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ACQUISITION OF SIGN LANGUAGE BY AUTISTIC CHILDREN. I: EXPRESSIVE LABELLING

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There has been growing interest in teaching sign language to autistic children who have failed to develop speech. However, controlled experimentation in this area is nonexistent. In the present study, four nonverbal autistic children were taught expressive sign labels for common objects, using a training procedure that consisted of prompting, fading, and stimulus rotation. The efficacy of the procedure was demonstrated in a multiple-baseline design across objects. The results were reliable, replicable across children, and generalizable across therapists. A stimulus control analysis demonstrated that, for three of the children, correct signing was controlled solely by the visual cues associated with the presentation of a given object and was independent of the auditory cues related to the same object. These latter results are discussed with respect to the known perceptual and linguistic deficits of autistic children.

DESCRIPTORS: language, sign language, expressive sign labels, stimulus control, generalization, therapists, autistic children

Approximately half of all autistic children fail to develop speech and language (Rimland, 1964; Rutter, 1966). The importance of this deficit is underscored by the fact that those individuals who do develop some communicative facility have a better prognosis than those who do not (Rutter, 1968). For this reason, considerable effort has been expended to teach communication skills to this population. In particular, the application of operant conditioning procedures has produced impressive gains in the speech and language abilities of a significant number of such children (Lovaas, 1966; Lovaas, Koegel, Simmons, and Long, 1973). But there remain many autistic children who do not acquire verbal skills despite intensive training efforts. The possibility that these individuals might acquire a system of communication seemed remote until recently, when it was demonstrated that chimpanzees could be taught to use sign language (Gardner and Gardner, 1969). A number of clinicians wondered whether other nonverbal organisms, such as autistic children, could also be taught to sign. The initial reports were quite positive in suggesting that sign training could be a viable treatment intervention with such children (Bonvillian and Nelson, 1976; Creedon, Note 1; Fulwiler and Fouts, 1976; Miller and Miller, 1973). However, in the rush of enthusiasm to teach autistic children to use sign language, little attention has been paid to questions of experimental control. Further, the techniques reported often consisted of complex treatment packages whose components were described in insufficient detail for purposes of replication. For example, in a recent study by Benaroya, Wesley, Ogilvie, Klein, and Meany (1977), a procedure was outlined for training signs that involved a series of elaborate sensory-motor integration exercises, prompting and fading, imitation training in both structured and unstructured settings, reinforcement of successive approximations, and the use of a Language

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Master machine together with audio cassettes. It would be useful to know whether all of the above components were necessary to produce sign acquisition or whether signs could be successfully trained using only a subset of these procedures. With regard to this issue, it is interesting to note that Konstantareas, Oxman, and Webster (1977) presented data suggesting that an intervention that consisted of prompting, fading, and imitation training only was sufficient for teaching signs. The interpretation of their results is, however, complicated by the fact that two of the five children in their study had some speech skills, and four of the children already had some sign-language facility due to prior training. In addition, because the data were reported only in terms of overall sign output, there was no direct demonstration in the study that the children could discriminate, using expressive signs, among the various objects and events in their environment.

The above studies, though suggestive, leave unanswered a number of questions pertaining to the acquisition of sign language by the autistic child. The present study was undertaken to provide information on several of these questions. First, we sought to evaluate whether the prompting and fading techniques typically employed in other studies were by themselves sufficient for teaching sign language to autistic children who lacked both speech skills and any demonstrable signing repertoire before our study. A second purpose was to determine whether the systematic application of the above procedures would enable a child to master a number of expressive sign discriminations. A third objective was to assess the "simultaneous communication" procedure commonly used in sign-language training programs (Fulwiler and Fouts, 1976; Miller and Miller, 1973; Smith, 1975). In this method, the therapist simultaneously presents both auditory and visual stimuli related to the sign being trained. An important question left unanswered by previous studies pertains to what is being learned when this procedure is used or, put another way, what stimulus or stimuli come to control a given child's signing?

This paper presents systematic data on the above three questions with respect to one fundamental aspect of sign language: the acquisition of expressive noun labels. The basic task was to teach a nonverbal autistic child to make a specific sign when shown a specific object.

