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Teaching Manual Signs to Adults With Mental Retardation Using Matching-to-Sample Procedures and Stimulus Equivalence

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The objective of this study was to teach manual signs through an automated matching-to-sample procedure and to test for the emergence of new conditional relations and imitative behaviors. Seven adults with mild to severe mental retardation participated. Four were also hearing impaired. Relations between manual signs (set A) and pictures (set B) were initially taught, followed by the training of corresponding printed words (set C) and pictures (set B). Further presentations of conditional discriminations tested for the emergence of AC, followed by tests for the emergence of imitative signing behavior (D) in the presence of either pictures (B) or printed words (C). Each stimulus set was comprised of 9 elements. The stimuli were still pictures, printed words, and dynamic presentations of manual signs. A pretest was conducted to determine which signs the participants could make pre-experimentally. Teaching was arranged in a multiple baseline design across 3 groups of 3 words each.The purpose of the present study was to determine whether participants would emit manual signs in expressive signs tests as a result of observation (video modeling) during match-to-sample training in the absence of explicit training. Five of the 7 subjects passed tests of emergence and emitted at least 50% of the signs. Two were hearing impaired with signing experience, and 3 were not hearing impaired and had no signing experience. Thus, observation of video recorded manual signs in a matching-to-sample training procedure was effective at establishing some signs by adults with mental retardation.

Key words: manual signs, mental retardation, matching-to-sample, stimulus equivalence

Stimulus equivalence paradigms have been used to study complex human behavior, and to effectively teach academic and other socially relevant skills to individuals with or without learning disabilities (i.e., Mackay, 1985; McLean, Brady, & McLean, 1996; Neves, 1995; Rossit & Goyos, 2004; K. Saunders & Spradlin, 1990, 1993; Sidman, 1971; Sidman & Cresson, 1973; Stromer & Mackay, 1993). According to Sidman (2000), equivalence is the direct result of reinforcement contingencies where such contingencies produce at least two types of results: analytical units and equivalence relations. A four-term analytical unit (conditional stimulus, discriminative stimulus, response, and reinforcement) is called conditional discrimination.

Conditional discrimination may be established through a matching-to-sample (MTS) procedure. This procedure is used to organize four-term contingencies in discrete trial series. In a typical MTS trial, a sample stimulus is presented first. Following a response to the sample (i.e., touching the sample with a finger), two or more comparison stimuli are presented in distinct places. For each sample, only one comparison stimulus is arbitrarily designed by the experimenter as positive or discriminative for reinforcement (S+), whereas the other comparison stimuli presented simultaneously are negative (S-). However, such S- stimuli are typically designed to be correct with other sample stimuli in other trials.

Following the subject's response to a comparison stimulus in a trial, programmed differential consequences are provided for S+ or S- selections followed by an intertrial interval. To consistently meet these contingency requirements, the subject must discriminate between sample stimuli presented through successive

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trials and between comparison stimuli presented simultaneously within a trial (Green & Saunders, 1998).

A possible example would be, given two discriminative stimuli, B1 and B2, the subject selects B1 in the presence of the conditional stimulus A1 and selects B2 in the presence of the conditional stimulus A2. B1 and B2 are called comparison stimuli, whereas A1 and A2 are called sample stimuli. The relation between the sample stimulus and its appropriate comparison stimulus is an identity relation if the physical features are identical, and symbolic or arbitrary if sample and comparison stimuli are physically different (Sidman & Tailby, 1982).

After establishing conditional relations among the stimuli, in order to determine if the relations are equivalence relations, it is necessary to show the presence of three properties derived from a mathematics definition: reflexivity, symmetry, and transitivity. Reflexivity corresponds to the conditional relation between two identical stimuli. Symmetry corresponds to the conditional relation inverse to the trained relation between two stimuli. Transitivity is the conditional relation between two stimuli where each is related to a third in-common stimulus. As an example, suppose that the conditional discriminations AB and BC are trained, in which the first letter corresponds to the conditional stimulus and the second letter corresponds to the discriminative stimulus. Reflexivity is shown through tests of the relations AA, BB, and CC; symmetry is shown through tests of the relations BA and CB; and transitivity, tests of the relation AC. Finally, a direct test for equivalence (CA) combines two properties: transitivity and symmetry.

In a seminal paper, Sidman (1971) taught a microcephalic young man to select printed words (stimulus set C) in the presence of the corresponding dictated words (stimulus set A) through conditional discriminations. At the onset of the study, the participant already presented the relations between dictated words (stimulus set A) and pictures (stimulus set B). Subsequent testing showed that relations between the printed words (set C) and their corresponding pictures (set B) and the oral reading response (set D) emerged without direct teaching. Sidman's (1971) study introduced a procedure to establish new oral reading and comprehension skills via expansion of receptive and expressive language skills using conditional discrimination procedures.

Lowenkron (1998) proposed that children first learn a receptive repertoire (object names spoken by another person serve to control selections, or other responses, to objects), and later, children acquire expressive repertoires (for example, they tact the objects they have selected as well as the actions they have imitated). The author also points out that along with the acquisition of names for objects, accurate selection of objects in response to their names often appear spontaneously, the generality of which has been extensively demonstrated (Lowenkron, 1984, 1988, 1989). This name-object bidirectionality is commonly understood to be a pivotal process in the acquisition and use of language because it permits the efficient acquisition of much behavior without direct training (Horne & Lowe, 1996).

