that, with position fading, the participant continued to match both the word CLOCK (A3) and the word plant (A2) to the picture of the clock (B3). At this point in training, instead of gradually increasing the size of the clock stimulus, the picture of the clock was decreased in size from 175%, to 150%, to 125%, to 112.5%, and, finally, to the initial size. Additionally, intensity fading was used such that the color of the face began at dark gray and was faded to light gray and, finally, to white (i.e., color fading). Following this modification, the participant achieved 10 consecutive correct responses on Level 6 and proceeded through the remaining steps.

Training BC and continuing to review AB. When Participants 4 and 5 met criterion for AB, they were trained, using the same procedure, on BC. For Steps 1 through 5 of size fading, the picture of the disk (B1) and cactus (B2) were sample stimuli and the symbols IBM (C1) and H20 (C2) were comparison stimuli. For Steps 1 through 5, the symbol H20 (C2) increased in increments in the same manner that the cactus (C2) was increased for the training of AB. When Step 5 was mastered, the picture of the clock (B3) and the symbol 10:00 pm (C3) were introduced, with the symbol 10:00 pm (C3) increasing in size across Steps 6 through 10.

For Participant 4, a review of 36 AB trials was conducted, at the beginning of each session, before training on BC began. For Participant 5, when switching from training AB to training on BC, problem behaviors occurred (e.g., removing stimulus materials from table, hitting his head on a stationary object, striking the table with the palm of his hand). Subsequent to the first session, BC training consisted of presenting one sample and correct comparison. Over sessions, two-choice match-to-sample was gradually faded in after every 12th trial, 6th trial, 3rd trial, and, finally, all trials. However, after two sessions of two-choice match-to-sample training on BC, behavioral problems still occurred. For the remainder of training, an AB trial was interspersed after approximately every third BC trial. Also, to meet passing criterion for Step 8, a prompt-fading procedure, similar to that used for training of AB, was implemented. Participant 4 was fluctuating between Steps 5 and 6. Each time the sample was the picture of the cactus (B2) or the picture of the clock (B3), the symbol of one of two incorrect comparisons (i.e., B1 or B2) was gradually faded toward and away from the respective S+ in ¼ increments. After four sessions of advancing and backing up increments on Step 8, Participant 5 was able to achieve 10 consecutive correct responses and proceeded through the remaining steps. Similar to AB, mastery criterion was two consecutive sessions of at least 15 out of 18 correct responses, with no more than one incorrect response per stimulus class. The criterion for advancing to the posttest was four consecutive sessions (two of AB and two of BC) of at least 15 out of 18 responses, with no more than one incorrect response per relation.

Appendix F

Data Sheets and POR Sheets For Pretesting, Training, and Posttesting

Name :
Date :
Experimenter :
IOR :

Relation AA

A1 to A1, A2 to A2, and A3 to A3, with A1, A2, and A3 as comparisons

A1 = word (disk) = D
A2 = word (cactus) = Ca
A3 = word (clock) = Cl

Cl Ca D	Ca Cl D	Cl D Ca	D Cl Ca	Ca Cl D	D Cl Ca
Cl	D	D	Cl	Ca	Ca
1	2	3	4	5	6
Cl Ca D	D Cl Ca	Ca D Cl	Cl Ca D	D Ca Cl	Cl Ca D
D	D	Cl	Ca	Ca	Cl
7	8	9	10	11	12
Ca D Cl	Ca D Cl	D Ca Cl	D Ca Cl	Ca Cl D	Cl D Ca
D	Ca	D	Cl	Cl	Ca
13	14	15	16	17	18
Cl Ca D	Ca Cl D	Cl D Ca	D Cl Ca	Ca Cl D	D Cl Ca
Cl	D	D	Cl	Ca	Ca
19	20	21	22	23	24
Cl Ca D	D Cl Ca	Ca D Cl	Cl Ca D	D Ca Cl	Cl Ca D
D	D	Cl	Ca	Ca	Cl
25	26	27	28	29	30
Ca D Cl	Ca D Cl	D Ca Cl	D Ca Cl	Ca Cl D	Cl D Ca
D	Ca	D	Cl	Cl	Ca
31	32	33	34	35	36

Name :
Date :
Experimenter :
IOR :

Relation BB

B1 to B1, B2 to B2, and B3 to B3, with B1, B2, and B3 as comparisons

B1 = picture (disk) = d
B2 = picture (cactus) = ca
B3 = picture (clock) = cl

d cl ca ca 1	ca cl d ca 2	d cl ca cl 3	cl d ca d 4	ca cl d d 5	cl ca d cl 6
cl ca d cl 7	d ca cl ca 8	cl ca d ca 9	ca d cl cl 10	cl ca d d 11	d cl ca d 12
cl d ca ca 13	ca cl d cl 14	d ca cl cl 15	d ca cl d 16	ca d cl ca 17	ca d cl d 18
d cl ca ca 19	ca cl d ca 20	d cl ca cl 21	cl d ca d 22	ca cl d d 23	cl ca d cl 24
cl ca d cl 25	d ca cl ca 26	cl ca d ca 27	ca d cl cl 28	cl ca d d 29	d cl ca d 30
cl d ca ca 31	ca cl d cl 32	d ca cl cl 33	d ca cl d 34	ca d cl ca 35	ca d cl d 36