Experimental Design

Two types of experimental sessions were conducted: training sessions and test sessions. During the first set of training sessions, each child was taught the sign label for one of five common foods until a criterion performance was attained. Then, test sessions were carried out in which each child was presented with all five food objects to assess the effect of the training procedures on correct signing. Next, during a second set of training sessions, conducted as above, each child was taught the sign for a second food object and then a discrimination between the two objects. After this additional training, another set of test sessions was administered. Training and testing alternated in the above manner until the signs for all five objects had been acquired. The sequence of test sessions thus conformed to a multiple-baseline design (Baer, Wolf, and Risley, 1968) across the five objects. This design was employed so that any gains in sign-language acquisition observed during the study could plausibly be attributed to the training procedure under investigation, rather than to uncontrolled variables such as the sporadic attempts at sign training known to have been carried out from time to time by volunteers and teachers at the hospital.

After the final set of test sessions had been completed, a stimulus control assessment was conducted to determine which component(s) of the stimulus complex presented by the therapist controlled each child's correct signing.

Subjects

Four residents from a local children's psychiatric hospital participated. Bob and Dan

were 15 yr old and Doug and Darrick were 14 and 10 yr old, respectively. All had been diagnosed as autistic by the psychiatric staff. The children had been institutionalized for a period ranging from 5 to 10 yr. They were selected for this study because they did not speak; their vocal behavior was limited to infrequent and meaningless sounds. The children could carry out a few commands such as "Come here" or "Sit down".

Over a 1- to 3-yr period, each child had received a number of language training sessions conducted by several certified speech pathologists. These sessions were typically 20 min in length and were carried out two to three times per week during the school year. Part of each session consisted of vocal imitation training. During such sessions, Bob mastered an imitative discrimination between a "ba" and "ma" sound, but could not be taught a three-way discrimination. Dan and Darrick were unable to learn reliably a single vocal imitation. For example, when they were presented with an "ah" sound, they would either make the wrong sound or would open their mouths without making any sound. Finally, Doug responded with an "ee" sound to all of the therapist's vocalizations and thus did not acquire any discriminative vocal imitation.

The children displayed no appropriate play, either with peers or with toys, nor did they initiate social contacts with adults. Considerable self-stimulatory behavior, such as rocking and hand-flapping, was present. They were untestable on standard intelligence tests and had a mean social age of 2.4 yr on the Vineland Social Maturity Scale (range: 2.1 to 2.9 yr). Motor milestones such as crawling and walking were within the normal range and physical examinations revealed that both vision and hearing were unimpaired.

Procedure

Training sessions. Training was conducted three to four days per week, 1 hr per day. During training sessions, the child and therapist sat facing each other. A trial was begun only when the child was sitting quietly and attending to the therapist. Inattentiveness and self-stimulatory behaviors that interfered with the training were verbally punished. Trials were presented at an average rate of four to six per minute. The child was allowed 5 sec in which to respond to the therapist, after which the trial was terminated.

Each child was taught the signs for five common foods (apple, cookie, banana, milk, and candy) based on the American Sign Language for the deaf (Bornstein, Hamilton, Saulnier, and Roy, 1976). Figure 1 gives a diagrammatic representation of the five signs that each child was taught to produce. Training was carried out in three steps. In Step 1, the therapist presented the object to the child while saying the name of the object. For example, the therapist held up an apple and simultaneously said "apple". If the child failed to make the correct sign, the therapist would employ a *prompt.* That is, after repeating the above procedure, he/she would immediately lift the child's hand and mold it into the correct sign configuration while saying "apple". Thus, during Step 1, the child would receive simultaneous presentations of a visual stimulus and an auditory stimulus. That is, either the sight of the object would be paired with the spoken name of the object, or the sight of a specific sign configuration (produced by the therapist's molding the child's hands) would be paired with the spoken name of the object. This procedure is routinely used in the simultaneous communication method (Smith, 1975, pp. 52 and 57). Finally, the child would receive social reinforcement (*e.g.,* "Good") and a piece of apple (or candy, if that stimulus object were being trained, and so on) contingent on signing.

Step 2 was identical to Step 1, except that the therapist gradually *faded* the prompt until the child was able to make the sign unaided. By the end of Step 2, the therapist would merely hold up the object while saying its name and the child would sign correctly.