As proposed by Michael (1985), the term *receptive repertoire* can be defined as stimulus selection-based verbal behavior and the term *expressive repertoire* as topography-based verbal behavior. Sundberg and Sundberg (1990) designed a study to examine the difference between topography-based verbal behavior and stimulus selection-based verbal behavior with regard to speed of acquisition, accuracy of responses, generality, maintenance, spontaneous usage, and the formation of equivalence classes. Four individuals with mental retardation with moderate to severe language deficits aged from 33 to 50 years old participated in the study. Each subject was taught to point to a symbol (selection-based verbal behavior), or make a sign (topography-based verbal behavior) when shown an object and when an object's name was spoken. Tests for the emergence of the relation between the objects and their corresponding spoken names were then conducted. The results showed that 3 of the 4 subjects demonstrated faster acquisition of every relation trained and higher percentages of correct responses in the tests with the topography-based procedure. Sundberg and Sundberg (1990) noted, however, that some of their subjects did respond to a testing stimulus during the topography-based phase by naming it or making the sign before they chose one of the three objects, and that these subjects seemed to perform better during testing when the mediating response was made.

According to Osborne and Gatch (1989), the relative absence of associations between words and their corresponding stimuli may

Table 1
*Participants' Description**

Participant**	Age	Deafness	Level of MR***	MR test	Other features
Mary	43	No	Mild	WAIS-R	None
Rose	61	No	Mild	WAIS	Epilepsy
John	34	No	Mild	WAIS	None
Paul	21	Profound bilateral/ sensorineural hearing loss	Severe	Hiskey Nebraska Test of Learning Aptitudes	Cerebral palsy
Peter	25	Profound bilateral/ sensorineural hearing loss	Low average to mild	Test of Nonverbal Intelligence Form A	None
Kate	23	Profound bilateral/ sensorineural hearing loss	Moderate		Cerebral palsy
Bob	58	sensorineural hearing loss (67dB right, 65dB left)	Upper mild	French Pictorial Test of Intelligence	Mild cerebral palsy

Note: * Data obtained from JCDS medical records. ** The names are fictitious. *** MR – Mental Retardation

constitute one of the reading problems experienced by hearing impaired people. Osborne and Gatch (1989) replicated and extended Sidman's (1971) findings to profoundly hearing impaired preschool children, using visual stimuli only to develop receptive reading via equivalence relations. One child was taught relations between manually signed words and their pictures and between manually signed words and their printed forms. Testing showed that relations between the pictures and the printed words emerged without further training. A second child was taught relations between manually signed words and their pictures and between the pictures and their printed words. Testing also showed emergence of the relations between the manually signed words and the printed words. Osborne and Gatch (1989) also showed, in additional tests for the first child, that both the printed words and the pictures were controlling the child's signing response (expressive reading and tact, respectively).

Sundberg and Sundberg (1990) and Osborne and Gatch (1989) strengthened the notion that conditional discrimination procedures and stimulus equivalence could be a basis for teaching both receptive and expressive language for the hearing impaired population. However, they did not systematically test for the emergence of the expressive repertoire after teaching a receptive repertoire. The latter also suggested that these procedures could greatly benefit from computer technology.

Considering the prospective practical applications derived from these studies to the teaching of language in general, and particularly to the teaching of manual signing, the present study replicated and extended Osborne and Gatch's (1989) study to hearing impaired, mentally disabled adults. We investigated whether receptive exposure to manual signs in an automated matching-to-sample task would generate the behavior of expressively emitting a sign in the presence of pictures (expressive tact) or printed words (expressive reading) without direct training of signing. Participants were taught the relations between manual signs and pictures and between printed words and pictures. Subsequent tests were conducted for the emergence of the relation between pictures and expressive signing and, more importantly, printed words and expressive signing.

METHOD

Participants

Seven adults with mental retardation participated in this study. Four of them were also hearing impaired. All participants were clients at Johnson County Developmental Supports (JCDS), located in Lenexa, Kansas, USA. Table 1 shows participants' characteristics.