Name :
Date :
Experimenter :
IOR :

Relation CC

C1 to C1, C2 to C2, and C3 to C3, with C1, C2, and C3 as comparisons

C1 = symbol (disk) = I
C2 = symbol (cactus) = H
C3 = symbol (clock) = 10

H I 10	H I 10	I H 10	I H 10	H 10 I	10 I H
I	H	I	10	10	H
1	2	3	4	5	6
10 H I	H 10 I	10 I H	I 10 H	H 10 I	I 10 H
10	I	I	10	H	H
7	8	9	10	11	12
10 H I	I 10 H	H I 10	10 H I	I H 10	10 H I
I	I	10	H	H	10
13	14	15	16	17	18
H I 10	H I 10	I H 10	I H 10	H 10 I	10 I H
I	H	I	10	10	H
19	20	21	22	23	24
10 H I	H 10 I	10 I H	I 10 H	H 10 I	I 10 H
10	I	I	10	H	H
25	26	27	28	29	30
10 H I	I 10 H	H I 10	10 H I	I H 10	10 H I
I	I	10	H	H	10
31	32	33	34	35	36

Name :
Date :
Experimenter :
IOR :

Relation AB

A1 to B1, A2 to B2, and A3 to B3, with B1, B2, and B3 as comparisons

Samples
A1 = word (disk) = D
A2 = word (cactus) = Ca
A3 = word (clock) = Cl

Comparisons
B1 = picture (disk) = d
B2 = picture (cactus) = ca
B3 = picture (clock) = cl

cl ca d	ca cl d	cl d ca	d cl ca	ca cl d	d cl ca
Cl	D	D	Cl	Ca	Ca
1	2	3	4	5	6
cl ca d	d cl ca	ca d cl	cl ca d	d ca cl	cl ca d
D	D	Cl	Ca	Ca	Cl
7	8	9	10	11	12
ca d cl	ca d cl	d ca cl	d ca cl	ca cl d	cl d ca
D	Ca	D	Cl	Cl	Ca
13	14	15	16	17	18
cl ca d	ca cl d	cl d ca	d cl ca	ca cl d	d cl ca
Cl	D	D	Cl	Ca	Ca
19	20	21	22	23	24
cl ca d	d cl ca	ca d cl	cl ca d	d ca cl	cl ca d
D	D	Cl	Ca	Ca	Cl
25	26	27	28	29	30
ca d cl	ca d cl	d ca cl	d ca cl	ca cl d	cl d ca
D	Ca	D	Cl	Cl	Ca
31	32	33	34	35	36

Name :
Date :
Experimenter :
IOR :

Relation BC

B1 to C1, B2 to C2, and B3 to C3, with C1, C2, and C3 as comparisons

Samples
B1 = picture (disk) = d
B2 = picture (cactus) = ca
B3 = picture (clock) = cl

Comparisons
C1 = symbol (disk) = I
C2 = symbol (cactus) = H
C3 = symbol (clock) = 10

I 10 H ca 1	H 10 I ca 2	I 10 H cl 3	10 I H d 4	H 10 I d 5	10 H I cl 6
10 H I cl 7	I H 10 ca 8	10 H I ca 9	H I 10 cl 10	10 H I d 11	I 10 H d 12
10 I H ca 13	H 10 I cl 14	I H 10 cl 15	I H 10 d 16	H I 10 ca 17	H I 10 d 18
I 10 H ca 19	H 10 I ca 20	I 10 H cl 21	10 I H d 22	H 10 I d 23	10 H I cl 24
10 H I cl 25	I H 10 ca 26	10 H I ca 27	H I 10 cl 28	10 H I d 29	I 10 H d 30
10 I H ca 31	H 10 I cl 32	I H 10 cl 33	I H 10 d 34	H I 10 ca 35	H I 10 d 36

Name :
Date :
Experimenter :
IOR :

Relation BA

B1 to A1, B2 to A2, and B3 to A3, with A1, A2, and A3 as comparisons

Samples
B1 = picture (disk) = d
B2 = picture (cactus) = ca
B3 = picture (clock) = cl