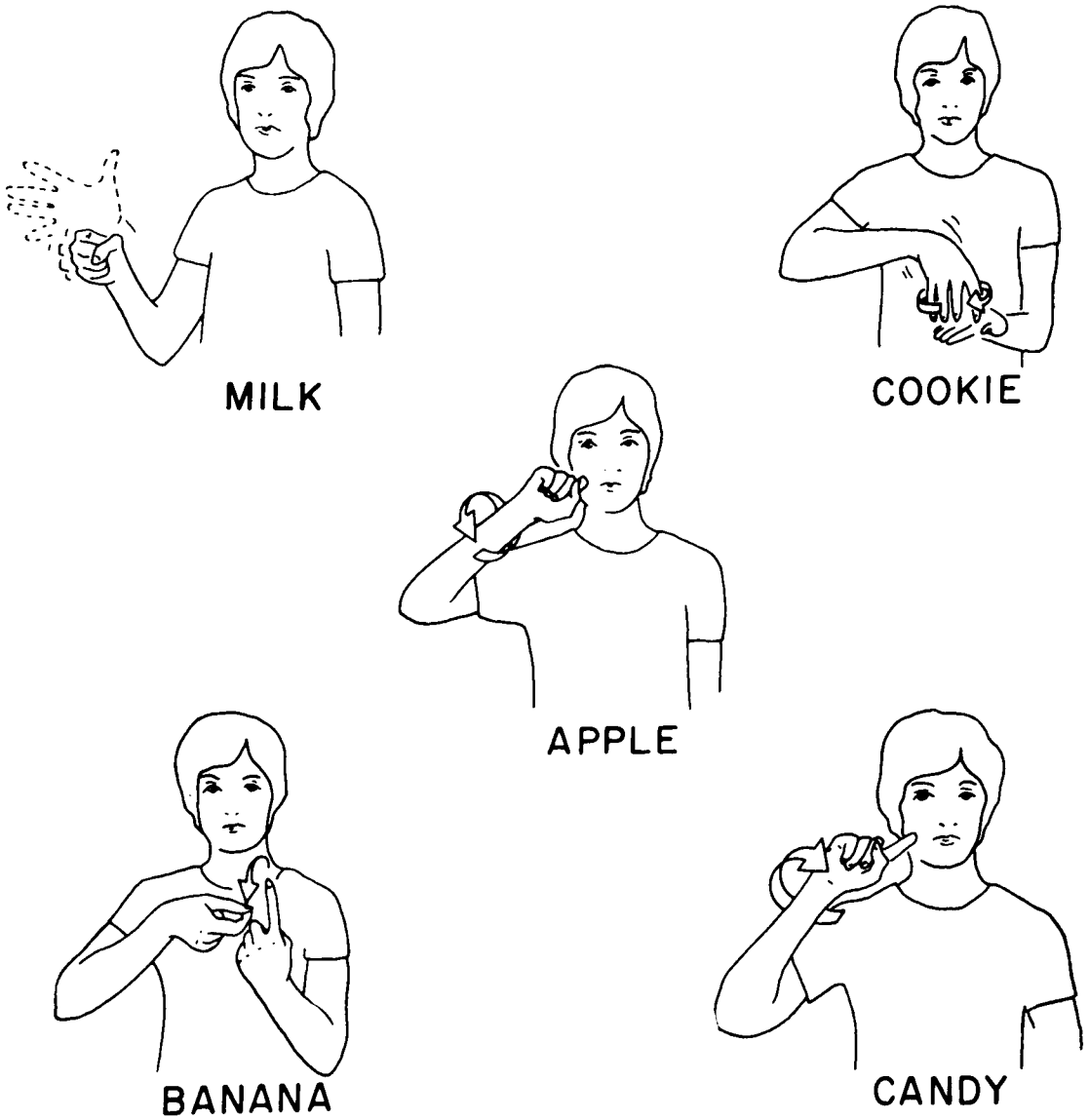

Fig. 1. Diagrammatic representation of the five signs each child was taught to produce during the experiment.

An example of the above training is afforded in teaching the sign for milk. This sign consists of slowly closing the outstretched five fingers to form a fist while moving the hand in a downward motion, an iconic representation of milking a cow. In Step 1, the therapist would prompt the sign by lifting the child's hand from the lap, spreading the fingers, and then placing his/her hand behind the child's hand so as to squeeze it into a fist while forcing the hand downward. In Step 2, the therapist would fade the prompt, first by squeezing and pushing down on the child's hand using less and less force, and then by reducing help with spreading the fingers, and finally by eliminating the aid provided in raising the hand from the lap. If the child signed incorrectly after all the prompts had been faded, the therapist shouted "No" and repeated the trial, reinstating prompts if necessary. The child received social reinforce-

ment for correct signing on these prompted trials but did not receive food reinforcement. A sign was considered trained when the child could make the correct sign, unprompted, on 10 successive presentations of the object. When this criterion had been met, test sessions (described below) were conducted.