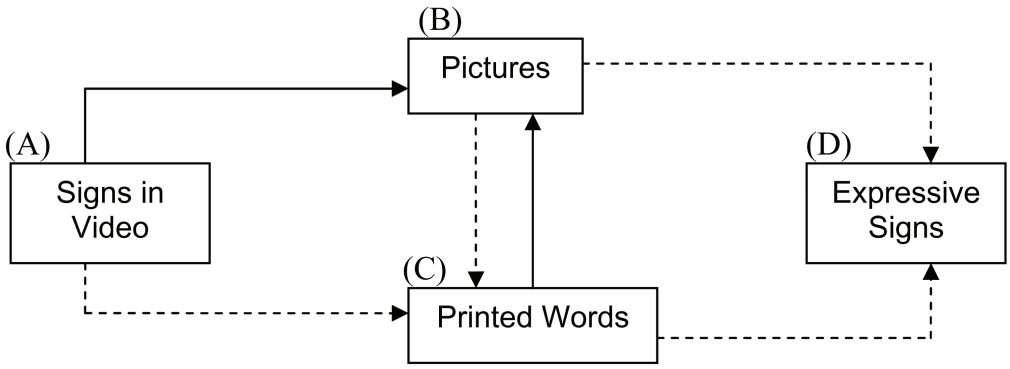

Figure 1. Stimulus (A, B, and C) and response (D) sets and relations used in the conditional discrimination tasks. Full arrows indicate training and broken arrows indicate test. Set A are video signs showed by the computer, Set B are static images (picture, drawing), Set C are printed words, and Set D are the signs emitted by the participants.

Mary and Rose had experience with signing; John and Paul could emit some simple signs; Peter, Kate, and Bob were proficient in sign language.

Stimuli

The stimuli were pictures of objects and their corresponding printed words and manual signs (according to the American Sign Language) for the words. Pictures were approximately 2.8 x 2.8 in. drawings. Printed words were presented in lower case Arial font, in bold, black, size 30 type against a white background. Manual signs were recorded using a digital camera as a QuickTime® movie. The camera was mounted on a tripod in front of a white wall and the experimenter stood facing the camera. Signs were made slowly so that hand configuration and movement were clear. Each video segment lasted about 10 s.

Selection of stimuli was based on two criteria: (a) they were nouns (i.e., object, food, animal), and (b) the corresponding sign could not be iconic. The signs were taken from Heeter et al. (1996). The relations between these stimuli are shown in Figure 1. Trained relations were AB (signs in video–pictures) and CB (printed words–pictures); tested relations were AC (signs in video–printed words), BD (pictures–expressive signs), and CD (printed words–expressive signs).

Prior to training, pretests were conducted with 29 signs (set A) and their corresponding pictures (set B) and printed words (set C) to identify which signs the participants already emitted, if any. This phase was important because some participants had been trained in sign language in the past. From the 29 original stimuli in each set, 9 signs and their corresponding pictures and printed words were selected to be used in the subsequent phases for each participant. The 29 words were *banana*, *barometer*, *boat*, *bone*, *butterfly*, *candle*, *cow*, *flashlight*, *fire*, *helicopter*, *hyena*, *kaleidoscope*, *knife*, *letter*, *microscope*, *missile*, *mosquito*, *oar*, *octopus*, *poncho*, *popcorn*, *raccoon*, *refrigerator*, *ruler*, *satellite*, *speedometer*, *turtle*, *walrus*, and *xylophone*. To select the final stimuli for each participant, four relations were tested: relations AB, BC, AC (MTS task, described below), and also relation BD (signing task, described below). The tasks showed all original stimuli in a random order for sample and comparison stimuli.

At the end of the pretest, 3 sets of 9 stimuli were selected for each participant: manual signs (A1, A2, …, A9), pictures (B1, B2, …, B9), and printed words (C1, C2, …, C9). A1 was the corresponding sign for picture B1 and for the printed word C1, and so on. Table 2 shows each participant's chosen words divided in three groups of three words.

Setting and Apparatus

Sessions were presented using a Macintosh LC III® computer with a 14-inch touchscreen monitor using Troll Touch® Software (Version 1.8.8). A computer program created by the experimenter (Goyos, Elias & Ribeiro, 2005) was used to organize and show stimuli and conse-

Table 2
Stimulus Names Divided by Group for Each Participant

Group Participant	Group 1	Group 2	Group 3
Mary	boat, fire, popcorn	candle, letter, mosquito	flashlight, ruler, turtle
Rose	boat, cow, knife	flashlight, mosquito, refrigerator	bone, helicopter, ruler
John	boat, candle, letter	turtle, refrigerator, flashlight	ruler, bone, helicopter
Paul	banana, fire, butterfly	popcorn, helicopter, candle	flashlight, bone, ruler
Peter	barometer, kaleidoscope, speedometer	microscope, oar, poncho	raccoon, missile, hyena
Kate	barometer, oar, walrus	microscope, satellite, speedometer	kaleidoscope, missile, poncho
Bob	barometer, kaleidoscope, octopus	walrus, missile, oar	satellite, hyena, microscope

quences, and to record training and testing data from the MTS tasks. For signing tasks, pictures and printed words were presented using PowerPoint®. During training and testing sessions, the participant sat in a chair facing the monitor and the experimenter sat to his/her right side.

Tasks

Matching-to-sample (MTS). Each trial started with the sample stimulus in the upper portion of the monitor. When the participant touched the stimulus with a hand or finger, three comparison stimuli were presented below the sample. Depending upon the participant's selection, during training sessions, the computer delivered the programmed consequences for correct and incorrect responses. Correct choices produced an animation shown on the monitor and verbal praise provided by the experimenter; incorrect responses produced a black screen shown on the monitor. The animation showed a coin falling into a piggy bank. Verbal praise, for hearing participants, consisted of short sentences such as "Good!", "Very good!", or "Right!"; for hearing impaired participants, the experimenter used some gestures or touched them on the shoulder. Participants' selections produced an intertrial interval of 2 s, immediately followed by the next trial. During test sessions, no differential consequences were programmed except the intertrial presentation followed by advancement to the next trial. Each session comprised 12 trials.

