Matrix Training for Expressive and Receptive Two-Word Utterances in Children With Autism

Nozomi NAOI*, Kumiko YOKOYAMA*, and Jun-ichi YAMAMOTO**

The present study examined the effectiveness of matrix training procedures for establishing adjective-object two-word utterances in children with autism. The procedure included training both receptive and expressive responses in one trial. Participants were 3 children with autism who were at the one-word production stage. A multiple baseline design across participants was employed. Participants were taught 3 of 9 receptive and expressive responses. The results showed that generalization to the untrained stimuli of the matrix was achieved by all the children. Furthermore, all the children demonstrated generalization to the matrix, including untrained objects. The intervention strategy, including both expressive and receptive training in one trial, facilitated both expressive and receptive responses to the untrained stimuli in these lower-functioning children with autism.

Key Words: matrix training, two-word utterances, children with autism

In typical development, children's speech changes from one-word to two-word utterances without special training. Some individuals with developmental disabilities, especially low-functioning children with autism, however, have difficulties with this transition, and are unable to acquire two-word utterances, even though they can make one-word requests and label some objects with one word. (Menyuk & Quill, 1985; Pierce & Bartolucci, 1977; Tager-Flusberg, 1985).

Matrix training is a procedure in which stimuli used in teaching are arranged in a matrix organization. Various studies of matrix training have shown that it is an economical and efficient training approach for teaching multi-word utterances to individuals with mental retardation (Ezell & Goldstein, 1989; Goldstein, 1983; Goldstein, Angelo, & Mousetis, 1987; Goldstein & Mousetis, 1989), children with language delay (Mineo & Goldstein, 1990), and children with autism (Yamamoto & Miya, 1999).

For example, Goldstein et al. (1987) used a three-dimensional matrix organiza-
tion (object-preposition-location) to teach receptive and expressive three-word utterances to children with mental retardation. Training on only a limited number of responses was sufficient to promote generalization to untrained stimuli.

Matrix training has been employed mainly with participants who have mental retardation (Ezell & Goldstein, 1989; Goldstein, 1983; Goldstein et al., 1987; Goldstein & Mousetis, 1989). Although most children with autism have severe language delays or disorders, the effectiveness of matrix training has not been examined fully in children with autism. Yamamoto and Miya (1999) demonstrated that five-word utterances, including two Japanese particles, could be established and transfer to untrained stimuli after a small amount of matrix training in children with autism. Although Yamamoto and Miya (1999) demonstrated the effectiveness of matrix training for establishing multi-word utterance in children with autism who already were making two-word utterances, the effectiveness of this approach for children with autism who have lower verbal mental age has not been examined.

Many studies have indicated that children with autism demonstrate a lack of responding to multiple cues in visual stimuli (Hedbring & Newsom, 1985; Koegel & Wilhelm, 1973; Kovattana & Kraemer, 1974; Sonoyama & Kobayashi, 1986), auditory stimuli (Katoh & Kobayashi, 1985; Reynolds, Newsom, & Lovaas, 1974; Schreibman, Kohlenberg, & Britten, 1986), and bidimensional visual and auditory stimuli (Edwards, Shigley, & Edwards, 1976; Lovaas & Schreibman, 1971). This phenomenon is often referred to as stimulus overselectivity. Intervention to teach children with autism to respond to multiple cues in the environment has been shown to facilitate acquisition and generalization of language and social behavior (Burke & Cerniglia, 1990; Koegel, Bimbela, & Schreibman, 1996; Koegel, Koegel, & Harrower, 1999). Matrix training might be an effective strategy for teaching responding to visual and auditory stimuli that include multiple cues.

The first research question of the present study is the effectiveness of matrix training procedures for teaching two-word utterances to children with autism who are at the one-word production stage. Two-word utterances appear in typical development starting at approximately 23 to 27 months (Watamaki, 1979; Yoshida, 1975). In the present study, participants with verbal mental age in this range were included, in order to examine the efficacy of the intervention on lower functioning children.

Previous matrix training examined cross-modal transfer between trained and untrained modalities (Cuvo & Riva, 1980; Ezell & Goldstein, 1989; Guess & Baer, 1973; Lee, 1981; McIlvane, Bass, O'Brien, Gerovac, & Stoddard, 1984; Mineo & Goldstein, 1990). However, in these previous studies, teaching receptive responses was not necessarily accompanied by transfer to the expressive modality (Cuvo & Riva, 1980; Guess & Baer, 1973; Lee, 1981; McIlvane, Bass, O'Brien, Gerovac, & Stoddard, 1984).

