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# Developmental Auditory Agnosia in Retarded Adolescents: A Preliminary Investigation

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Four mentally retarded adolescents who showed little or no expressive or receptive language were given a series of tests to determine if they could respond to meaningful nonlinguistic sounds. The tests required the subjects to respond to sounds on the basis of meaning by classifying the sounds according to the objects which produced them, i.e., the sound sources. The results show that the subject could not classify the sounds on the basis of their source although they could discriminate between them. These results are in contrast to the near perfect classification by another retarded subject who lacked speech due to a motor disorder but, nevertheless, showed good understanding of language. The finding that some nonverbal children have difficulty in responding to the meaning of nonlinguistic sounds suggests the possibility that the failure of these children to develop language may have been due to an agnosia not unlike that found in adult stroke patients.

## INTRODUCTION

In studying the language disorders of nonverbal retarded children, we have found some who exhibit the more common signs of aphasia manifested by adults who have sustained cortical damage (Geschwind, 1970; Luria, 1970; Schuell, Jenkins, & Jimenez-Pabon, 1964). For example, these children have no sensory deficit severe enough to account for their language disability, any language which they do possess is markedly abnormal, and they become emotionally upset when required to communicate verbally. In addition, the medical histories of such children often include birth trauma, seizures, and neuromotor impairment such as ataxia and hemiplegia which tend to support a diagnosis of brain damage that could easily be the cause of the aphasia (Benton, 1964). Without the accompanying retardation in other aspects of their behavior, these children would be classed as aphasic. Since, however, it is apparent that the language failure exhibited by these children is not the only disability from which they suffer, the aphasia may be only one manifestation of a broader deficit.

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Many investigators have examined the sensory capacities of such patients in an effort to determine the extent and exact nature of their reduced ability to deal with their environment. For example, audiologic testing has shown that retarded populations have a higher incidence of hearing loss than normal populations (Lloyd, 1970). However, the failure of some severely retarded children to develop language cannot be explained in terms of a simple hearing defect such as reduced puretone sensitivity or difficulty detecting small frequency and intensity differences since many nonverbal children have normal hearing sensitivity (Fulton, 1974). Thus, if the lack of language encountered among severely retarded children is the result of a more general auditory deficit, we must look elsewhere than to the routine audiologic tests to define the deficit.

In an effort to account for the language deficit of retarded nonverbal children, it would be helpful to discover whether the apparent aphasia is one of several manifestations of a single neurological disorder or is limited to an aphasia that occurs in combination with other deficits that are neurologically unrelated to aphasia. In searching for a general deficit which might underlie the failure to develop normal language, we considered the possibility that some of the nonverbal children might suffer from a difficulty in recognizing the meaning of auditory stimuli in general (Chappell, 1970; Gordon, 1966). Such a disorder could be limited to the auditory system or could involve other sense modalities as well. That is, not only might nonverbal children have difficulty understanding and using linguistic stimuli, but they might also have difficulty recognizing the meaning of any sounds in their environment (auditory agnosia) or recognizing the meaning of visual and somesthetic stimuli as well (general agnosia). In other words, the underlying problem in some nonverbal children who are also severely retarded might be an auditory or a general agnosia rather than a purely linguistic aphasia.

Although, in adults, aphasia and auditory agnosia are sometimes dissociated (Spreen, Benton, & Fincham, 1965), there is reason to expect that such a dissociation would not occur in a case of auditory agnosia present from very early life. A child whose auditory agnosia prevented him from learning to recognize natural sounds would be unlikely to learn to recognize the more abstract sounds of language (Stein & Curry, 1968). Children who had difficulty recognizing the meaning of stimuli from other sense modalities as well would be increasingly incapacitated in their efforts to cope with their environment.