Comparisons
A1 = word (disk) = D
A2 = word (cactus) = Ca
A3 = word (clock) = Cl

D Cl Ca ca 1	Ca Cl D ca 2	D Cl Ca cl 3	Cl D Ca d 4	Ca Cl D d 5	Cl Ca D cl 6
Cl Ca D cl 7	D Ca Cl ca 8	Cl Ca D ca 9	Ca D Cl cl 10	Cl Ca D d 11	D Cl Ca d 12
Cl D Ca ca 13	Ca Cl D cl 14	D Ca Cl cl 15	D Ca Cl d 16	Ca D Cl ca 17	Ca D Cl d 18
D Cl Ca ca 19	Ca Cl D ca 20	D Cl Ca cl 21	Cl D Ca d 22	Ca Cl D d 23	Cl Ca D cl 24
Cl Ca D cl 25	D Ca Cl ca 26	Cl Ca D ca 27	Ca D Cl cl 28	Cl Ca D d 29	D Cl Ca d 30
Cl D Ca ca 31	Ca Cl D cl 32	D Ca Cl cl 33	D Ca Cl d 34	Ca D Cl ca 35	Ca D Cl d 36

Name :
Date :
Experimenter :
IOR :

Relation CB

C1 to B1, C2 to B2, and C3 to B3, with B1, B2, and B3 as comparisons

Samples
C1 = symbol (disk) = I
C2 = symbol (cactus) = H
C3 = symbol (clock) = 10

Comparisons
B1 = picture (disk) = d
B2 = picture (cactus) = ca
B3 = picture (clock) = cl

ca d cl	ca d cl	d ca cl	d ca cl	ca cl d	cl d ca
I	H	I	10	10	H
1	2	3	4	5	6
cl ca d	ca cl d	cl d ca	d cl ca	ca cl d	d cl ca
10	I	I	10	H	H
7	8	9	10	11	12
cl ca d	d cl ca	ca d cl	cl ca d	d ca cl	cl ca d
I	I	10	H	H	10
13	14	15	16	17	18
ca d cl	ca d cl	d ca cl	d ca cl	ca cl d	cl d ca
I	H	I	10	10	H
19	20	21	22	23	24
cl ca d	ca cl d	cl d ca	d cl ca	ca cl d	d cl ca
10	I	I	10	H	H
25	26	27	28	29	30
cl ca d	d cl ca	ca d cl	cl ca d	d ca cl	cl ca d
I	I	10	H	H	10
31	32	33	34	35	36

Name :
Date :
Experimenter :
IOR :

Relation AC

A1 to C1, A2 to C2, and A3 to C3, with C1, C2, and C3 as comparisons

Samples
A1 = word (disk) = D
A2 = word (cactus) = Ca
A3 = word (clock) = Cl

Comparisons
C1 = symbol (disk) = I
C2 = symbol (cactus) = H
C3 = symbol (clock) = 10

10 H I	H 10 I	10 I H	I 10 H	H 10 I	I 10 H
Cl	D	D	Cl	Ca	Ca
1	2	3	4	5	6
10 H I	I 10 H	H I 10	10 H I	I H 10	10 H I
D	D	Cl	Ca	Ca	Cl
7	8	9	10	11	12
H I 10	H I 10	I H 10	I H 10	H 10 I	10 I H
D	Ca	D	Cl	Cl	Ca
13	14	15	16	17	18
10 H I	H 10 I	10 I H	I 10 H	H 10 I	I 10 H
Cl	D	D	Cl	Ca	Ca
19	20	21	22	23	24
10 H I	I 10 H	H I 10	10 H I	I H 10	10 H I
D	D	Cl	Ca	Ca	Cl
25	26	27	28	29	30
H I 10	H I 10	I H 10	I H 10	H 10 I	10 I H
D	Ca	D	Cl	Cl	Ca
31	32	33	34	35	36

Name :
Date :
Experimenter :
IOR :

Relation CA

C1 to A1, C2 to A2, and C3 to A3, with A1, A2, and A3 as comparisons

Samples
C1 = symbol (disk) = I
C2 = symbol (cactus) = H
C3 = symbol (clock) = 10

Comparisons
A1 = word (disk) = D
A2 = word (cactus) = Ca
A3 = word (clock) = Cl

Ca D Cl	Ca D Cl	D Ca Cl	D Ca Cl	Ca Cl D	Cl D Ca
I	H	I	10	10	H
1	2	3	4	5	6
Cl Ca D	Ca Cl D	Cl D Ca	D Cl Ca	Ca Cl D	D Cl Ca
10	I	I	10	H	H
7	8	9	10	11	12
Cl Ca D	D Cl Ca	Ca D Cl	Cl Ca D	D Ca Cl	Cl Ca D
I	I	10	H	H	10
13	14	15	16	17	18
Ca D Cl	Ca D Cl	D Ca Cl	D Ca Cl	Ca Cl D	Cl D Ca
I	H	I	10	10	H
19	20	21	22	23	24
Cl Ca D	Ca Cl D	Cl D Ca	D Cl Ca	Ca Cl D	D Cl Ca
10	I	I	10	H	H
25	26	27	28	29	30
Cl Ca D	D Cl Ca	Ca D Cl	Cl Ca D	D Ca Cl	Cl Ca D
I	I	10	H	H	10
31	32	33	34	35	36