Lee (1981) demonstrated that transfer to another modality occurred when the topographically differential responses were already present in the participants' repertoire. That is, when verbal expressive responses were not present in the participants' repertoire, simply teaching receptive response might not result in cross-modal transfer.
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to expressive responses.

Guess and Baer (1973) suggested that language delayed children with mental retardation may require training concurrently in both receptive and expressive modalities. Ezell and Goldstein (1989) demonstrated that training vocal imitation of a target phrase facilitated generalized receptive learning and transfer to production in children who could imitate multi-word utterances. A problem with the procedure used in Ezell and Goldstein (1989) is that it cannot be used with participants who are not able to imitate multi-word utterances.

In the present study, we developed an efficient teaching procedure for generalization of the matrix, which included training receptive and expressive responses in the same trial. We examined whether this teaching procedure would produce generalization of receptive and expressive responses to untaught stimuli.

In sum, the purpose of the present study was to examine the effectiveness of matrix training procedures for teaching two-word utterances to children with autism. Second, we examined the effectiveness for generalization to untrained items of a training procedure that included receptive and expressive responses in the same trial. In addition, we examined whether acquired receptive and expressive responses were maintained at a follow-up assessment conducted two months after training.

Method

Participants

Three children with autism (all males) participated in the present study. The children were enrolled in special education classes in public schools. All three children had an expressive language level equal to one-word utterances. From parental reports and semi-systematic observation, we found that they did not produce spontaneous, functional two-word utterances. The children were between 6 years 5 months and 8 years 8 months old (mean = 7 years 2 months) at the beginning of the study. All three children met the DSM-IV criteria for autistic disorders, as diagnosed by pediatricians not related to our laboratory: the diagnoses were confirmed by the first and second authors through use of the Childhood Autism Rating Scale (CARS; Schopler, Reichler, & Renner, 1988).

The Kyoto Scale of Psychological Development 2001 (KSPD; Ikuwasa, Matsushita, & Nakase, 2002) was used to assess physical, language, and cognitive functioning in all three participants. This instrument yields standard scores on Physical-Movement, Language-Sociability, and Cognitive-Adaptive subscales, and also total developmental age. In Japan, it is commonly administered both to typically developing infants and to low functioning children with autism.

We used the standard scores for Language-Sociability as the measure of the participants' verbal mental age, because both receptive and expressive language can be assessed on the Language-Sociability subscale. (See Table 1 for characteristics of participants.)

At the time of the present study, Child A was 8 years 8 months old, and had a
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<table>
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<tr>
<th>Table 1 Characteristics of Participants</th>
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<tr>
<td>Chronological age</td>
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<tr>
<td>Child A</td>
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<td>Child B</td>
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<td>Child C</td>
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<td>Average</td>
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Note. Verbal mental age was measured by the Kyoto Scale of Psychological Development 2001 (KSPD; Ikuzawa, Matsushita, & Nakase, 2002); severity of autism was measured by the Childhood Autism Rating Scale (CARS; Schopler, Reichler, & Renner, 1988).

verbal mental age of 2 years as measured by the KSPD. Although he could label objects and colors, he did not have any verbal repertoire of action words (verbs). He often produced delayed echolalia; the delayed echolalia increased when he was frustrated. He displayed occasional tantrums (crying and screaming) when he was given strong verbal instructions by an adult. He preferred reading, and exhibited a strong preference for materials such as advertisements, trademarks of credit cards, and picture books.

At the start of the present study, Child B was 6 years 5 months old, with a verbal mental age of 1 year 11 months (KSPD). He did not respond verbally until he was 5 years old. Although he could label objects and colors, he did not have any verbal repertoire of action words (verbs). His expressive speech was often unclear, he often produced jargon, and he rarely uttered spontaneous speech. He could not imitate two-word utterances.

At the time of the present study, Child C was 6 years 5 months old at the time of the study, with a verbal mental age of 2 years 5 months (KSPD). Child C often produced delayed echolalia; the delayed echolalia increased when he was frustrated. Although he could label some objects, colors, and actions, he did not use functional two-word utterances without an adult’s prompt.

Materials

The matrix used in the present study is shown in Fig. 1. This matrix contained a total of 9 adjective-object pairs, consisting of 3 color adjectives, red, blue, and yellow (“akari”, “aoi”, and “kirara” respectively in Japanese), and three objects, car, cup, and trousers (“kuruma”, “koppu”, and “zubon” respectively in Japanese). The 9 color pictures depicting these objects (3 × 3) were used as the stimuli. The size of the picture cards was 3 cm × 3 cm.