Once the child had mastered one sign, a new sign was trained via Step 3, which was a recycling of Steps 1 and 2 with respect to the new sign. Also, during Step 3, trials involving the previously mastered sign were interspersed with trials involving the new sign in a ratio of one to three. This method of *stimulus rotation* was undertaken as a means of practicing the old sign and of facilitating the discrimination between the two signs. Once the child could sign correctly to each object in a random sequence containing at least 10 presentations of each object, test sessions were again conducted. Following these sessions, Step 3 was repeated with a third sign. A child was alternately trained and tested in the above manner until the signs for all five objects had been acquired. The order of training specific objects varied from child to child.

Test sessions. A test procedure was undertaken to assess the effect of the training procedures described above on the acquisition of sign labels. Test sessions were conducted in groups of three at six different points in the experiment, for a total of 18 test sessions. To provide a baseline, one triad of test sessions was conducted at the start of the study before any sign training was undertaken. In addition, one triad was conducted after each sign label had been trained to criterion. Two sessions of each triad were conducted by the therapist who originally trained the child; a third session was conducted by one of several therapists not associated with the original training. These latter therapists were introduced to see if correct signing would generalize to new therapists.

Each test session consisted of 50 trials, distributed as follows. During the initial baseline, before any training had been undertaken, the child received 10 trials on each of the five objects randomly intermixed. Following acquisition of each new sign label, the child received five trials on each remaining untrained object, with the rest of the trials being assigned to the trained object(s). If more than one object had been trained, the trials were divided as equally as possible among the several trained objects.

On each trial of a test session, the therapist held up the object while saying the name of the object. As in the training sessions, trials were presented at an average rate of four to six per minute, with the child being allowed 5 sec in which to respond. To avoid any learning effects during test sessions, responses were not reinforced on any trial. Therefore, to maintain the child's motivation, novel food reinforcers (different from the food objects being trained) were given every minute, on the average, contingent on good attending behavior. After the final set of test sessions had been carried out, the stimulus control of signing (described below) was assessed.

Scoring of responses and reliability. Reliability scores were calculated for trials in both the training and test sessions. Reliability was assessed in every test session and in every fourth training session by one of seven student observers. Immediately before a reliability session, the observers were shown the signs for each of the five objects as they appeared in a standard sign-language book (Bornstein *et al.*, 1976). A response was scored as correct if it matched, in essence, the sign that appeared in the book; otherwise, the response was scored as incorrect. A failure to respond was also counted as an incorrect response. The responses that the observers recorded on each trial of a test session were compared to those recorded by the therapist. The reliability index was the number of agreements on occurrences and nonoccurrences divided by the number of agreements plus disagreements. The mean interobserver reliability across the four children was 99% in both the training and test sessions (range: 98% to 100%).

A second method of reliability assessment was undertaken to determine whether those individuals at the hospital who were charged with the direct care of the children could identify the signs that each child had learned. This assessment was important because it was intended that, at a later date, hospital staff would become part of a sign-language program. To aid in the reliability assessment, two different photographic slides were made of each child's signs after the child had acquired the signs for all five objects. In addition, two different slides were made of a representative type of each child's self-stimulatory hand movements. Four ward attendants, not familiar with sign language, were each asked to identify the 12 slides after they had been shown pictures of the relevant signs from the sign-language book (Bornstein *et al.*, 1976). They were told that each slide could be scored as either depicting a sign for one of the five objects or as representing self-stimulatory behavior. The responses that the attendants recorded for each slide were compared to the label of the slide assigned by the therapist. If, for example, a slide were labelled by the therapist as "apple" and the attendant identified it as such, an agreement was scored; if a slide were labelled as "apple" and the attendant identified it as "candy" or as "self-stimulation", a disagreement was scored. Likewise, if the therapist labelled a slide as "self-stimulation" and the attendant identified the slide as a sign for an object, a disagreement was scored. Reliability was computed as above. The mean interobserver reliability across the four pairs of observers was 87% for Darrick (range: 83% to 100%), 86% for Dan (range: 75% to 92%), 88% for Doug (range: 75% to 100%), and 88% for Bob (range: 83% to 100%).