Expressive signing. The participant was presented pictures or printed words and asked to show the corresponding manual sign. A sign was considered correct if it corresponded to, or was similar to the corresponding sign for the picture or printed word being shown. Similarity, in this case, was important because a sign may be performed with the left or right hand. For example, the sign for *cow*, which begins with the hand-shape in an *L*, is performed by touching the temple with the thumb and making semi-circular movements bending the index finger to the back. These movements may be performed with the left or right hand, or even with both hands together. There were no differential consequences programmed on signing tasks. If the participant signed, even if it was not the correct sign, an intertrial interval of 2 s was presented, immediately followed by the next trial. If, after 10 s from the onset of the stimulus, the participant did not perform the sign, the response was considered incorrect.

Table 3
Training and Test Procedures With Experimental Phases and Relations

Experimental phase	Relations
Pretraining (identity MTS)	BB (pineapple, bee, tree)
Pretests	BC (29 stimuli) AC (29 stimuli) AB (29 stimuli) BD (29 stimuli)
CB training	C1B1, C2B2, C3B3
AB training	A1B1, A2B2, A3B3
AC test	A1C1, A2C2, A3C3
Signing test	B1D1, B2D2, B3D3, B4D4, B5D5, B6D6, B7D7, B8D8, B9D9, C1D1, C2D2, C3D3, C4D4, C5D5, C6D6, C7D7, C8D8, C9D9
CB training	C4B4, C5B5, C6B6
AB training	A4B4, A5B5, A6B6
AC test	A4C4, A5C5, A6C6
Signing test	B1D1, B2D2, B3D3, B4D4, B5D5, B6D6, B7D7, B8D8, B9D9, C1D1, C2D2, C3D3, C4D4, C5D5, C6D6, C7D7, C8D8, C9D9
CB training	C7B7, C8B8, C9B9
AB training	A7B7, A8B8, A9B9
AC test	A7C7, A8C8, A9C9
Signing test	B1D1, B2D2, B3D3, B4D4, B5D5, B6D6, B7D7, B8D8, B9D9, C1D1, C2D2, C3D3, C4D4, C5D5, C6D6, C7D7, C8D8, C9D9

Procedure

Pretraining. Pretraining consisted of identity MTS with pictures (relation BB) as sample and comparison stimuli, to insure that participants could emit the requisite performance for MTS tasks. The pictures were drawings of a pineapple, a bee, and a tree, and were not used in the subsequent phases. The criterion for terminating this step was 100% of correct responses in 12 consecutive trials in a task. All 7 participants needed only one session to reach criterion in the identity MTS task.

Pretest. Pretests were conducted to select nine pictures and nine corresponding printed words that did not yet evoke the corresponding signs (except as noted below). Relations AC (sign–printed word), BC (picture–printed word), and AB (sign–picture) were pretested on MTS tasks and relation BD (picture–expressive sign) was pretested on signing tasks for the original 29 stimuli in each set. Relation CD (printed words–expressive sign) was not pretested because pretests on relations AC and BC showed participants did not recognize the printed words. Data obtained on pretests served as a baseline for the subsequent phases.

Training and test procedures. After nine novel signs were identified, participants were trained on relation CB for Group 1, until they reached 100% of correct responses in a session, or at least 90% in two consecutive sessions. Then, they were trained on relation AB for the same group, until they reached the same criterion. After reaching criterion on relation AB, they were tested on relation AC.

If the participant did not reach 100% of correct responses for relation AC, he or she was retrained on relations CB and AB and retested on relation AC. When the participant reached criterion on relation AC, he/she was tested on signing tasks for relations BD and CD for all stimuli. Relations CB and AB training were then conducted for the next stimulus group followed by tests on relations AC, BD, and CD until all stimulus groups were trained and tested. At the end of each daily session, participants received money regardless of performance.

Table 3 shows the training and test procedures.

Experimental design. A multiple baseline design across stimulus groups was used.

Reliability. Signing tasks were recorded so that a second observer could analyze participants' responses. Each response was analyzed as correct or incorrect considering hand configuration, location, and movement. Reliability was 100% on a trial-by-trial analysis.

Instructions. During training sessions, each participant sat in front of the computer. The experimenter sat on the participant's right side and gave him or her simple instructions:

> "I will show you what to do. First, you look here," (experimenter points to the sample stimulus) "and then you touch it. Then, you touch one here," (experimenter points to the three comparison stimuli). "If it is right, you will see this," (computer shows an animation). "Now, it is your turn.

During test sessions, the instructions were:

> "I will show you some pictures and words. You will try to make/perform the sign for them." (Experimenter points to a picture or word on the monitor.) "What is the sign for this?"

For hearing impaired participants the experimenter signed the instructions.