To investigate the possibility of agnosia in retarded children, it was necessary to devise a somewhat unusual testing procedure. Unlike adult neurologic patients, nonverbal retarded children could not be tested by the usual brief and wide-range clinical procedure of hearing a sound and simply pointing to an object, or picture of an object, which could have made the sound (Albert, Sparks, vonStockert, & Sax, 1972; Spinnler & Vignolo, 1966). Instead, because we could not explain or easily demonstrate the task, we relied on a procedure that could be taught by standard operant procedures and a task that could be solved only if the child recognized the meaning of the sounds presented. In addition, the sound classes were limited, for this preliminary investigation, to two sound sources which were commonly found in the children's environment. The way we chose for testing is based on methods developed for testing generalization in animals (Blough, 1969; Heffner, 1975). The test is based on the premise that the recognition of the meaning of a sound involves at least two similar skills: first, the ability to associate the sound with the object that made the sound (i.e., its source) (Masterton & Diamond, 1973); second, the ability to associate that object with similar objects in past experience (Nelson, 1974). Recognizing the meaning of visual stimuli would similarly require intact associations between a picture, the object it represents, and other similar objects and pictures.

## METHOD AND PROCEDURE

The following tests are based on the assumption that auditory agnosia is implicated if a patient is unable to match a sound to its source or to classify together sounds from similar sources. For this preliminary study, a limited number of sound-producing objects was chosen and an attempt was made in a carefully controlled setting to determine whether the children were able to: (1) identify the sounds with their source and (2) treat different sounds from the same source as similar. To answer these questions, a battery of auditory tests was devised to compare the nonverbal children with a mute child of similar age and developmental delay who did understand speech. In brief, two categories of natural sounds (human and dog) with widely varying and overlapping intensity and spectra were chosen. The children were tested to determine whether they could identify these sounds on the basis of the sound source alone. In the cases where a child could not successfully perform this task, attempts were made to determine the nature of the difficulty.

### *Subjects*

The subjects consisted of five mentally retarded teenagers who had had previous experience in operant situations. Four were nonverbal: They neither spoke nor understood speech. The fifth retarded subject was mute but did understand speech and communicated using gestures of his own devising. Details of the medical history of the retarded subjects in this study are given in Table 1. Observation of the nonverbal subjects demonstrated that all of them could produce some sounds. CB and MG produced grunts, sighs, and "uh, hunh," with labored imitation of labial consonants. Their comprehension of spoken words and sentences appeared negligible. The other two nonverbal subjects, CC and DG, produced words and occasional simple sentences. Their comprehension of language seemed to be at least minimal (simple commands). The behavior of each of the subjects (except MG) was characterized by inconsistency and emotional disturbance whenever confronted with a situation in which they were expected to try to produce or understand speech. In contrast, MG was placid and seemed unaware of the sounds around him.

FH differed from the other retardates in several important respects. He had good comprehension of spoken language, was learning to read and write some words, and had rapidly completed an experimental language program using visual rather than auditory symbols. This subject, in contrast to the silence of the nonverbal children, continually attempted to

TABLE 1

DESCRIPTION OF THE MENTALLY RETARDED SUBJECTS

| Subject | Age (years) | Sex | MI[a] | AB[a] | History |
|---|---|---|---|---|---|
| CB | 16 | F | III | III | Nonverbal, difficult birth, normal hearing[b] |
| CC | 12 | M | II–III | III | Nonverbal, hydrocephalus, seizures, right spastic hemiplegia, normal hearing[b] |
| MG | 13 | M | IV | IV | Nonverbal, Down's syndrome, high frequency hearing loss[b] |
| DG | 18 | M | IV | III | Nonverbal, autistic, prenatal encephalopathy of unknown origin, retarded physical development, possible high-frequency hearing loss[b] |
| FH | 15 | M | III | III | Dysarthric, difficult birth, premature closing of skull sutures, mild seizures, normal hearing[b] |

[a] MI and AB refer to measured intelligence and adaptive behavior rankings of the degree of retardation (Grossman, 1973). III denotes moderate and IV denotes severe retardation.

[b] Hearing was tested on all subjects by operant puretone audiometry as part of the routine admission procedure of the hospital.

communicate vocally and with gestures. However, his speech was unintelligible. Upon careful testing we found his poor speech to be due to a dysarthric condition. He could not wag his tongue voluntarily, place his tongue on his upper teeth, lick his upper lip, or protrude his tongue straight out even with the aid of a mirror. His vocal repertoire consisted of "ha! unh uh, uh hunh." In short, his speech problem seemed to be motor rather than auditory.

