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Training Novel Language Systems in Severely Aphasic Individuals: How Novel Is It?

Anthony P. Salvatore and T. Russell Nelson

Some individuals who suffer brain damage become totally dependent in communication, and are labeled severely/globally aphasic. Traditionally, treatment is directed at developing some form of functional communication, such as use of a language board or gestural signs. The establishment of such functional communication systems is a monumental challenge (Collins, 1990; Salvatore & Thompson, 1986). Alternative functional communication systems based upon novel visual stimuli increasingly are receiving attention from clinicians: Blissymbols (Funnell & Allport, 1989), Visual Action Therapy (Gardner, Zurif, Berry, & Baker, 1976), Premack Symbols (Velletri-Glass, Gazzaniga, & Premack, 1973), and a computerized symbol system (Steele, Kleezewska, Carlson, & Weinrich, 1992). Unfortunately, reports on these systems do not address directly the role of generalization.

The ability to generalize performance across stimuli and conditions is used as a measure of treatment effectiveness (Thompson, 1989). Some researchers have suggested that generalization may play a role in investigating various theoretical approaches to treatment (Sullivan & Brookshire, 1989). From a slightly different perspective, one might also argue that generalization can be used as an indicator of the potential for a patient to benefit from treatment (Haynes, Pindzola, & Emerick, 1992). If an individual demonstrates generalization to untrained stimuli and/or across environments, one might conclude that the individual has the potential to benefit from further treatment efforts. From this perspective, assessment of an individual's ability to generalize may be clinically quite useful (Horner & LaPointe, 1979).

The equivalence model described by Sidman (1986) may offer a framework for assessing a patient's ability to generalize. Sidman based his definition of equivalence upon the mathematical definition of equivalence to describe what he believes happens in training conditional relations. He suggested that emerging equivalence relationships are defined by the presence of three characteristics: (1) *reflexivity* (demonstration of generalized matching across stimuli without specific training; A = A), (2) *symmetry* (demonstration of bidirectional matching without specific training; if A = B, then B = A), and (3) *transitivity* (when two stimuli that previously were related only indirectly through their relationship to a third common stimulus emerge as directly related to one another; if A = B and B = C, then A = C emerges without specific training). In *equivalence*, the relationship demonstrates all three of the characteristics. Table 1 summarizes the model.

To date, the model has been used to analyze verbal behavior in a variety of normal and language-disordered populations. Preliminary work with retarded children, college students, and nonhumans suggests that there is an apparent correspondence between stimulus–stimulus relationships, referred to as equivalence relationships, and language (Devany, Hayes, & Nelson, 1986; Hayes, Thompson, & Hayes, 1989; Saunders, Wachter, & Spradlin, 1988; Sidman et al., 1982; Sigurdardottir, Green, & Sanders, 1990). Given this apparent relationship, the model may provide a framework within which an individual's generalization across untrained relationships may have implications for treatment potential. Finally, the reasons for using such a novel visual system are the following: (1) the stimuli are arbitrary and discrete, (2) the system is generative in nature, (3) the patient has no history with the stimuli, and (4) the system can be used across multilingual/multicultural populations.

Our interest was to address the following issues. First, we attempted to determine whether severely aphasic individuals could learn stimulus–stimulus conditional relationships as defined by Sidman (1986). Second, could these individuals generalize their training to previously untrained stimulus–stimulus equivalence relationships. Based on our results, we discuss the application of the equivalence model to the investigation of generalization in the severely aphasic individual.

METHOD

Subjects

Four severely aphasic adults agreed to participate. Three Hispanic males and one white female are described in Table 2. The three Hispanic males were all multilingual, with Spanish as their primary language and

Table 1. Equivalence Relations Model Defining Characteristics of an Equivalence Relationship

Reflexivity	=	Generalized matching across all stimuli within the relationship A = A B = B C = C
Symmetry	=	Conditional relationship holds true even when the sample and comparison stimuli are interchanged A = B then B = A
Transitivity	=	Context-sensitive relation between stimuli A = B and B = C then A = C
Equivalence	=	Relationship demonstrates reflexivity, symmetry, and transitivity C = A Which is symmetric with A = C

Based on "Functional Analysis of Emergent Verbal Classes" by M. Sidman, in *Analysis and Integration of Behavioral Units* by T. Thompson and M. D. Zeiler (Eds.), 1986, Hillsdale, NJ: Erlbaum.

