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AN EVALUATION OF THE RELATIONSHIP BETWEEN RECEPTIVE SPEECH SKILLS AND EXPRESSIVE SIGNING

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We examined the effects of receptive speech on the acquisition of manual signing among three mentally retarded children. In an alternating treatments design, we compared the acquisition of expressive signs that were, versus were not, in a child's receptive vocabulary. The children were trained via total communication in which pictorial referents were named during sign training. Signs corresponding to known words were generally acquired faster and retained better than signs corresponding to unknown words. We conducted posttests to assess the stimulus control of signing and any changes in expressive and receptive signing and speech. Observed changes in performance could be accounted for by attention to aspects of the stimulus complex during training and functional equivalence of stimuli established by training.

DESCRIPTORS: sign language, retarded children, receptive labeling, functional stimulus equivalence, stimulus control

In recent years, research on teaching functional communication skills for severely mentally retarded individuals has broadened from an exclusive focus on speech to include the use of nonoral communication systems as alternatives (e.g., Fulwiler & Fouts, 1976; Light, Remington, & Porter, 1982). Although many of these studies contain methodological flaws (see Remington & Light, 1983, for a review), practitioners working with language-deficient individuals are adopting nonoral communication programs with increasing frequency (Fristoe & Lloyd, 1978; Kiernan, Reid, & Jones, 1979a, 1979b). These programs are being initiated at a time when basic research questions that may be crucial to their success remain unanswered.

One such issue concerns the relationship between receptive speech and the acquisition of manual signs. Research has shown that pretraining involving the learning of expressive verbal labels for stimuli improves the performance of mentally retarded individuals when those stimuli are used on subsequent discrimination tasks (Cantor & Hottel, 1957; Dickerson, Giradeau, & Spradlin, 1964; Smith & Means, 1962). Because expressive labeling using manual signs involves the development of conditional discriminations, it follows that speech, if present, may play a similar mediating role. Signs corresponding to referents that subjects can already name may be acquired more quickly than signs for referents that subjects are unable to name. For this reason, our first aim was to compare the effects of receptive speech on the acquisition of expressive signing.

Although the effects of speech on signing have rarely been considered, both researchers and clinicians have frequently discussed the complementary issue of facilitation of speech by signing (e.g., Carr, 1979; Schaeffer, Musil, & Kollinzas, 1980). Our study examined the effects of total communication training on speech-related skills by monitoring (a) stimulus control of signing by the verbal referent following training, and (b) changes in receptive and expressive speech. Because Carr and Dores (1981) have argued that among autistic or "autistic-like" children only good verbal imitators acquire receptive speech functions, our study also incorporated a verbal imitation pretest. Its purpose

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was to assess the generality of Carr and Dores' conclusion in the case of children who were mentally retarded but not autistic.

Our final aim was to examine more generally the question of whether associations that had not been directly trained would emerge as a result of training; Table 1 illustrates the relevant associations between signs, words, and picture referents. The concept of functional equivalence (Sidman & Tailby, 1982; Spradlin & Dixon, 1976; Van Biervliet, 1977) provides a theoretical framework within which this issue can be examined. If two or more stimuli are functionally equivalent (i.e., control the same response) then a second response conditioned to one stimulus should be controlled by the other stimulus, even without direct training. For example, assuming that a child can imitate signs (sign imitation) and match identical pictures (picture matching) prior to training, training in expressive signing may lead to the acquisition of receptive signing performance without directly teaching this class of associations. Because signed stimuli control signing responses (sign imitation) and picture stimuli also control signing responses (expressive signing), signs and pictures are functionally equivalent stimuli following expressive sign training. Therefore, as picture stimuli already control picture selection responses (picture matching), signs should also control picture selection responses (i.e., receptive signing).

To summarize, the aims of this study were (a) to assess the effects of receptive speech on the acquisition and maintenance of signing trained using the total communication procedure; (b) to examine the effect of total communication training on receptive and expressive speech skills; and (c) to assess what associations between signs, pictures, and words were acquired as a result of training.