A small group of normal subjects was also run in some of these tests. They provided a behavioral verification of the clarity and meaningfulness of the tape-recorded stimuli presented through earphones—an admittedly unnatural situation. In addition, since the testing procedure used is not a common one and had not been used in quite this way before, we felt it was also appropriate to verify its usefulness. To accomplish both of these goals, a small group of 5-year-old normal children was trained and tested using the same stimuli and procedures. We do not wish to imply that 5-year-old normal children are comparable to retarded adolescents. These two groups differ in innumerable ways. Their inclusion as an experimentally naive group served to provide confidence that the stimuli used were interpretable and that the testing procedure could be used for extended periods without unforeseen difficulties. Verification on both points was later provided by the retarded subjects as well.

## *General Training Method*

Briefly, the subjects were trained to categorize sounds into either "human" or "dog" categories by pressing one response panel in the presence of human sounds and another panel in the presence of dog sounds. Three strategies could have been used to solve this task successfully: (1) responding on the basis of human source vs dog source, (2) responding on the basis of human source vs nonhuman source, and (3) responding on the basis of dog source vs nondog source. After the subjects had learned to categorize a number of different examples of the two categories, they were placed on a "partial feedback" schedule so that their responses were rewarded or given an error signal only part of the time. In this way, the subjects were accustomed to a situation in which they received no feedback on some of the trials. Once they had adapted to the partial feedback schedule, test stimuli were presented for which the subjects never received any feedback. After the subjects had been trained to respond without frequent feedback, they consistently responded to the test stimuli.

The subjects were seated before a box containing two lighted panels on which symbols were placed. The auditory stimuli which had been recorded on a cassette tape recorder were played back to the subjects through headphones. All stimuli were presented binaurally at a comfortable listening level for each subject and were continuously monitored by the experimenter.

A trial began with the presentation of an auditory stimulus following which the subject was required to press the response panel which corresponded to the category of the sound stimulus. Correct choices were followed by a bell and a tangible reward. Errors were followed by a buzzer and no reward was given. The reward was determined by the subject's preferences and varied from small amounts of soda pop delivered after each correct response to pennies, toys, music, or candy given to the subject at the end of an experimental session. All testing was conducted with the subject sitting alone inside an IAC double-walled chamber. Sessions lasted approximately 20 min and were conducted twice daily for the retardates and once daily for the normal children.

### *Testing Procedure*

When the subjects had learned to respond correctly to two examples of each of the two categories of sounds, they were accustomed to a situation of partial feedback by placing them on a partial reward schedule. This schedule consisted of providing a reward or an error signal on 25% of the trials (chosen randomly) so that on three out of four trials the subject had no indication of whether his response was correct or incorrect. The subjects were trained on this partial feedback schedule until they met the 95% criterion for an entire session of 50 or more trials.

After the training criterion had been met, test trials were introduced. A test trial consisted of the presentation of a *new* stimulus from either of the two categories. Subjects were never reinforced or given feedback for responses to these test stimuli. In any single session, four of the test stimuli were presented on a random schedule (40% of the trials), along with four training stimuli such that the overall feedback ratio remained at 25%. A minimum of 10 trials was given for each test stimulus spanning two or more experimental sessions.

In all, five tests were given: (1) test for auditory categorization using geometric symbols as response cues; (2) test for auditory categorization using photographs of the sources as response cues; (3) test for ability to discriminate test sounds; (4) test for categorization of sounds from very familiar sources; (5) categorization of visual stimuli. The details of these tests are best described as the results unfold.