English as their second language. The female was a monolingual English speaker. All subjects were born, raised, and educated in the United States. Each had a high school education and had served in the U.S. military. All were assessed with the *Porch Index of Communicative Ability* (PICA) (Porch, 1981). Hearing acuity was sufficient for communication, and there was no history of psychiatric problems.

To date, we have assessed/trained seven severely aphasic individuals. Four of these seven are reported here. We had attrition rates beyond what we anticipated due to factors such as declining medical condition, scheduling difficulties, and transportation.

Setting

Assessment, training, and testing took place in a quiet, well-lighted room adequate to accommodate a subject in a wheelchair, an examiner, an observer, chairs, and video equipment. All sessions were videotaped for subsequent analysis.

Table 2. Description of Subjects and Their Performance on Selected Subtests of the *Porch Index of Communicative Ability* (PICA) and the Mean Overall Score for Subtests (*) Used for the Short Form of the PICA (SPICA)

Patient	*Sex*	*Age*	*Months Post-onset*	*SPICA*	**I*	*IV*	*V*	**VI*	**VII*	*X*	*XII*	**D*
1 (FG)	M	60	12	6.33	2.0	2.0	9.2	6.6	10.7	9.5	2.0	2.0
			17	6.34	2.0	2.0	10.3	7.0	10.3	10.7	2.0	2.0
			18	6.70	2.0	2.0	—	8.6	9.8	10.0	2.2	2.5
2 (BH)	M	61	2	8.44	4.7	7.4	9.0	9.3	11.5	13.6	3.6	5.5
3 (RB)	M	66	57	7.87	4.4	7.6	7.5	8.4	10.6	11.4	13.7	5.0
			57	8.53	5.1	6.9	7.9	9.7	10.6	10.6	14.2	6.0
			57	6.87	4.9	7.2	10.0	10.8	10.9	11.2	11.1	6.0
4 (SR)	F	75	10	8.91	5.0	4.9	8.9	11.7	11.7	11.2	5.0	5.0
			10	7.50	5.0	5.0	—	5.6	10.5	12.3	5.0	5.4
			10	8.01	5.0	5.0	8.2	9.3	9.9	11.5	—	4.8

Note: The short form of the PICA (DiSimoni et al., 1975) uses only selected standard subtests from the PICA: I, VI, VII, and D.

Stimuli

Novel visual stimuli from the report of Devany et al. (1986) were used for this study. For this report, each novel visual form is given a letter label: ABC or DEF.

Procedure

The following sequence of activities was carried out for each subject: (1) medical record review, (2) assessment with *Porch Index of Communicative Ability*, (3) matching-to-sample pointing response training, (4) stimulus–stimulus conditional relationships training, and (5) testing generalization to untrained stimulus–stimulus relationships. Table 3 outlines the training and probe sequence for each subject.

After PICA testing was completed, training was initiated to establish a pointing response. The subject was seated at a table in front of the visual stimuli presented via three-ring notebook. The examiner demonstrated the match-to-sample pointing response to the subject. A simple dot-to-dot matching task was used to train the match-to-

Table 3. Procedure Sequence for Training and Probes

1. Assessment with *Porch Index of Communicative Ability* (PICA) and with the short form of the PICA (SPICA)
2. Train match-to-sample response topography
3. Training
   A = A, B = B, C = C; D = D, E = E, F = F
4. Generalization probes
   X = X, Y = Y, Z = Z
5. Training of conditional stimulus–stimulus relationships
   A = B, B = C; D = E, E = F
6. Generalization probes/transitivity
   A = C
   D = F
7. Generalization probes/equivalence
   C = A
   F = D