Stimulus control assessment. Following the final triad of test sessions, an attempt was made to isolate the stimulus variables that controlled each child's signing. Throughout the training and testing sessions, a visual stimulus (either the sight of the object or a specific sign configuration) was presented at the same time as an auditory stimulus (the spoken name of the object). This method of "simultaneous communication" is commonly used in the training of sign language (*e.g.*, Fulwiler and Fouts, 1976; Smith, 1975). It is often implied that when this method is used, the children will not only learn to discriminate between the various objects on a visual basis but will also learn to discriminate between the spoken words as well (Creedon, 1973; Miller and Miller, 1973; Smith, 1975). To test for this possibility, a stimulus control assessment was carried out as follows. At the start of the study, before any signs had been trained, and at the end of the study, after all five signs had been trained, an assessment consisting of three different conditions was carried out to determine which of the several stimuli simultaneously presented had come to control each child's signing. The manner in which trials were conducted was the same as that described above for trials in the test sessions, with the following modifications. In the "visual" condition, the therapist held up the object without saying anything. In the "vocal" condition, the therapist said the name of the object without displaying the object. In addition, the therapist placed his/her hand 5 cm in front of his/her mouth to eliminate any visual cues arising from lip movements. In the "lipreading" condition, the therapist silently mouthed the name of the object without displaying the object. This latter condition was added because of prior research, which demonstrated that autistic children are capable of learning discriminations based on lipreading cues alone (Lovaas, Koegel, Schreibman, and Rehm, 1971).

Each condition consisted of 50 trials with each of the five objects being represented 10 times in a randomized order. Reliability was assessed in each condition using members from the same set of seven observers described above, as well as the same scoring method. The interobserver reliability across all conditions and all children was 100%.

Table 1

Number of Training Trials Required to Reach the Criterion Run for the Five Stimulus Objects

	Child			
Training Order	***Darrick***	***Dan***	***Doug***	***Bob***
First object	(Co) 166	(M) 233	(A) 453	(C) 140
Two-way discrimination	(Co + M) 2577	(M + A) 1166	(A + C) 3371	(C + M) 270
Three-way discrimination	(Co + M + C) 4461	(M + A + Co) 137	(A + C + M) 1942	(C + M + Co) 110
Four-way discrimination	(Co + M + C + A) 302	(M + A + Co + B) 675	(A + C + M + B) 1107	(C + M + Co + A) 34
Five-way discrimination	(Co + M + C + A + B) 163	(M + A + Co + B + C) 234	(A + C + M + B + Co) 406	(C + M + Co + A + B) 394
TOTAL TRIALS	7669	2445	7279	948

Co: Cookie M: Milk C: Candy A: Apple B: Banana

RESULTS

Table 1 shows the number of trials that each child needed to acquire the sign for a single object or to discriminate among several objects. Since the objects were trained in a different order for each child, the table also lists, in parentheses, the specific object or object discrimination being trained. The number of trials shown does not include the final run of correct responses needed to meet the criterion. For example, Darrick required 4461 trials to acquire the three-way discrimination between cookie, milk, and candy. That is, he needed this many trials to reach the point at which he could succeed on the criterion run, defined as correct responding on a random sequence containing at least 10 presentations each of "milk", "cookie", and "candy". As can be seen, each child needed relatively few trials to acquire the first sign. However, the training of the second sign, which involved a discrimination between two objects, required many more trials. Finally, the total number of trials required to learn all five signs and correctly discriminate among them varied considerably across children, from a low of 948 trials for Bob to a high of 7669 trials for Darrick.

The test results for Darrick are plotted in the upper-left quadrant of Figure 2. The abscissa denotes test sessions and the ordinate, percentage correct on each object. In each frame of the figure, data to the left of the solid vertical line were collected before any training was undertaken for that object; that is, these data constitute a baseline. Data to the right were collected after the training criterion had been met for that object. During baseline, all children, including Darrick, would respond in a variety of ways to the therapist's holding up an object. The most common responses were to attempt to take the object away from the therapist, to utter one of several meaningless sounds, or simply to sit quietly and look at the object. As can be seen, Darrick scored 0% correct on the first triad of baseline sessions for "cookie". However, once he had been trained to make the correct sign for "cookie", his performance became nearly perfect, as shown in the second triad of test sessions. Meanwhile, his performance on the remaining four untrained objects remained at 0% correct. The figure shows, however, that as the training package was sequentially applied to teach the signs for each of the remaining four objects, Darrick's performance on each object in turn improved to a high percentage of correct responses. In addition, Darrick's nearly perfect responding after training carried over from the original therapist who trained him (closed circles) to new, generalization therapists (open circles).

The remaining quadrants of Figure 2 show the data for Doug (upper right), Bob (lower left), and Dan (lower right) respectively. These data are very similar to those obtained for Darrick in demonstrating sharp increases in correct responding following application of the training package, together with generalization of correct responding to new therapists. Finally, for all children, including Darrick, incorrect responding, when it did occur, always consisted of sign substitutions, rather than a failure to respond. There was no discriminable pattern for these substitutions, however.