## RESULTS

### *Test I: Test for Auditory Categorization*

For the first test, each subject was trained to respond correctly to two examples of dog vocalizations (D1, D2) and two examples of human vocalizations (P1, P2) (Table 2). They were then tested by presenting five other examples in each category (P3–P7, D3–D7) and recording the responses. On these test trials the child received no feedback as to whether or not

TABLE 2

AUDITORY STIMULI USED IN TESTS I, II, AND III

| | | | |
|---|---|---|---|
| P 1 | Natives singing | D 1 | Bark, long howl |
| P 2 | "Hi there!" (male voice) | D 2 | Series of bark howls |
| P 3 | "Would you like a Coke?" (male voice) | D 3 | Puppies whining |
| P 4 | Baby cooing | D 4 | Two barks |
| P 5 | Child giggling (child voice) | D 5 | Series of howling barks |
| P 6 | Backward recording: "Would you like a Coke?" | D 6 | Backward recording: two barks |
| P 7 | Backward recording: baby cooing | D 7 | Backward recording: bark, long howl |
| P 8 | "I really like to ride motorcycles" (male voice 2) | D 8 | Bark bark, bark, bark bark |
| P 9 | "Do you like to run fast?" (female voice) | D 9 | Bark, howl, bark |
| P10 | One little, two little, three little Indians" (three children singing) | D10 | Series of whines |
| P11 | "My shoe's untied" (male voice 3) | D11 | Series of warning barks |
| P12 | "What did you have for lunch?" (male voice 4) | D12 | Pants, bark, pants |
| P13 | "You look nice today!" (female voice 3) | D13 | Two growls, three barks |
| P14 | "How are you today?" (male voice 5) | D14 | Long howl |
| P15 | "Have you seen any robins?" (female voice 4) | D15 | warning growls, bark |
| P16 | "I like to play with puppies" (child voice 1) | D16 | Bark bark bark, bark bark |

his response was correct. A minimum of 10 presentations was made to each child for each of 10 test sounds.

At the outset, it should be noted that there are a variety of ways a subject could respond to the new examples of each class of vocalizations. First, he could respond correctly ($p < .05$) by touching the same symbol for the new examples of dog and human vocalizations that he touched for the trained examples of dog and human vocalizations. Second, the subject could respond consistently but incorrectly—for example, always responding to new dog vocalizations as if they were human vocalizations. This response pattern can be interpreted either as a bias for selecting one symbol over the other or, since the side on which the symbols occurred was not changed in this test, as a side preference. Third, the subject might demonstrate a more complicated position habit such as alternating between response panels (i.e., left, right, left, right . . .). Finally, the subject might respond randomly, that is, with no apparent relation to the meaning or physical characteristics of the sounds (intensity, duration, etc.) or to a position pattern.

Turning to the results (Fig. 1), subject FH responded correctly to all of the new examples of dog and human vocalizations. Thus, the dysarthric subject displayed no difficulty categorizing these sounds on the basis of their source. On the other hand, all four of the other nonverbal children

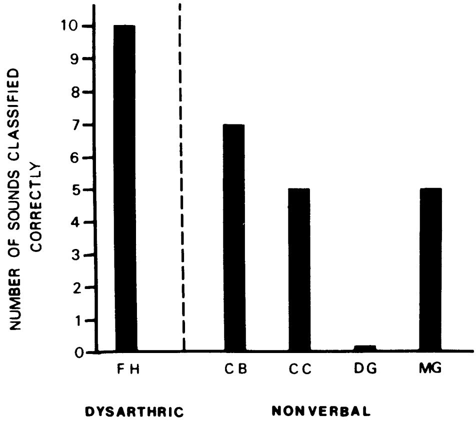


FIG. 1. Total number of human and dog sounds correctly classified by mentally retarded subjects in Test I. Note that subject FH, who was unable to speak as the result of a motor disorder, was able to classify all of the sounds. In contrast, all of the nonverbal subjects had difficulty classifying at least some sounds.

had difficulty in categorizing the new sounds. In two cases (CB and CC), the subjects responded correctly to the new dog sounds and inconsistently to the new human sounds, while the third case (MG) responded correctly to the new human sounds and incorrectly to the new dog sounds—often treating them like human sounds. The fourth case (DG) responded randomly to all of the new sounds regardless of class, showing no categorization of the sounds. In spite of their poor performance on the *test* sounds, all of the subjects maintained their high level of correct performance on the four *training* stimuli.