Training AB (two-choice)

Name :
Date :
Experimenter :
IOR :

Relation AB

A1 to B1, A2 to B2, and A3 to B3, with B1, B2, and B3 as comparisons

Samples
A1 = word (disk) = D
A2 = word (cactus) = Ca

Comparisons
B1 = picture (disk) = d
B2 = picture (cactus) = ca

ca B d D 1	B d ca D 2	ca B d Ca 3	d B ca Ca 4	B ca d D 5	d B ca D 6
B ca d Ca 7	d ca B Ca 8	ca d B D 9	ca d B Ca 10	d ca B D 11	B d ca Ca 12
ca B d D 13	B d ca D 14	ca B d Ca 15	d B ca Ca 16	B ca d D 17	d B ca Ca 18
B ca d Ca 19	d ca B Ca 20	ca d B D 21	ca d B Ca 22	d ca B D 23	B d ca Ca 24
ca B d Ca 25	B d ca D 26	ca B d Ca 27	d B Ca Ca 28	B ca d D 29	d B ca D 30
B ca d Ca 31	d ca B Ca 32	ca d B D 33	ca d B Ca 34	d ca B D 35	B d ca Ca 36

Training BC (two-choice)

Name :
Date :
Experimenter :
IOR :

Relation BC

B1 to C1, B2 to C2, and B3 to C3, with C1, C2, and C3 as comparisons

Samples
B1 = picture (disk) = d
B2 = picture (cactus) = ca

Comparisons
C1 = symbol (disk) = I
C2 = symbol (cactus) = H

I B H ca 1	H B I ca 2	B I H d 3	H B I d 4	I H B ca 5	B H I ca 6
B H I d 7	I B H d 8	B I H ca 9	I H B d 10	H I B ca 11	H I B d 12
I B H ca 13	H B I ca 14	B I H d 15	H B I d 16	I H B ca 17	B H I ca 18
B H I d 19	I B H d 20	B I H ca 21	I H B d 22	H I B ca 23	H I B d 24
I B H ca 25	H B I ca 26	B I H d 27	H B I d 28	I H B ca 29	B H I ca 30
B H I d 31	I B H d 32	B I H ca 33	I H B d 34	H I B ca 35	H I B d 36

POR Sheet For Pretesting and Posttesting

Name: ____________________________

Tester: ____________________________

POR: ____________________________

Date: ____________________________

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	2
Set up (correct position of apparatus; correct manipulandum)																				
Present array of six edibles and say, "Pick one."																				
Demonstration																				
Guided Trial																				
Correct Auditory Cue from experimenter (Independent Response)																				
If participant does not respond after 10s, verbal/physical prompt is provided																				
If Correct/Incorrect… Thank-you																				

POR - Training Relations AB AC

Name: ____________________________

Tester:____________________________

POR:____________________________

Date:____________________________

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Set up (correct position of apparatus; correct manipulandum)																				
Prompt Fading																				
Correct Auditory Cue from experimenter (Independent Response)																				
If participant does not respond after 10s, verbal/physical prompt is provided																				
If Correct… Present array of six edibles and say, "Pick one." (but only on testing trials). Provide LOTS of verbal praise during intro and testing.																				
If Incorrect…provide Block / Extinction																				

Appendix G

Error Analysis of Posttests 1 and 2 for Participant 4

AB

	DISK (A1)	Plant (A2)	CLOCK (A3)
Picture of Disk (B1)	6+		
Picture of Cactus (B2)		6+	
Picture of Clock (B3)			6+

BC

	Picture of Disk (B1)	Picture of Cactus (B2)	Picture of Clock (B3)
IBM (C1)	6+		1-
H20 (C2)		6+	
10:00 p.m. (C3)			5+

BA

	Picture of Disk (B1)	Picture of Cactus (B2)	Picture of Clock (B3)
DISK (A1)	7+		5-
Plant (A2)	3-	12+	3-
CLOCK (A3)	2-		4+

CB

	IBM (C1)	H20 (C2)	10:00 p.m. (C3)
Picture of Disk (B1)	12+	2-	4-
Picture of Cactus (B2)		7+	7-
Picture of Clock (B3)		3-	1+

AC

	DISK (A1)	plant (A2)	CLOCK (A3)
IBM (C1)	8+		1-
H20 (C2)	2-	12+	5-
10:00 p.m. (C3)	2-		6+

CA

	IBM (C1)	H20 (C2)	10:00 p.m. (C3)
DISK (A1)	8+	1-	3-
plant (A2)	2-	9+	6-
CLOCK (A3)	2+	2-	3+