Figure 3 shows the results of the stimulus control assessment for each child. Before any signs were trained (open columns), each child displayed 0% correct in each of the three assessment conditions, as one might have expected. After all five signs had been trained (hatched columns), three of the children (Darrick, Dan, and Doug) responded almost perfectly in the visual condition, but remained near 0% correct in both the auditory and lipreading conditions. In contrast, Bob responded nearly perfectly in both the visual and auditory conditions. However, Bob, like the other children, responded incorrectly on a high proportion of trials in the lipreading condition. For each child, more than 90% of incorrect responses consisted of runs of a given incorrect sign (*i.e.*, sign substitution), rather than a failure to respond.

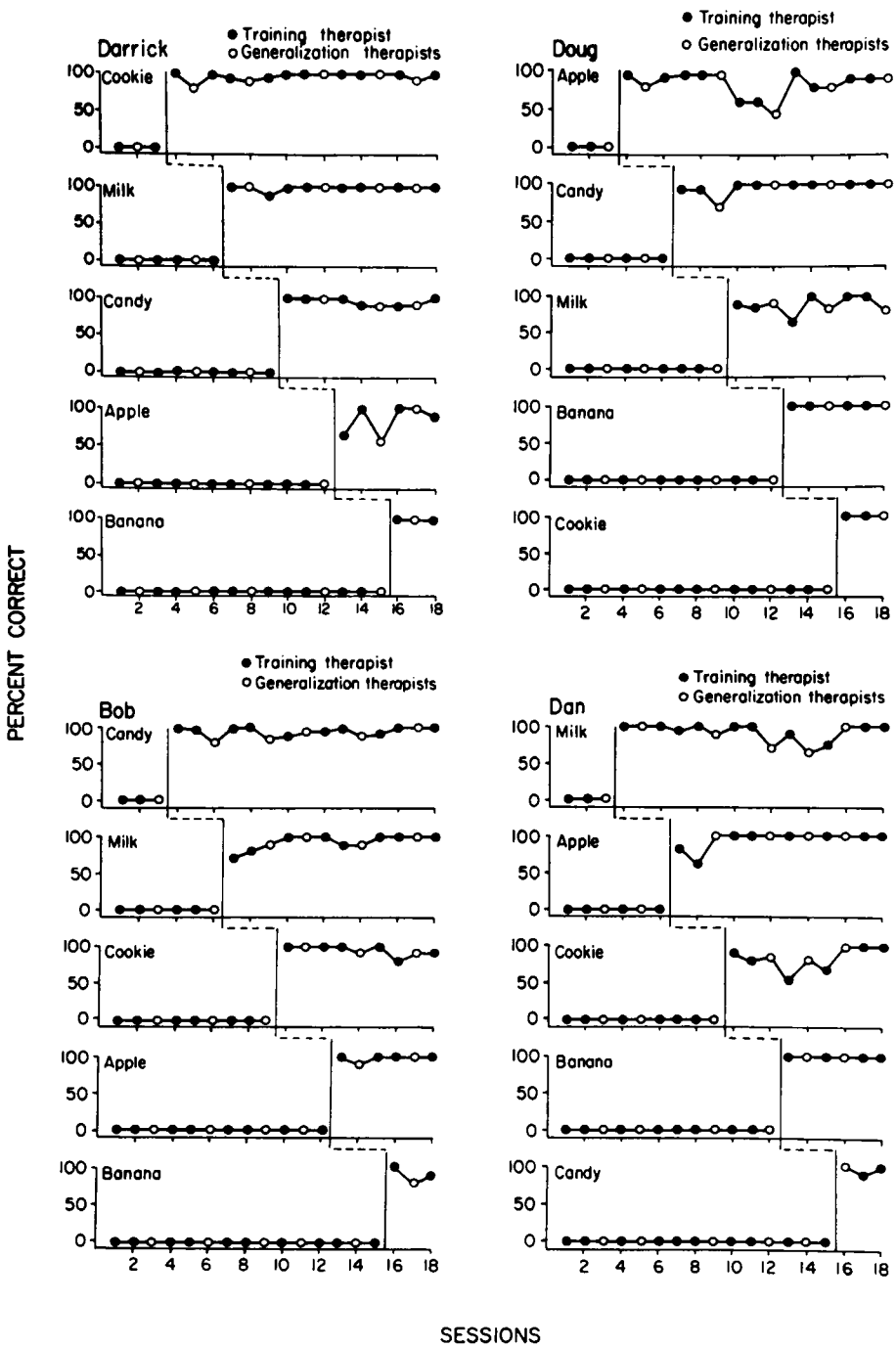

Fig. 2. Percentage correct of expressive signs made by each of four autistic children to five objects before and after sign training. Closed circles depict data taken by the original training therapist and open circles, data taken by new, generalization therapists.