Of the 9 items, only the 3 cells on the diagonal of the matrix (the cells designated with a “T” in Fig. 1) were trained. The remaining 6 items were left available for probing generalization in Probe 1.

In Probe 2, the matrix contained a total of nine adjective-object pairs, consisting of 3 untrained objects, umbrella, balloon, and cap (“kasa”, “fuusen”, and “boushi”
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respectively in Japanese) and the same 3 color adjectives, *red*, *blue*, and *yellow*. These were used as test stimuli. All of the lexical items employed in the present study were ones with which the children were familiar. They could respond receptively and expressively when the constituents of the stimuli (objects and colors) were presented separately.

**Setting**

Baseline, training, and probe tests, and the two-month follow-up were conducted in a room of the university-based laboratory. The room had a table, two chairs, and toys. A one-way observation mirror was in place for unobtrusive viewing. Sessions were conducted individually, and were videotaped for later behavioral coding.

**Procedures**

The design of the present study included baseline measures of both expressive and receptive responses, matrix training, a probe test with untrained stimuli from the training matrix (Probe 1), a probe test with untrained objects (Probe 2), and a two-month follow-up. A multiple baseline design across children was used in order to evaluate the effect of matrix training. The children's baseline was evaluated first for expressive responses and after that, for receptive response.

*Baseline: Expressive responses.* In baseline, the experimenter sat facing the child, and presented each card to the child in a random order, asking them, “What is this?” Any verbal response made by the children was followed by the experimenter’s verbal

<table>
<thead>
<tr>
<th>Adjectives</th>
<th>Objects</th>
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<tr>
<td><strong>Blue (aoi)</strong></td>
<td>T</td>
</tr>
<tr>
<td><strong>Red (akai)</strong></td>
<td></td>
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<tr>
<td><strong>Yellow (ki’iroi)</strong></td>
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*Fig. 1* The 3 × 3 Adjective-Object Language Matrix

The matrix contains three color adjectives and three objects totaling 9 two-word combinations. Teaching items in the submatrices are designated with a T.
response, “So da’ne” (a neutral “OK” in Japanese). Each session consisted of 9 trials. The order of the presentation of the stimuli varied across sessions. The experimenter scored the participants’ responses as correct or incorrect, and, if incorrect, recorded the participants’ verbal responses. The number of expressive-response baseline sessions varied from 2 (Child A) to 3 (Child B and Child C).

Baseline: Receptive response. All 9 stimuli were arrayed in random order on the table. The experimenter said, “Give me the red car”. After all responses, the experimenter said a neutral “OK”. Each session consisted of 9 trials. The order of the experimenter’s requests varied across sessions. The experimenter scored participants’ responses as correct or incorrect, and, if incorrect, recorded the actual choice made by the participant.

The baseline measurement of Child A for receptive responses was not completed, because he displayed tantrums when he received the verbal instructions from the experimenter. Child A was able to read single written words and match words to pictures, so we assessed his two-word utterance receptive responses by using written two-word expressions, instead of verbal instructions. The experimenter presented printed two-word cards to Child A one by one in random order, and instructed him to read them. Child A was then asked to match the words on the card with one of the 9 pictures on the table. A correct response was defined as placing the word card on the corresponding picture.

The number of receptive-response baseline sessions varied from 1 (Child A and Child B) to 2 (Child C).

Matrix training. Three adjective-object responses were selected for training from the three by three matrices. Both receptive and expressive training were done in one trial. Three training stimuli were arrayed in random order on the table. Training began with the experimenter’s instruction, “Give me the red car” (receptive training). Participants were then asked to choose the corresponding card. If no response was made, or an incorrect response occurred within approximately 5 sec, a gestural prompt such as pointing was provided.

Then the experimenter held up the picture card that the child had chosen and asked, “What is this?” (expressive training). If no response was made, or an incorrect response occurred within approximately 5 sec in expressive training, an echoic prompt was given. Vocal prompts were gradually faded from the full word to the initial sound of the word. If the child made correct receptive and expressive responses, those responses were followed by verbal praise, “Yoku dekita ne” (“That’s good” in Japanese), and the next trial started. The experimenter scored participants’ responses as either correct or prompted. Each session consisted of one to three 3-trial training blocks.

As a pre-assessment, the experimenter tested acquisition of the expressive response to the 3 training stimuli at the start of each training session. The experimenter presented each of the 3 cards to the children in random order, and asked them, “What is this?” The criterion for successfully completing the matrix training was 3 correct responses (100% correct) in the pre-assessment of 2 consecutive
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sessions. Following the training sessions, the participants received two kinds of probe tests.