Although it is clear that the nonverbal retardates were unable to categorize the test sounds as well as the dysarthric subject, the details of their inability are difficult to derive from this test alone because of the presence of possible side bias. For example, the behavior of subject MG can be interpreted to mean either that he thought that all of the test sounds were human sounds or else that he did not know what their source was and so he simply responded in a fixed pattern to all of the sounds for which there was no feedback. To eliminate the confound of side bias, a replication of Test I was designed using three training (P8–P10, D8–D10) and six test (P11–P16, D11–D16) examples from each category and eliminating side biases by having the category symbols alternate sides in the response windows.

The results of the replication (Fig. 2) show that only one of the nonverbal children (MG) improved substantially. However, his good performance proved to be temporary since it deteriorated, as will be seen in later tests. Such inconsistency of response has previously been found in agnosia when repeated tests were carried out on adult stroke patients (cf. Spreen

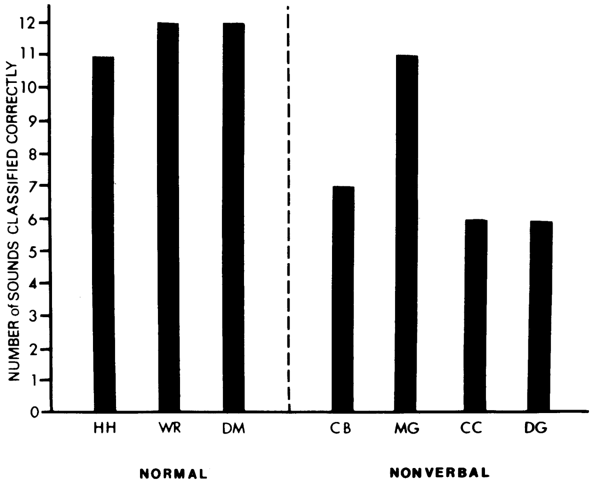


FIG. 2. Total number of human and dog sounds correctly classified by normal 5-year-olds and mentally retarded subjects in a replication of Test I. Note the uniformly high level of performance of the normal children, demonstrating the adequacy of both the sounds themselves and the procedure to test for their perception. Subject MG, who showed improvement on this test (cf Figs. 2 and 3), was unable to maintain this level of performance on subsequent tests.

et al., 1965). The dysarthric, whose performance was perfect in the original test, was not tested on the replication.

Three normal 5 year olds were run through the test at this point in order to verify the meaningfulness of the tape-recorded stimuli and the applicability of the procedure. As a group, their performance was nearly perfect, indicating that meaning could be extracted from the sound stimuli and that categorization could be displayed with this procedure.

One possible contribution to the difficulty experienced by the nonverbal children in Test I was the use of abstract symbols on the response panels. A less abstract visual cue closer to that normally accompanying sounds in the environment, such as a photograph of the source, might make it easier for the nonverbal subjects to associate the sounds with their source. Indeed, using photographs of sources has in the past improved recognition in patients with agnosia (Stein & Curry, 1968). Test II was designed to test this hypothesis.

### *Test II: Categorization of Sounds Using Photographs of the Source*

The purpose of this experiment was to determine whether the addition of a visual representation of the sound categories would improve the performance of the nonverbal subjects. To accomplish this, the abstract geometric symbols on the response panels in Test I were replaced by photographs of dogs and of people. The subjects were trained and tested as in the replication of Test I.

As a group, the nonverbal children did not improve on this test (see Fig. 3). However, in each case, concurrent performance on the training stimuli remained above criterion. CB generalized appropriately to all dog sounds but only to 2 of the 5 human sounds. MG responded appropriately to only 1 of the 10 test stimuli. CC showed improvement by responding above chance to 7 out of 10 stimuli. DG responded randomly to all test stimuli. Thus, nonverbal children were still unable to respond to sounds on the basis of their source as well as did the dysarthic retarded child even when the new response target was a picture of the sound source.