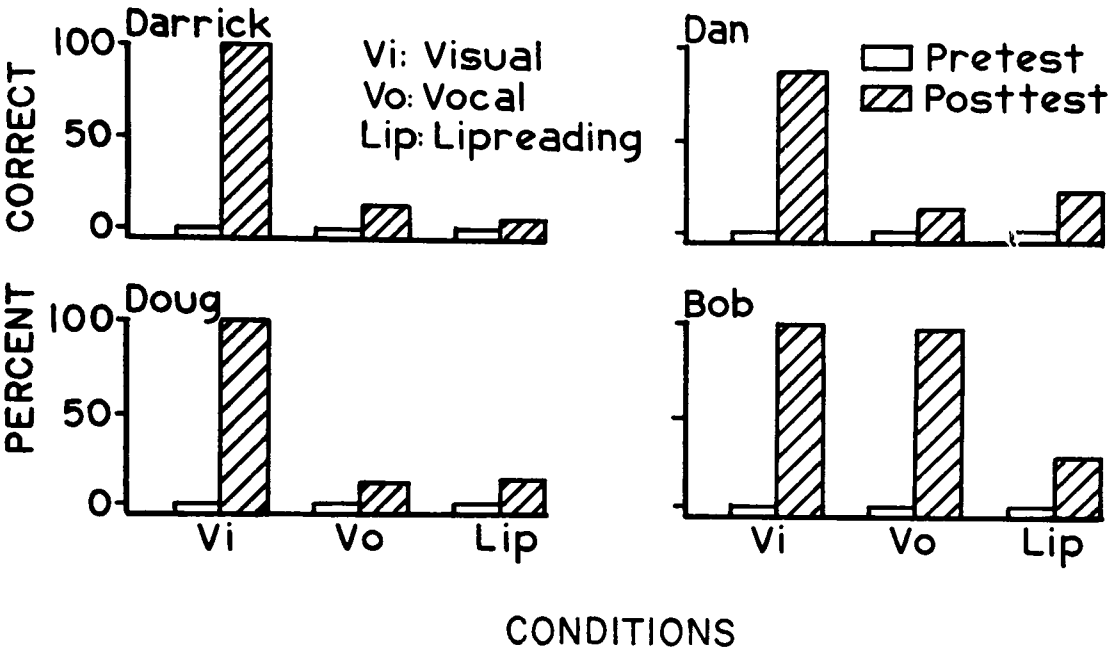

Fig. 3. Percentage correct of expressive signs made by four autistic children as a function of the sensory modality employed by the therapist. Vi (visual): the therapist merely displayed the object to be labelled; Vo (vocal): the therapist merely spoke the name of the object while concealing his/her lips; Lip (lipreading): the therapist silently mouthed the name of the object. Open columns depict data taken before any sign training; hatched columns depict data taken after all sign training was completed.

DISCUSSION

The multiple-baseline data of Figure 2 demonstrate that a combination of prompting, fading, and stimulus rotation constitutes a sufficient treatment intervention for teaching expressive sign labels to a group of nonverbal autistic children. Although there was considerable variability across children, with respect to the number of trials required to reach criterion on specific sign discriminations, it was nevertheless clear from the test-session data that systematic gains in the acquisition of specific signs occurred only when the training package was applied to a given stimulus object. Further, the fact that similar data were generated across the four children shows that the training package was capable of producing replicable effects.

Both the student observers and the ward attendants showed a high level of agreement with the child's therapist as to the identification of the five sign labels. This fact demonstrates that the training package was also capable of producing reliable behavior changes. Finally, the finding that each child's correct signing remained at a high level even when therapists who were not associated with the original training conducted the sessions shows that correct signing was not controlled merely by idiosyncratic cues associated with the original training therapist.