Probe 1: Generalization probe. Three of 9 stimuli had previously been trained, whereas 6 were untrained. The purpose of this probe test was to examine whether the effect of the limited training that had been given to the children would be generalized to the untrained stimuli of the matrix. Both receptive and expressive responses were assessed. The procedure was the same as that used in baseline for expressive and receptive responses. All responses were followed by a neutral "OK" from the experimenter.

Probe 2: Untrained object probe. In Probe 2, the matrix consisted of 3 untrained novel objects (umbrella, balloon, and cap) used with the 3 trained color adjectives (red, blue, and yellow). Both receptive and expressive responses to the matrix were assessed. The procedure was the same as that used in baseline for receptive and expressive responses.

Two-month follow-up. Baseline for both receptive and expressive responses were remeasured two months later as a follow-up.

Reliability

Inter-observer reliability data were collected and reported for a randomly selected 32% of all training sessions and 45% of baseline, probe, and follow-up sessions. The first author and an independent coder who did not know the children's diagnoses or the experimental condition coded the videotapes of the sessions as to whether the children's responses were correct. The mean Cohen's kappa (the percentage of agreement corrected for chance) was 94%, ranging from 91% to 96%, indicating an excellent level of agreement.

Results

The participants' performance during baseline, probe tests, and follow-up are presented in Fig. 2.

During measurement of the children's baseline for expressive response, all three children did not make any correct responses (0% for all 3 children). All three of the children had difficulty in expressing adjective plus object two-word utterances. The children's initial errors involved labeling only the objects.

During the measurement of the baseline for receptive responses, Child B made 1 correct response (11%), and Child C, 7 correct responses (78%). Child B and C's errors involved choosing the correct stimuli but in the wrong color.

As was mentioned above, Child A's baseline evaluation for receptive responses was incomplete because of his tantrums, and we assessed his receptive responses of two-word utterances using written two-word expressions, instead of verbal instructions. Child A did not make any correct responses (0%); nevertheless he could match the words to the pictures when the constituents of the stimuli (objects and colors) were presented individually. Child A's errors involved both colors and objects. In
The verbal mental age of two of the participants (Child A and Child B) was below or equal to 24 months. Child C, with a verbal mental age of 29 months, had higher receptive ability than Child A or Child B. However, there were no differences among the three children in performance of expressive responses.

The participants’ performance during the training sessions is presented in Fig. 3. Child A required 12 sessions, and Child B required 7 sessions to complete the
training. Child C required 3 sessions to reach the criterion of 100% correct.

In Probe 1, Child C made 6 correct responses (100%), and Child A and Child B, 5 correct responses (83%) for untaught stimuli in expressive response (Fig. 2). After training on 3 items, expressive generalization to the rest of the matrix was achieved by all 3 participants. For receptive responses, Child A and Child C made
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6 correct responses (100%), and Child B, 3 correct responses (50%). Child A, who could not complete the baseline evaluation of receptive responses, made 6 correct responses (100%), even though the instruction was given by written words, rather than being presented orally.

In Probe 2, each of the children made 8 correct expressive responses (89%). These results suggest that, after training on only 3 items, generalization of expressive responses to the whole matrix, including untrained objects, was achieved by all 3 participants.

Child A and Child C made 9 correct receptive responses (100%), and Child B, 4 (44%).

At the two-month follow-up, Child C was correct on all 9 items (100%), including both receptive and expressive responses. Child A made 7 correct expressive responses (78%) and 9 correct receptive responses (100%). Child B made 8 correct receptive responses (89%), and 9 correct expressive responses (100%).

In general, at the two-month follow-up, both expressive and receptive two-word utterances were found to be maintained by all 3 children. Child A demonstrated slight decline in expressive response, while Child B exhibited an increase in both expressive and receptive response from probe test to follow-up.

**Discussion**

The first research question for the present study was to determine the effectiveness of matrix training procedures for teaching two-word utterances to children with autism. In baseline, none of the children made any correct expressive responses across matrices. All three children demonstrated a lack of responding to multiple cues in visual and auditory stimuli, and their responses were limited to single words.

During intervention, only three of the cells of the matrices were taught directly. Performance of receptive responses was generally higher than that of expressive responses, because responding to only one dimension of the stimuli (color or object) was required in receptive training.