RESULTS

Mary, Rose, John, and Paul had little or no experience with signing. Of primary interest for these participants was whether they would emit the signs after observing the videos in the MTS tasks. Therefore, the procedure for these participants started with two sets of stimuli (pictures and manual signs) and relations AB and BD. After reaching criterion on relation AB for all stimulus groups and being tested on relation BD, the other set (printed words) was included. Mary, Rose, and John already knew how to read, so only relations AC and BC were tested; as they reached criterion for relations AC and BC without training, they were tested once again on the signing relation BD as well as on the signing relation CD.

For Mary, Rose, John, and Paul, pretest results on relation AB (see pretest sessions in Figure 2) indicate that they did not consistently choose the correct picture in the presence of the corresponding sign at the beginning of the study.

For Peter, Kate, and Bob, pretest results on relations BC and AC (see pretest sessions in Figure 3) indicate that they did not consistently choose the correct printed word in the presence of the corresponding sign or picture at the beginning of the study. However, pretest results on relation AB (see pretest sessions in Figure 3) indicate that Peter consistently chose the correct picture in the presence of the corresponding sign for stimuli in Groups 2 and 3, Kate did not show this repertoire for any stimuli, and Bob showed this repertoire for stimuli in Group 2.

Higher correct response percentages on pretests may have occurred by chance, since participants had one chance in three to choose the correct comparison stimulus.

Figures 2 and 3 show participants' results on MTS tasks.

After a number of training sessions with the first word group, it was noted that Mary, Rose, John, Paul, Kate, and Bob were responding by chance (i.e., the number of correct responses was not improving). To solve this problem, an additional teaching procedure was included (Green & Saunders, 1998; Saunders & Spradlin, 1989; Saunders & Williams, 1998), in which the same sample stimulus was presented in trial blocks.

In the additional teaching procedure, the same sample stimulus is presented in trial blocks. The number of trials in a block was gradually reduced until sample stimuli were randomly presented. For example, to train relations between three signs (A) and three corresponding pictures (B), tasks were designed as follows: the first sign (sample stimulus) was presented in a 12-trial block task with the three pictures (comparison stimuli) presented in distinct positions in each trial, until errors occur