In the present study, a highly structured teaching situation was coupled with the use of massed training trials in order to demonstrate rigorous experimental control over the acquisition of sign language. To facilitate the generalization of signing to other, more naturalistic contexts, however, it might be desirable to supplement the procedures described above by training the use of signs concurrently in a variety of situations. For example, food signs could also be taught during lunch or snack periods. These procedural modifications might potentially facilitate the direct carryover of training to the daily routines of both the chil-

dren and staff. Second, it would seem desirable to change the schedule of reinforcement for correct signing, as soon as possible, from a continuous one, as described above, to an intermittent one. Such a change could help maintain the children's signing over time, especially in a busy school or ward setting where staff are frequently unable to reinforce each correct instance of signing.

Finally, we may consider the data of Figure 3. These data represent the first attempt to answer experimentally the question of what is learned in the simultaneous communication procedure. The data are clear in indicating that for the majority of the children (three of four), correct sign labelling was controlled by the visual stimuli associated with the sight of specific objects, but was independent of the auditory stimuli associated with the spoken name of the same objects. This outcome suggests that the common assumption that children will benefit from the simultaneous communication procedure by acquiring *auditory* as well as visual discriminations has, as yet, little empirical basis. However, two qualifications must be noted. First, one could plausibly argue that the standard simultaneous communication procedure, which was the one assessed in the present study, does not provide the child with an equal opportunity to attend to each of the three types of cues (visual, vocal, and lipreading). Thus, it is possible that by modifying the procedure to increase the saliency of the vocal and lipreading cues, one might eventually be able to bring the child's signing under control of these cues as well. A second point pertains to the fact that the children's receptive language ability was not assessed in the present study; therefore, it is not known to what extent the narrow stimulus control that characterized responding in the expressive mode was also characteristic of responding in the receptive mode. Thus, an important issue for future research would be to determine the degree to which sign-language skills in the expressive mode generalize to the receptive mode and *vice versa.*

The theoretical significance of the data of Figure 3 lies in their relationship to current knowledge about the perceptual characteristics of autistic children. Specifically, the present data are consistent with previous studies that found that when autistic children are simultaneously presented with two stimuli drawn from different sensory modalities, the children typically attend to only one of the stimuli (Lovaas and Schreibman, 1971; Rincover and Koegel, 1975). Further, the data are consistent with previous studies that showed that autistic children generally perform poorly on auditory comprehension tasks (Rutter, 1966, 1968). Given the auditory comprehension deficit, and the inability to attend to multiple stimulus modalities, a reasonable argument can be made for employing a system of communication that emphasizes visual stimuli. Sign language is just such a communication system.

After this study was completed, sign training was extended for Bob, Dan, and Darrick so that each child was eventually taught a total of 20 signs involving foods, clothes, grooming items, toys, and eating utensils. (Doug was unavailable because of competing treatment activities.) The results were suggestive of a "learning set" phenomenon. That is, while Darrick required 50 sessions to acquire the first 10 signs, he needed only 19 sessions to acquire the second 10 signs. Likewise, Bob required 21 and 11 sessions, and Dan, 37 and 16 sessions, to acquire the first and second set of 10 signs respectively. Although these new signs were trained using the procedures described above, the absence of multiple-baseline controls during the teaching of these signs necessitates a cautious interpretation of these findings. Nevertheless, this additional information is presented to give some indication of the kinds of changes that might be expected over prolonged training.

The children with whom we worked in this study were considerably beyond preschool age, and had failed to acquire speech despite a number of treatment efforts. Typically, children such as these have a very poor prognosis (Rutter,

1966) and are regarded as having no potential for developing a system of communication. The fact that such children did, in the present study, acquire multiple sign discriminations suggests that sign-language training may represent a viable treatment intervention for this population. On the other hand, the preliminary nature of the study described above makes it necessary to insert several cautions at this point. First, it is not at present known whether such children can also acquire, through the use of signing procedures, more complex communicative functions, such as those involving syntax or abstract language (Keith, Gunderson, Reifman, Buchsbaum, and Mosher, 1976, p. 549). Further, it may be that even relatively simple parts of speech, including verbs and adjectives, might require training procedures different from those described above. Second, it remains an empirical question whether children will show generalized improvement across a variety of social and academic skills as a consequence of learning to sign. Finally, there are no measures, as yet, to predict which nonverbal children will ultimately profit most from sign-language training. In light of the above, the present data should be viewed as a first step toward the development of a comprehensive method for producing sign language, and the limitations of these data should be viewed as a prod to explore the unanswered questions. In this vein, we are currently investigating whether more complex sign-language acquisition, such as that involving sentence and concept formation, is possible for such children. Our initial results in this area are promising and constitute grounds for continued optimism regarding the viability of sign-language training as a treatment for childhood autism.

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