METHOD

Subjects

Three children from schools for the severely educationally retarded participated in the study. With the exception of Mick, who was diagnosed as having phenylketonuria, none of the children carried a specific diagnosis. Merrill Palmer Scales and Reynell Developmental Language Scales were used to assess the children's mental age scores and their level of expressive language and verbal comprehension. A verbal imitation test (detailed below) was also used. Mick was 11 years 3 months old with a mental age score of 3 years 4 months; he was functioning at the 10-month level for expressive language and the 2-year 4-month level for verbal comprehension. His verbal imitation score was 39%. Gary was 11 years 2 months old with a mental age score of 2 years 10 months; he was functioning at the 10-month level for expressive language and the 2-year 10-month level for verbal comprehension. His verbal imitation score was 72%. Mandy was 6 years old and had a mental age score of 4 years 1 month; she was functioning at the 2-year 3-month level for expressive language and 2-year 10-month level for verbal comprehension. Her verbal imitation score was 94%. All three children had hearing and vision within the normal range.

Setting

Except for the few occasions on which practical constraints prevented it, all training and testing sessions were conducted daily, on a one-on-one basis in a quiet room in the children's school. Video recordings of training and testing sessions were taken for later scoring and reliability rating, and all sessions were timed. Preferred foods and the teacher's praise were used as reinforcers throughout the study.

Materials

Illustrations of various categories of people (e.g., nurse, fisherman, and policeman) were selected as targets for expressive sign training. In order to make these illustrations comparable in terms of distinctiveness, line drawings executed in an identical style were produced, and each was mounted on a 32 cm × 26 cm white card. Each picture was new to the child prior to training. Signs corresponding to these pictures were rated for transparency and performance difficulty. Robinson and Griffith (1979) defined the transparency of a sign in terms of the

ease with which nonsigners can guess its meaning. Transparency was assessed by presenting all the potential to-be-trained signs to 27 normal 8-year-old children, who were asked to guess the meaning of the signs using a multiple-choice procedure. In a subsequent session the children were asked to rate the signs for performance difficulty using a 4-point scale. Raters were informed that features such as one- versus two-handed signs, simple versus complex movements, and the visibility versus nonvisibility of the sign to the child defined performance difficulty. On the basis of these ratings two groups of signs were established for each child such that (a) five signs corresponded to known, and five to unknown, words, and (b) these two groups of signs were equivalent in transparency and performance difficulty.

Experimental Design

An alternating treatments design (Barlow & Hayes, 1979) was used in which five signs corresponding to words in the child's receptive vocabulary were trained under one treatment (known words condition), and five signs corresponding to unknown words were trained under the other treatment (unknown words condition). Sessions in each of the two conditions were conducted daily, in counterbalanced order.

Procedure

Pretests. Participants were assessed using a verbal imitation test, which closely resembled that of Carr and Dores (1981). Sounds were generated by combining one of six consonants (p, b, t, d, m, n) with one of six vowels (i, u, e, o, ah, uh) to present 36 consonant-vowel segments. A correct response was defined as one in which either the consonant or vowel portion of the sound (or both) was correct (cf. Carr & Dores, 1981). An incorrect response was defined as any sound that did not match the vowel or consonant part of the consonant-vowel segment or a nonresponse. The teacher, who subsequently carried out all training and testing, presented a sound and allowed the child 3 s in which to respond. The test differed from Carr and Dores' (1981) only in terms of the number of sounds presented. Whereas Carr and Dores randomly selected an additional 14 segments from the pool of 36 to generate a total of 50 sounds, we restricted the number to the original 36.

Next, participants were given six types of pretests to establish baseline measures of their familiarity with the relationships between training items and their signed and spoken equivalents. The details of stimuli presented and response requirements for each type of pretest are shown in Table 1. The basic procedure involved in each test was the same as that used in the verbal comprehension test described in detail by Remington and Clarke (1983). This consisted of a warm-up procedure followed by 50 trials in which five items were each tested 10 times in a random sequence. Prompting was not used during any of the pretests or posttests. Edible and social reinforcement was delivered at the end of the trial on an average of one trial in three, regardless of whether or not the response was correct. This noncontingent reinforcement procedure was used throughout the tests to maintain performance without training the discrimination.