Because Tests I and II demonstrated a difference between the nonverbal and dysarthric subjects on a test designed to detect auditory agnosia, additional tests were given in an attempt to further define the difficulties encountered by the nonverbal children. We suspected that if the subjects were suffering from an auditory agnosia, they should nevertheless be able to memorize the correct response to each of the different sounds if their hearing were adequate and if the sounds were discriminable to a retarded population. Thus, Experiment III was designed to answer the question: Can the child discriminate the sounds well enough to *learn* the correct response to each?

### *Test III: Discrimination of Test Sounds*

Each nonverbal subject was trained, using random presentation of all of the sounds in each session, to identify each of the human and dog vocalizations with the appropriate geometric symbol until 19 out of 20 presentations

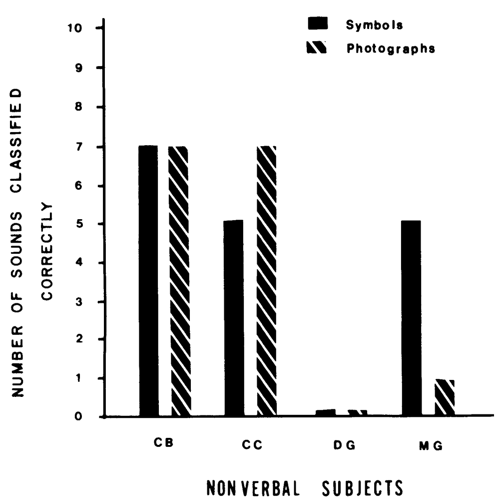


FIG. 3. Effect of placing a visual representation of the sound source on the response panels. Photographs of a group of dogs and a group of people were used. Performance of only one of the retarded nonverbal children improved slightly over his performance when abstract geometric symbols were the only visual cues on the response panels.

were responded to correctly for all 32 stimuli. All of the subjects reached criterion on this task, requiring no more than 12 training sessions to do so. This result indicates that the hearing of each child was adequate to allow him to distinguish between the sounds and that none lacked the motivation to do so. Furthermore, it demonstrates that the sound reproduction was of such quality that all of the sounds were distinguishable.

This result suggests that the children were successful in associating each particular sound with one of the two symbols in a learning situation when feedback was provided continuously. This is compared to the situation in which they had been unsuccessful in associating the sounds with the symbols when similarity of sound source was the only cue.

There are several possible explanations for the poor performance of the nonverbal subjects on Tests I and II as contrasted with their success in Test III. It may have been due to an inability to associate meaningful sounds with meaningful visual stimuli in a cross-modal association (Geschwind, 1970) or to an inability to perceive the photographs as meaningful. We also had to consider the possibility that these children cannot generalize consistently at all. To investigate these possibilities, we attempted to make the task even easier by using sounds and sources with which the subjects were known to be very familiar—that is, two people with whom they had daily friendly contact. Thus, Test IV was designed to test again the ability of the nonverbal children to generalize sounds using the present method. The task involved responding to familiar voices by touching a picture of the individual owner of the voice.

### *Test IV: Categorization of Sounds from Very Familiar Sources*

The results of the previous tests have shown that some nonverbal children do indeed have difficulty responding to natural sounds on the basis of their source when the source is a group of individuals. However, the possibility remained that the difficulty was not truly one of recognition but simply an inability to perform well on this specific generalization task using classes of natural sound sources. To explore this possibility, a set of stimuli was composed to conform to two specifications: First, the stimuli were complex natural sounds; second, they were emitted by single, *specific* familiar sources (adults with whom the children had daily friendly contact) rather than two *groups* of sources. Our reasoning was that if the children could successfully categorize the sounds from this less abstract source, it could be assumed that the nature of the stimulus sources and not the structure of the previous generalization tests themselves had caused the failures. The new stimuli (Table 3) consisted of sentences spoken by two individuals: a man and a woman. These stimuli were similar to the human vocalizations from different individuals which the nonverbal children were unable to categorize in the earlier experiments.