Note: Each subject was initially administered the full PICA before any training was completed. When possible, the patient was administered selected subtests of the PICA on two or more occasions before training was begun, with the long-term goal of assessing the stability of each patient's communication. An overall score was abstracted from each of these test administrations using the formula for calculating the short form of the PICA overall (DiSimoni, Keith, Holt, & Darley, 1975).

sample pointing response (Salvatore, 1982; Salvatore & Schneider, 1984). The sample stimulus was presented to the subject, who was physically prompted to touch the sample stimulus with his or her finger. Next, the subject was presented with the array of choices and was prompted to touch the sample and then the choice that matched the sample. This training proceeded from a simple one-choice array, to an array of two and three stimulus choices. This technique of successive approximation of stimulus complexity is designed to reduce the occurrence of error responses, and therefore to reduce the occurrence of superstitious response patterns. Following each correct response, the subject was verbally praised. An error response was followed by the verbal statement, "No. Try again." The subject was presented the trial again, until he or she responded correctly. When the subject responded correctly on 10 consecutive trials, the patient was assumed to be able to perform the match-to-sample response. Performance during the training of conditional stimulus–stimulus relationships was not confounded, therefore, by questions of whether the patient understood the nature of the task.

Immediately following response training, the subject was trained to match A = A, B = B, C = C, then A = B, B = C, utilizing the sample pointing response. During training, a criterion of 80% accuracy was required before the patient was permitted to move onto the next level

Table 4. Example of Training Stimulus Array

Choices	A	—	—
Sample		A	
Choices	—	U	A
Sample		A	
Choices	U	A	V
Sample		A	

of training. The stimuli were arranged in blocks of 10 trials. Training was terminated if the subject failed to reach criterion on three consecutive blocks of 10 trials at the same level. Each subject was trained across two classes of novel stimuli: ABC and DEF. Training began with a single choice available (3 trials), then two choices (3 trials), and finally three choices (4 trials). An example of the training stimulus array is provided in Table 4.

Generalization Probes

After subjects reached criterion on the training relationships, probes were presented to determine if the subject generalized to untrained stimulus–stimulus relationships. Ten probe trials for each relationship were presented. An array of three choices was presented on each of the trials. The foils were visual stimuli the subject had not seen before. No verbal contingent stimulation was provided following each response to a probe.

Interobserver Agreement

Approximately 80% of the dependent training and generalization measures—that is, correct/incorrect pointing responses—for two of the four subjects were scored by an independent observer and compared with the scoring of the examiner. Overall point-to-point agreement was 99%. To determine if the obtained percentage of agreement is better than would be obtained by chance alone, given the high rate of correct responding, an overall chance calculation was done. The obtained percentage of agreement of 99% was greater than the 90% agreement expected by chance (Hopkins & Hermann, 1977).

Table 5. Performance of Each Subject Across Two Novel Visual Stimulus Classes, ABC and DEF, During Conditional Training, and Generalization Probes

	Patient			
	1	2	3	4
Match-to-sample response training	92%	83%	83%	92%
Conditional training				
A = A	89	89	89	89
B = B	100	89	100	89
C = C	100	100	100	100
A = B	100	90	100	100
B = C	100	100	100	100
A = B; B = C	100	100	100	—
Transitivity probes				
A = C	100	100	100	100
Equivalence probes				
C = A	—	—	100	100
D = D	—	100	100	100
E = E	—	100	100	100
F = F	—	—	100	100
Reflexivity probes				
X = X, Y = Y, Z = Z	—	100	100	100
Conditional training				
D = E	100	—	90	100
E = F	90	—	80	100
D = E; E = F	90	—	90	90
Transitivity probes				
D = F	100	—	90	100
Equivalence probes				
F = D	100	—	100	100