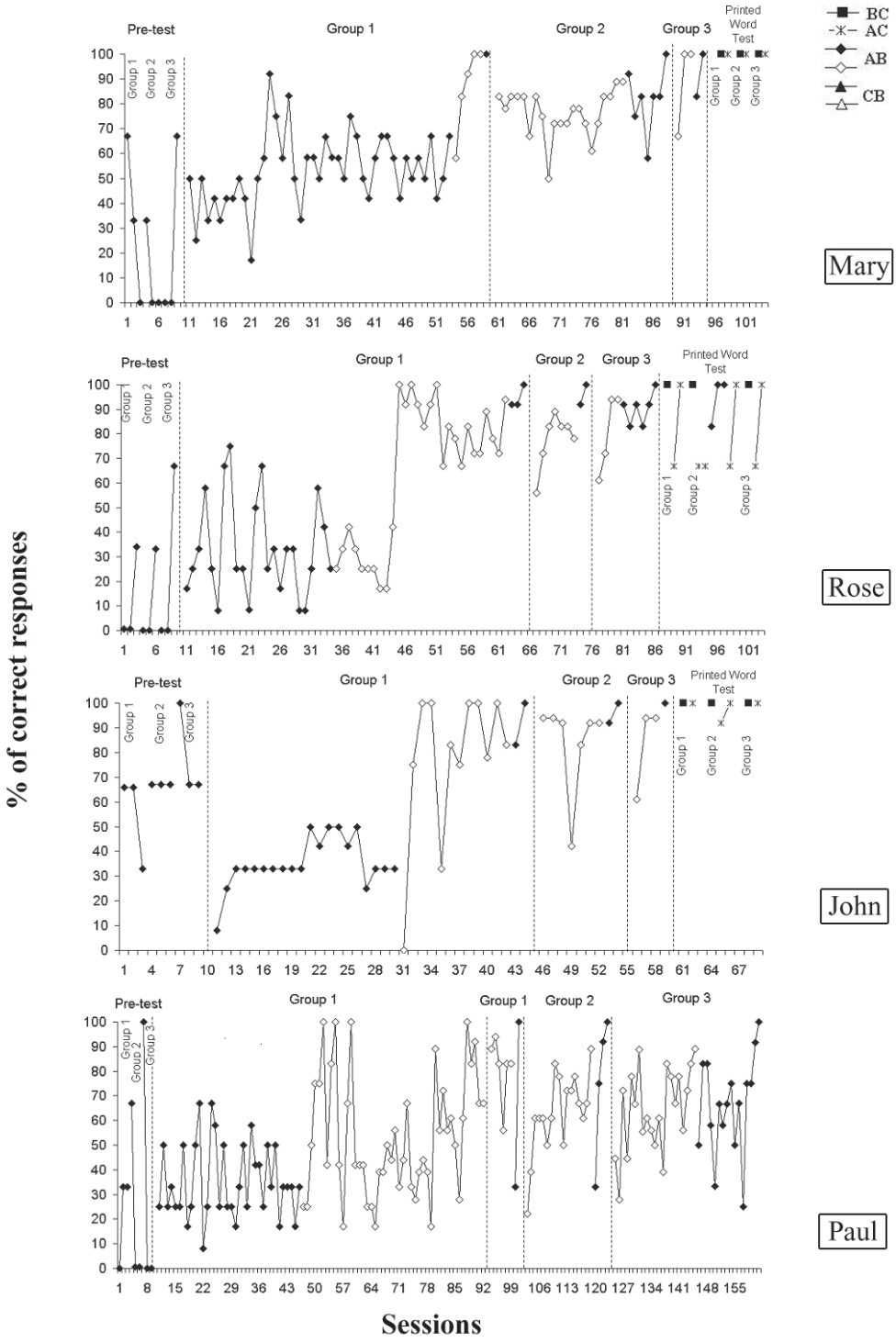

Figure 2. Percentage of correct responses on MTS tasks for Mary, Rose, John, and Paul. Filled points refer to pattern conditional discriminations and unfilled points to blocked trial conditional discriminations. Dotted lines indicate training and test sequence beginning for each group.

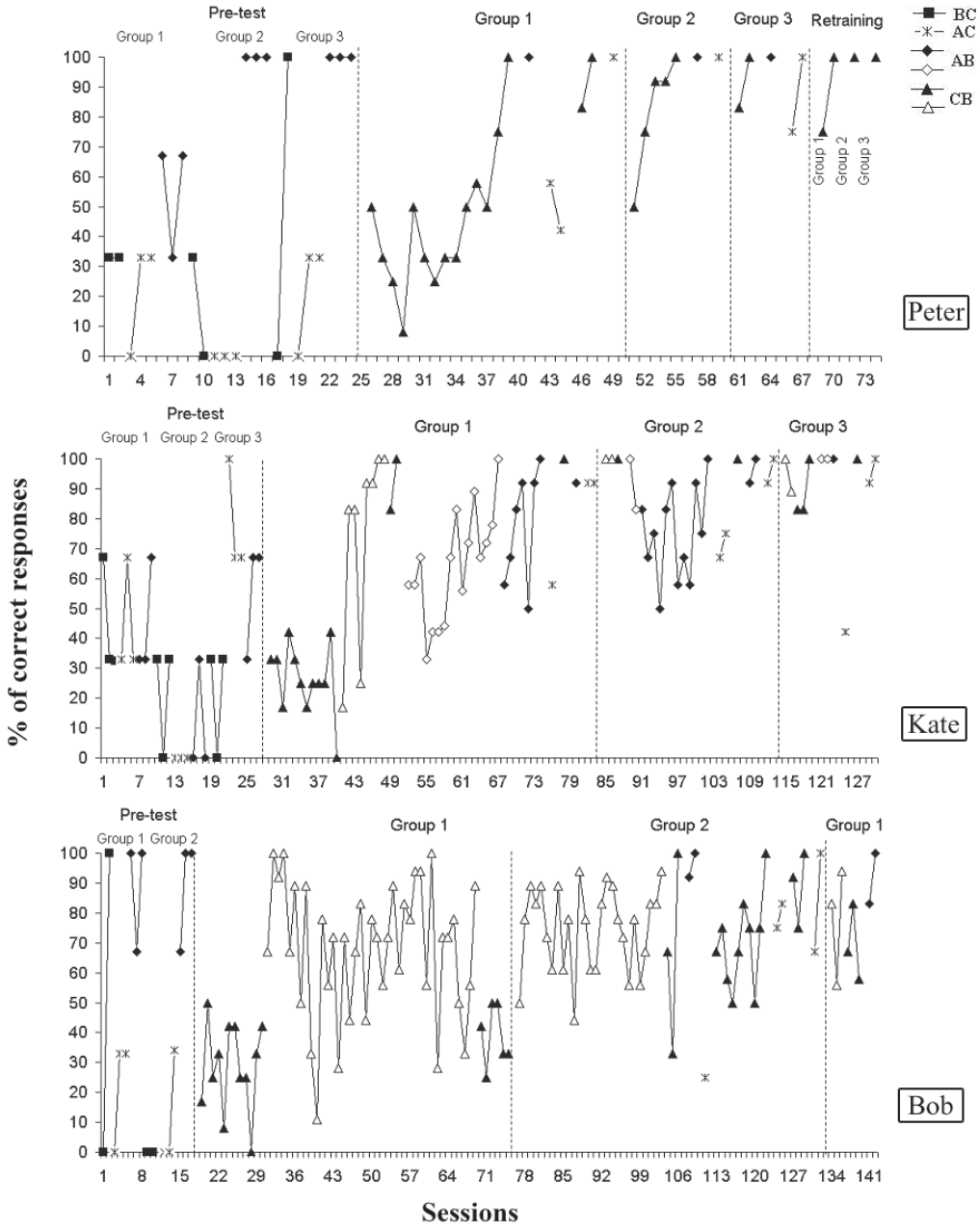

Figure 3. Percentage of correct responses on MTS tasks for Peter, Kate, and Bob. Filled points refer to pattern conditional discriminations and unfilled points to blocked trial conditional discriminations. Dotted lines indicate training and test sequence beginning for each group.

only in the two initial trials; then, the second sign was presented until the same criterion; finally, the third sign was presented. An 18-trial task was then introduced for the same relations, with each sign presented in six consecutive trial blocks and pictures presented in distinct positions for each trial until errors occured only in the first trial for each sign. Finally, an 18-trial task with three trial blocks was presented until errors occured only in the first trial of the first three blocks. This sequence is shown in Table 4.