All three children reached the criterion for learning. Child A required 12 sessions, and Child B, 7 sessions to complete the training. For Child C, the acquisition of expressive response to training stimuli was so immediate that he required only three blocks of trials to reach the criterion for learning. Child C demonstrated low performance in baseline; however, it is possible that, although he could make two-word utterances without any feedback, he did not understand, during the baseline assessment, that he was supposed to speak in two-word phrases. We examined the duration of his expressive responses in training, probe 1, and follow-up using software for speech signal analysis (PRAAT; Boersma & Weenink, 2005). This analysis of his utterances demonstrated that the mean duration of the 3 trained expressive responses (0.80 sec; range: 0.70–0.94 sec) was shorter than that of the 6 untrained responses in Probe 1 (2.58 sec; range 0.98–4.21 sec). Furthermore, the
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mean duration of utterances in follow-up (1.13 sec; range 0.63-1.66 sec) was shorter than for Probe 1. This finding suggests that Child C learned fluent two-word combinations through matrix training.

Following matrix training, expressive and receptive generalization to the untrained stimuli of the matrix was achieved by all children. Furthermore, all children demonstrated generalization to the untrained objects in the matrix.

Child B’s performance of receptive responses was lower than his expressive responses, both in Probe 1 and Probe 2. In baseline, Child A and Child C consistently demonstrated a higher percent correct in receptive responses than in expressive responses, however, Child B sometimes showed a decline in receptive response. In the present procedure, responding to only one dimension (color or object) of the stimuli would be sufficient for a response in the receptive training to be correct. In contrast, the expressive training required the children to attend to two dimensions of the stimuli. Child B might have attended to just the color or object name in receptive training. That might explain why he showed relatively lower receptive response performance.

The results of the present study demonstrate the efficacy of using matrix training for teaching two-word utterances (adjective plus object) to low-functioning children with autism. The children with autism who participated in the present study demonstrated a lack of responding to multiple cues in baseline. Through matrix training, all three of them acquired responding to auditory (receptive response) and visual (expressive response) stimuli composed of two dimensions.

Second, we assessed both receptive and expressive two-word utterances, and examined the effectiveness of the training procedure, including receptive and expressive responses, by testing generalization to untrained items. In comparison to participants in previous matrix training studies, the verbal ability of the children in the present study was lower, and the children did not echo more than one word. We therefore used an intervention strategy composed of receptive and expressive training in the same trial.

Previous studies suggested that language-delayed children with mental retardation may require training in both receptive and expressive modalities concurrently (Guess & Baer, 1973). An examination of the errors in baseline in the present study revealed that each child demonstrated different performance in receptive and expressive responses. All three children had difficulty in expressing two-word utterances.

In general, it is possible that teaching more than one target behavior at a time inhibits learning. The results of the present study, however, suggest that matrix training, including both expressive and receptive training in one trial, facilitated both receptive and expressive generalization to untrained stimuli. In one trial, we first trained the receptive response, and then the expressive response.

The children sometimes spontaneously partially imitated the experimenter’s two-word utterances in receptive training. This partial imitation might facilitate subsequent expressive training. It is possible that a teaching procedure including both receptive and expressive training would facilitate acquisition and generalization.
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of two-word utterances for children with vocal imitation skill, which might mediate the receptive and expressive modality of verbal behavior.

The effectiveness for generalization of verbal behavior of an intervention procedure that included a mixture of verbal operants has been reported (Sundberg & Partington, 1998). In future research, teaching procedures should be compared with participants at various levels of verbal response.

For Child A, transfer of stimulus control from the written word to verbal stimuli was demonstrated. During training, Child A read the word cards, and then chose the corresponding picture card. At the beginning of training, the controlling variable for Child A's response was the visual, written verbal stimulus. After that, equivalent relations between the written word and the child's vocal production might be formed during the training, so that finally stimulus control might be transferred from the written word to the verbal stimuli. Explicit reading in response to written words might be necessary for transfer of stimulus control between written verbal stimuli and auditory stimuli. A repertoire of reading words might be sufficient for such transfer. The findings of the present research suggest that teaching two-word utterances first in a child's stronger repertoire (e.g., reading) and transferring it to the weaker repertoire (receptive response) might be an effective way to teach children with autism who are oversensitive to sounds.

In previous matrix training research, action-object or person-action responses were targeted (e.g., Goldstein, 1983). Although all the children in the present study could label objects and colors using one-word utterances, they did not have any verbal repertoire of verbs. Acquisition of two-word utterances might be facilitated by the use of words already in a child's vocabulary.

Follow-up probe data collected after 2-months indicated that receptive and expressive two-word utterance had been maintained.

The present study demonstrated the effectiveness of matrix training for establishing two-word utterances in low-functioning children with autism.

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