RESULTS

Table 5 shows that all four subjects generalized performance to untrained stimulus–stimulus relationships. Subject 1 had no trouble learning the match-to-sample pointing response or learning the reflexivity relations A = A, B = B, or C = C. The patient also showed no problem in learning the conditional relations A = B and B = C. During the transitivity/generalization probes, the patient was able to match A = C correctly without any previous training. Subject 1 also was trained on a second three-member stimulus class: DEF. Training was not provided on the reflexivity relations D = D, E = E, and F = F, but the subject was trained directly on D = E and E = F, followed by training that alternated the presentation of D = E and E = F relationships. The patient performed with few errors on these training items. The patient then generalized to transitivity/generalization probe D = F and then successfully generalized to the equivalence probe F = D. Subject 2 demonstrated similar performance. This patient was provided additional training on the conditional relations A = B/B = C presented randomly over 10 trials. The motivation for this step was to ensure that the patient attended to the sample by requiring the patient to pay attention to the sample, since it varied from trial to trial. This patient also generalized performance to the relation A = C without any previous training. Subjects 3 and 4 were exposed to the same sequence of training and probe trials. They both demonstrated successful performance across all generalization probes. All four subjects demonstrated generalization to untrained relationships, and the three subjects probed for the equivalence relationship were successful.

DISCUSSION

The results of this study provide preliminary evidence that severely aphasic individuals can learn to use a match-to-sample pointing response, learn novel symbolic relationships, and generalize them to untrained relationships. What is important is that the subjects did more than learn a simple stimulus–response or "if . . . then" relationship; they learned generative symbolic relationships. This is the first demonstration of an equivalence relation in severely aphasic adults.

It is not clear that the subjects treated these "novel" stimuli as such. The subjects appeared simply to treat the training as any other categorizing activity, but, more importantly, they demonstrated an ability to generalize to untrained relationships. This is a clear case of severely aphasic individuals learning new stimulus–stimulus relationships and generalizing to untrained relationships. This evidence suggests that these subjects may benefit from similar training designed to produce functional communication using alternative visual communication systems.

The almost errorless performance of all four subjects suggests that the task was too easy. The question of "easy" or "difficult" begs the question since the training tasks incorporated stimulus shaping, which was used to reduce errors and avoid the possibility of superstitious response behavior. To date, we have trained only two classes of stimuli; to assess the capacity of these patients to learn new complex behavior, we will expand these classes. Of course, as we increase the number and complexity of stimulus classes trained, the subjects may begin to produce more errors. When they begin to produce errors, the challenge will be to determine how and if we can train them to proceed to more complex levels. That is, can we be creative enough to help them learn relationships that are initially difficult? Our success or failure will have direct clinical implications.

Another question raised is whether this type of training procedure can be applied to natural language training and particularly generalization to context. The answer is yes. The work reported by Sidman (1971, 1986; Sidman et al., 1982) and others (Kohlenberg, Hayes, & Hayes, 1991; Mackay & Sidman, 1984; Stromer & Mackay, 1992) provides sufficient preliminary information to warrant further research into training syntax and context-sensitive stimulus relationships. The implications for treatment are straightforward. We should be able to train these subjects to use much more complex and generative language systems than are presently being reported. However, what is probably crucial is how we train them. One interpretation of the initial equivalence model data is that training a few selected relationships results in the emergence of a large number of untrained relationships. For example, training A = B and B = C produces the following emerging relationships without training: A = A, B = B, C = C, B = A, C = B, A = C, and C = A. The apparent power of this model is worthy of further research.

Finally, a word about the potential interaction between the equivalence model and the exploding field of computational modeling (Churchland & Sejnowski,1992). Several have suggested that students of behavior, including students of complex human behavior such as speech–language, should examine closely the parallel distributed processing approach (PDP), for several reasons. First, the PDP approach is explicitly critical of many of the same constructs of mainstream cognitive psychology that are regarded as unhelpful in behavior analysis. Second, some of the specific accounts of complex behavior proposed in PDP functionally parallel the corresponding accounts advanced by behavior analysis. One possible point of contact between the models is that of training–learning. The extensive literature in the field of experimental analysis of behavior may have a significant role in providing computational modelers with numerous examples of expert teaching procedures. It is not clear which model, the inferential computational model or the behavioral equivalence model, provides more insight into our attempts to develop effective treatment procedures. What is important, however, is that we continue to explore the differences and similarities of the two approaches in the hope of producing data that may have an impact upon our treatment.

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