Receptive speech pretests were conducted to select for training two groups of signs that corresponded to words that (a) were and (b) were not in the child's receptive vocabulary. Sufficient words were identified to ensure that these groups of signs were matched for transparency and performance difficulty. During these receptive speech pretests, only words that were identified correctly on six or more of the 10 trials were assumed to be known; the binomially computed probability of obtaining this score by chance is 0.006. Only words identified correctly on three or fewer trials were presumed to be unknown (cf. Remington & Clarke, 1983).

Picture matching, sign imitation, and *word imitation* tests were conducted to test for reflexive responding (Sidman & Tailby, 1982) with the pictures and words used in training. Pretests of *expressive signing* were conducted to provide baseline measures of the target response. *Receptive signing* and *expressive speech* pretests provided a baseline for assessing the acquisition of associations between pictures, signs, and words that were not

Table 1
Tasks Used to Examine Associations Between Signs, Words, and Picture Referents

Task name	Stimuli	Instruction	Response	Type of association
Picture matching[a]	Pictures	"Show me the one like this"	Points to identical picture	Identity match
Word imitation[a]	Spoken words	"Say (word)"	Imitates word	Identity match
Sign imitation[a]	Manual signs	"Do this" (sign)	Imitates sign	Identity match (trained association)
Expressive signing[a]	Pictures and spoken words	None	Forms manual sign	Trained association
Visual stimulus control[b]	Pictures	None	Forms manual sign	Trained association
Vocal stimulus control[b]	Spoken words	None	Forms manual sign	Trained association
Receptive speech[ab]	Spoken words	"Show me the (name of picture)"	Points to named picture	Previously acquired (known word) or derived (unknown word) association
Receptive signing[ab]	Manual signs	"Show me this" (sign)	Points to signed picture	Derived association
Expressive speech[ab]	Pictures	"What's this called?"	Vocally names picture	Derived association
Sign naming[b]	Manual signs	"What's this called?"	Vocally names sign	Derived association

Note. Not all associations were both pretested and posttested.
[a] Pretested association.
[b] Posttested association.

to be directly trained (derived associations). The receptive signing test also indicated sign transparency. Signs correctly identified on three or more trials were rejected, and the two conditions were rematched with alternative signs.

Sign imitation training. Sign imitation training ensured that the signs could be performed before the children were trained to use them as expressive labels, and demonstrated sign reflexivity (Sidman & Tailby, 1982). Two 50-trial sessions involving signs from both conditions were run each day. In these trials, each of the 10 signs to be trained was presented 10 times. For each sign, the 10 training trials were grouped into two blocks of three and two blocks of two, and the blocks ordered in a random sequence. This procedure gave the child opportunities to practice a sign immediately after receiving performance feedback on the previous trial. A trial began with the teacher modeling the sign. Reinforcement was delivered if the child imitated the sign within 5 s. If the child failed to imitate the sign, he or she was physically prompted to do so. As signing became more reliable, prompting was gradually faded. This procedure was repeated until the child had completed two consecutive 50-trial sessions without prompting or error.

Training in expressive signing. In this phase, the aim of training was to shift stimulus control of signing from the teacher's prompt (imitative signing) to the pictorial and verbal stimuli present during total communication training (expressive signing). Signs for known and unknown words were taught in separate sessions but using identical training procedures. Each session consisted of 50 trials, 10 per sign, presented in a random sequence. The teacher began a trial by cueing the child, standing a picture on the table, and naming the card. Reinforcement was delivered if the child made the appropriate sign within 5 s. If the child failed to make the appropriate sign, his or her hands were placed in the sign's starting position as a prompt. Prompted responding was reinforced with praise but not food, providing a differential consequence for unprompted signing (cf. Olenick & Pear, 1980). Following reinforcement, the picture was removed

and a 5-s intertrial interval occurred. During training, prompts were faded. The child's performance of a sign met criterion when he or she responded correctly on all 10 trials in a training session. In each condition training continued until the child's performance of all five signs met criterion.