Table 4
Blocked Trial Procedure to Train Relations AB for Stimuli in Group 1

Steps	Relations	Number of trials
1	A1B1	12
2	A2B2	12
3	A3B3	12
4	A1B1	6
	A2B2	6
	A3B3	6
5	A1B1	3
	A2B2	3
	A3B3	3
	A1B1	3
	A2B2	3
	A3B3	3

After using blocked trial tasks, Mary, Rose, John, and Kate improved their performance significantly, reaching criterion in a few sessions. However, Paul and Bob did not reach criterion even after protracted exposure to blocked trial tasks. It was considered that the stimuli (manual signs) for *popcorn* and *fire* were too similar and therefore preventing an important discrimination for Paul. Thus, the sign and picture for *popcorn* were replaced by the sign and picture for *butterfly*, after which Paul reached criterion in a few sessions.

For Bob, all words were replaced. Words from the first group (barometer, kaleidoscope, and octopus) were replaced by words from the second group (walrus, missile, and oar) due to the complexity of the printed words in the first group. Bob reached criterion in 30 sessions for the new group while he had already completed 63 sessions for the first group without reaching criterion for relation CB.

Results of signing tests for Mary, Rose, John, and Paul are shown in Figure 4 and those for Peter, Kate, and Bob are shown in Figure 5. All participants emitted 100% correct signs for most groups for the relation BD after conditional discrimination training. Furthermore, increases in performance for BD were observed immediately after the introduction of the AB/CB training for most participants. Interestingly enough, for Mary and Rose, performance declined across sucessive test trials for word groups 2 and 1 respectively. Paul was not tested on relations containing printed words and Bob finished training and testing phases only for Groups 1 and 2.

Performance on CD tests for hearing participants Mary, Rose, and John (Figure 4) shows emergence of expressive signing in the presence of printed words for the three word groups. Although not all relations were tested, the emergence of expressive signing for these participants could be explained by the transfer of stimulus functions via equivalence class formation involving signs, pictures, and printed words.

On the other hand, for hearing impaired participants, the results show that performance on both BD and CD increased immediately after the introduction of AB and CB training, and that there was a greater performance difference in expressive signing according to the type of discriminative stimulus—pictures or printed words. Hearing participants Mary and Rose showed a similar performance for relations BD and CD, John, however, emitted 22% more correct responses for BD. Peter, Kate, and Bob, hearing impaired participants, showed a higher performance difference for both relations: respectively 56%, 29%, and 55% more correct responses for BD.

In general, expressive signing performance was more accurate for stimuli in the first trained word group. Such superiority of performance may be a function of the amount of exposure to the first group of signs during AB and CB training. For example, Mary required 53 sessions to reach criterion for the first group, 28 sessions for the second group, and 5 sessions for the third group; John required 34 sessions to reach criterion for the first group, 9 sessions for the second group, and 4 for the third group; Kate required 23 sessions to reach criterion for the first group, 14 sessions for the second group, and 3 sessions for the third group. This broader improvement in a generalized repertoire could have been produced by each exposure to the training task.

Maintenance data for BD relations involving all participants and all word groups indicated by successive data points showed that performance maintained for approximately one month after training.

DISCUSSION

The current study replicated Osborne and Gatch's (1989) findings with mentally re-

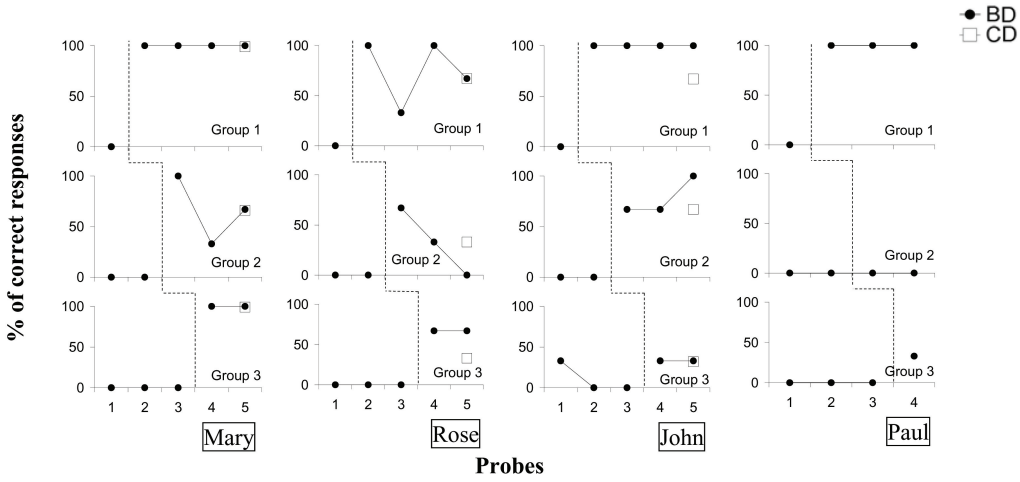

Figure 4. Results of participants Mary, Rose, John, and Paul on signing tests. BD represents expressive signing in the presence of pictures; CD represents expressive signing in the presence of printed words. Dotted lines show the introduction of training and define the multiple baseline design through stimulus groups. Each participant's set of graphics shows the results for stimulus group 1, 2 and 3, respectively.