Because Mick and Gary perseverated across trials and did not learn the conditional discriminations in either condition, the trial blocking procedure used in sign imitation training was introduced to train expressive signing. Initially, each of the five signs was presented in two blocks of two and two blocks of three trials. When performance of any sign met a criterion of three correct trial blocks out of four during a single session, the block size in the subsequent session was reduced, making five blocks of two trials. When a child responded correctly in two of these two-trial blocks, that sign was subsequently presented in single-trial form. Thus, as the children's performance improved, the blocking procedure was gradually withdrawn and replaced by the 50 trials in a random sequence.

Posttests. Following training, a series of posttests was conducted to assess acquired associations between signs, pictures, and words (see Table 1). These included tests of receptive and expressive speech, receptive signing, and sign naming. In addition, tests of stimulus control of the signs were conducted to establish whether the pictures and/or the spoken words corresponding to them had become effective discriminative stimuli. Follow-up tests of both expressive and receptive signing were conducted 2 months after training. All posttests were conducted in the same manner as pretests.

Data Collection and Reliability

Reliability scores were obtained on the last session of sign imitation training; on one in four of the maintenance sessions; and on all other training, pretest and posttest sessions. Reliability was assessed by having a second observer independently score videotaped sessions using clearly illustrated sign definitions. Only unprompted signing responses were scored as correct. Reliability scores were computed as the ratio of the number of trials on which the observers agreed divided by the number of trials on which they agreed plus the number on which they disagreed multiplied by 100. The mean interobserver reliability scores for all participants on the pretest, expressive sign training, and posttest phases of the experiment ranged from 93.1% to 99.4% (M = 96.4%). The verbal imitation test reliability scores were: Mick, 83.3%; Gary, 94.5%; and Mandy, 100%.

RESULTS

Following sign imitation training, all the children could imitate the signs correctly over 100 consecutive trials. The number of 50-trial training sessions required by each participant to reach criterion were: Mick, 20; Gary, 35; and Mandy, 10. Pretests showed that each child could match the pictures in both conditions with complete accuracy, but only Mandy could imitate any of the words involved in training. She was totally accurate in her imitation of known words, but her performance declined to 56% in the unknown words condition.

No child performed correctly during the expressive signing pretests but all children successfully completed the experimental task. Although the speed with which participants reached criterion varied greatly, all of the children required fewer trials to reach criterion in the known words condition than in the unknown words condition. The total numbers of trials required for each child to reach criterion on all of the signs in the known and the unknown words conditions, respectively, were: Mick: 820, 1,310; Gary: 710, 1,550; Mandy: 150, 210. For each child, Mann-Whitney U tests (or in the case of Mandy, Leach's [1979] rank sum tests for extensive ties) were performed on the trials-to-criterion scores for signs trained in the two conditions, and in every case a statistically significant difference was observed (Mick, $U = 1$, $p < .01$; Gary, $U = 0$, $p < .005$; Mandy, $Z = 2.02$, $p < .05$). This difference was not due to a difference in the mean duration of training trials between the two treatment conditions. The mean lengths of each training session in the known and unknown words conditions, respectively, were:

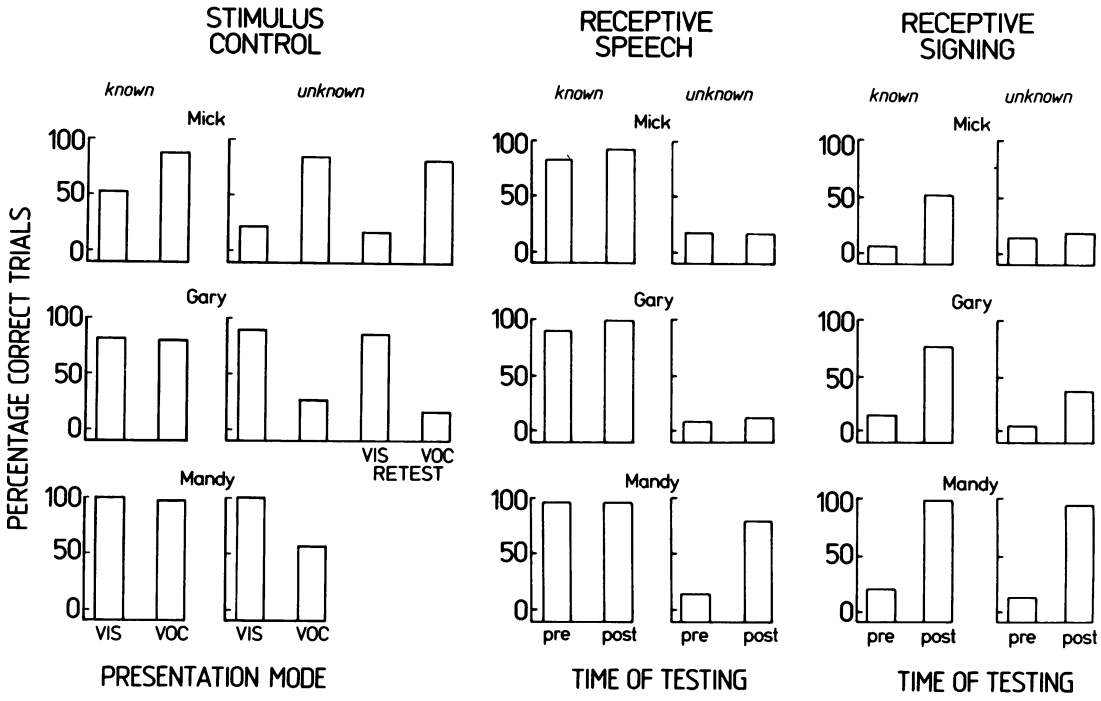

Figure 1. Percentage of correct responses obtained in the known words and unknown words condition during the stimulus control posttest. Left bar chart: under the visual condition (VIS), the teacher presented a picture to the child; under the vocal condition (VOC), she named the picture. Receptive speech and receptive signing posttests for each child appear in the center and right charts, respectively.

Mick: 9.7 min, 10.4 min; Gary: 11.2 min, 10.6 min; Mandy: 9.9 min, 9.2 min.

Results of the stimulus control assessment are shown on the left side of Figure 1. All three children showed control of signing by both spoken words and pictures in the known words condition, but Mandy was the only child to show control of signing by both components in the unknown words condition; Gary's signing was almost exclusively controlled by pictures, and Mick's by spoken words. Because these results were unexpected (cf. Carr & Dores, 1981), reassessments of verbal imitation and of stimulus control in the unknown words condition were conducted for Mick and Gary. Mick's second verbal imitation score was 39% and Gary's was 67%. Figure 1 shows that the stimulus control retest performance also closely matched the earlier test.

The results of the receptive speech pretests and posttests are shown in the center of Figure 1. Mandy was the only child to improve her receptive speech performance with previously unknown words.

The receptive signing data are shown on the right side of Figure 1. All of the children improved their receptive signing performance in both conditions between pretests and posttests with the exception of Mick in the unknown words condition.

The children received expressive speech posttests in the known words condition but, because it was assumed that expressive speech would not be acquired in the absence of receptive speech, only Mandy was posttested in the unknown words condition. She alone developed her expressive speech as a result of training. Her performance improved from 66% to 98% on known words, and from 0% to 42% on unknown words. Furthermore, Mandy was the only child to respond reliably in the sign naming tests. Her performance was better in the known words than in the unknown words condition, her scores being 78% and 42%, respectively.

The data from the signing posttests and the

Table 2
Percentage of Correct Expressive and Receptive Signing Responses at Posttest and 2-month Maintenance Test

	Expressive signing				Receptive signing			
	Posttest		Maintenance		Posttest		Maintenance	
Participant	Known	Unknown	Known	Unknown	Known	Unknown	Known	Unknown
Mick	92	90	60	8	52	18	36	14
Gary	98	96	44	0	76	40	56	28
Mandy	100	96	20	20	98	94	78	64

follow-up tests conducted 2 months after training are shown in Table 2. Although overall maintenance effects were small, Mick and Gary showed a higher level of retention of both receptive and expressive signing in the known words condition than in the unknown words condition.