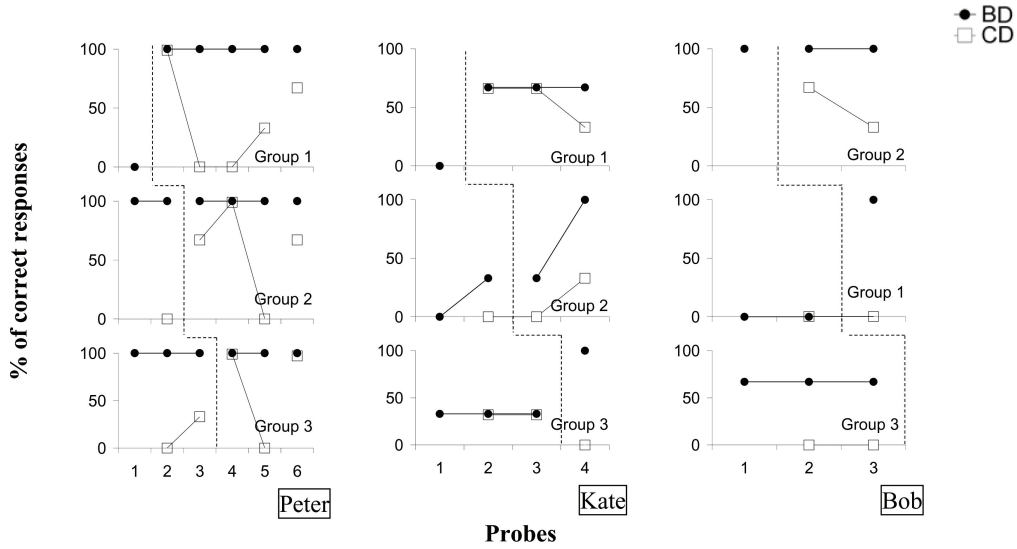

Figure 5. Results of participants Peter, Kate, and Bob on signing tests. BD represents expressive signing in the presence of pictures; CD represents expressive signing in the presence of written words. Dotted lines show the introduction of training and define the multiple baseline design through stimulus groups. Each participant's set of graphics shows the results for stimulus groups 1, 2 and 3, respectively.

tarded and hearing impaired adults, the latter using cards and live signing. Overall, the results showed that the presentation of manual signs via MTS training was sufficient for the emergence of expressive responses (signing) following receptive response training. According to Sundberg and Michael (2001), receptive and expressive relations are functionally independent. One may ask, then, why the receptive relations gave way to the expressive ones. The BD relation was a direct function of AB training and probably also a result of previously learned duplic relation (Michael, 1982) and some degree of generalized imitation. Indeed, ancillary data showed that Peter, who exhibited the best performances (least number of training ses-

sions to reach criterion and highest number of correct signs), systematically repeated the signs shown as samples in the MTS tasks before choosing the comparison stimulus. Peter's results may indicate that a signing history facilitates new sign learning and suggest that the mediating response (repeating the sign) may be an important component in the emergence of new signing relations (Horne & Lowe, 1996; Lowenkron, 1998). The automated stimulus presentation via MTS and video may have played an important role in evoking the appropriate imitative repertoire, but this still needs to be further investigated if effective teaching programs are to be derived from this methodology.

The CD (printed words–expressive signs) relation, on the other hand, may have taken place as a function of the emergent AC (signs–printed words) relation and, possibly, of equivalence classes involving stimulus sets A, B, and C. Although not all properties of stimulus equivalence have been tested for in the present study. However, it might be inferred that when the BD (pictures–expressive signs) relation was observed, it was a function of the referred equivalence classes. The reason why CD relation performance was inferior to performance on BD relations might be explained by defective equivalence relations between sets A, B, and C.

The many-to-one training structure was chosen because of the possible discriminations it engenders, which are relevant for equivalence outcomes (Saunders & Green, 1999). It is not clear, however, if the most practically appropriate training structure would have picture sets as nodal stimuli, as in the current study. In the training sequence used in this study (CB and AB), printed words were always presented as sample stimuli, and discriminations between printed words would have to take place through successive presentations. Such complex and unfamiliar discriminations could have been facilitated through simultaneous versus successive presentations. Finally, it is not clear if a training structure with manual signs, printed words, and pictures as stimulus sets which allowed testing for relevant, albeit not all, properties for stimulus equivalence formation, such as one-to-many, would yield similar results for an expressive repertoire controlled by both pictures and printed words.

Considering the practical applications for teaching reading to hearing impaired students, answers to the issues raised could help the development of more effective educational programs for this population.

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