DISCUSSION

Signs corresponding to known words were generally learned faster than signs corresponding to unknown words. Furthermore, for two of the children, a greater percentage of words in the known words condition than in the unknown words condition was scored as correct on the 2-month follow-up test. However, maintenance performance was generally disappointing, possibly because the words trained were not very functional outside of training. The results suggest that, other factors being equal, the selection of referents on the basis of a child's receptive vocal repertoire may facilitate signing acquisition and retention. A simply administered pretest can thus provide an efficient means of selecting appropriate training items.

We cannot determine from these data whether signing would be acquired as rapidly if unknown words were taught receptively prior to expressive sign training. However, results of the stimulus control tests suggest that training words receptively could have some compensatory benefits. All of the children showed stimulus control of expressive signing by both pictures and spoken words in the known words condition, but only one child (Mandy) showed control by both components in the unknown words condition. Thus, pretraining in receptive speech may reduce overselectivity occurring with total communication training.

Mick and Gary's stimulus control test performance in the unknown words condition does not support the generality of Carr and Dores' (1981) findings with a different subject population (autistic children). These authors argue that, among "autistic-like" children, only good verbal imitators will improve their receptive speech skills as a result of total communication training. Gary, a good verbal imitator, selectively attended to the visual component of total communication, and Mick, a poor verbal imitator, selectively attended to the vocal component. Neither child improved their receptive speech skills following training. However, it is not possible to make a direct comparison of these findings and those of Carr and Dores (1981) because they used receptive sign training, whereas the children in this study were trained in expressive signing.

The fact that Mick and Gary showed stimulus control of signing by both spoken words and pictures in the known words condition is not incompatible with the overselectivity seen in the unknown words condition. Gary's vocal stimulus control in the known words condition may be explained using the framework of functional stimulus equivalence. Prior to training, known spoken words and pictures were functionally equivalent stimuli because both controlled picture selection responses. Overselective attention to pictures during training would establish control of signing responses by picture stimuli. The equivalence hypothesis suggests that the corresponding spoken words should also acquire control of signing re-

sponses, leading to vocal stimulus control as observed in the posttest. The fact that, in the known words condition, Mick's signing was controlled by pictures may be similarily explained.

The functional equivalence model suggests that, in the unknown words condition, receptive signing would emerge as an acquired relationship only if the child attended to the pictures during training. Only Mick, the child who overselectively attended to vocal cues, failed to show receptive signing in the unknown words condition at posttest. Overselectivity to spoken words does not preclude the emergence of receptive signing when training takes place with known words. Because this training establishes that spoken words control signing responses, and the prior sign imitation training establishes that signed stimuli control signing responses, spoken words and signed stimuli become functionally equivalent. Therefore, because spoken words already control picture selection responses (receptive speech), the equivalent signed stimuli should also come to control picture selection (receptive signing). The posttest data for all children are consistent with this interpretation.

Development of receptive speech skills would be expected following total communication training only if children attended to both spoken words and pictures. This would make pictures and spoken words functionally equivalent stimuli. Assuming picture matching skills, picture selection responses would come to be controlled by the corresponding spoken words (i.e., receptive speech). Mandy was the only child not to show overselective attention during the stimulus control tests, and the only child whose receptive speech skills improved. Remington and Clarke (1983) reported similar findings with an autistic child trained via total communication.

For expressive speech acquisition, the functional equivalence framework requires that a child should be able to (a) imitate the words involved in training, and (b) attend to both spoken words and pictures during total communication training. Under these circumstances, (a) spoken word stimuli would control spoken word responses, and (b) spoken words and corresponding pictures would be established as functionally equivalent. Thus, picture stimuli would acquire control of spoken word responses (i.e., expressive speech). The data are consistent with this interpretation; only Mandy would be expected to show improvements in expressive speech.

In summary, results of this study suggest that signs corresponding to known words are generally learned faster, and a greater percentage are retained, than signs corresponding to unknown words. The implications of these findings for training may suggest a change of emphasis in relation to previous research and current practice, both of which stress the mediation of speech by signing. The assumption that receptive speech skills will be acquired incidentally may be ill-founded in some cases. Our data show that marked differences may occur in the outcome of total communication training, and these differences may be explained using the functional equivalence framework.

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