Two of the nonverbal children, CB and CC, were tested. (Subjects MG

TABLE 3

AUDITORY STIMULI USED IN TEST IV

| Male voice | Female voice |
|---|---|
| M1 "Touch my picture" | F1 "Touch my picture" |
| M2 "Hi, Caroline" | F2 "Hi, Caroline" |
| M3 "It's cold outside" | F3 "It's cold outside" |
| M4 "Do you like toys?" | F4 "Do you like toys?" |

and DG had been withdrawn for reasons unrelated to these experiments.) They were trained using only one example of each class and tested for generalization to three new examples of each class. Photographs of the speakers were placed on the response windows as visual cues. CB learned the response in one session and immediately generalized without error to each of the examples. CC also generalized to all of the untrained examples. Later, geometric symbols were placed on the response panels and the children again performed without errors.

In this condition, the two subjects who were available for testing performed better than on the previous tasks in which the sound sources were members of a familiar class but not single familiar individuals. It is possible that the meaning or source of these sounds was understood due to the strong familiarity of the two speakers to the children. However, it is also possible that the children were generalizing on the basis of physical cues, i.e., spectral differences between the male and the female voices. Nevertheless, regardless of how the children solved the problem, by relying on an overlearned correspondence between speaker and voice or by relying on physical cues, the point remains that they were capable of generalizing some stimuli in the present experimental conditions even when geometric symbols were the response cues. Thus, it is unlikely that their failures on the previous tests could be attributed to a peculiar inability to generalize in this experimental situation.

### *Test V: Categorization of Visual Stimuli*

To gain insight into the extent of the inability of the nonverbal children to respond to novel auditory stimuli on the basis of their meaning, a visual generalization experiment was conducted with two of the subjects. This experiment took advantage of the subject's past histories. They had been participants in a visual language training program (CB twice daily for 14 months, MG twice daily for 9 months) in which the shapes of symbols had been used to represent words by pairing them with drawings of objects and actions (Carrier, 1974). As part of this language training program, the children had learned symbols for 10 common nouns (i.e., cat, man, lady, baby, boy, girl, cow, horse, dog, bird). We wished to determine whether they had learned the concepts behind the noun drawings or, alternatively, had learned only to pair the symbol with what may have been to them meaningless lines instead of representational drawings. To do this, the original trainer presented the children with five different large color photographs as well as the originally trained drawings of each of the objects and allowed them to pick the appropriate symbol from among all 10 symbols placed before them. The child was rewarded each time he responded to the presentation of a photograph or drawing by choosing the symbol that he or she had learned previously. The test was administered twice to each child on two different days.

Their performance on this task was similar to that expected of patients with visual agnosia. MG responded throughout at a chance level (18%) to the photographs, indicating that for him there was no similarity between the drawings and the photographs of similar objects. CB, although correct above the chance level, peformed at only 65% correct—far below that expected from normal subjects. In contrast to the generally poor performance on the photographs, their performances on the drawings (the original training stimuli) were 100% (CB) and 80% (MG).

These results suggest that the categorization deficit of these two subjects was not limited to the auditory system. Instead, it appears to be a more general inability to respond to the meaning of stimuli. This may have contributed to their lack of dramatic improvement in Test II, in which photographs were used as visual cues to the category of sounds. If the photographs were meaningless, they would have provided little aid in recognition. It will be remembered that CB showed some improvement in Test II corresponding to her moderate success in visual categorization, whereas MG showed no improvement in Test II corresponding to his chance performance in visual categorization.

The performance of the dysarthric child in the same visual language program contrasts sharply with that of CB and MG. He was able, using the visual symbols, to acquire facility in reading and writing standard English and eventually used the symbols to generate novel sentences in two-person communications.

### *18-Month Follow-up*

We are fortunate to have available data on the progress made by three of the subjects in this study while receiving 18 months of continuing language training in addition to more than 1 year of training received before this study was completed. CB has gained a receptive and expressive reading vocabulary of nine words. She has learned the manual signs for 20 words although she uses them only with prompts. Her vocal repertoire has not changed and she has not improved in her ability to initiate meaningful communication even with the written words and signs she has learned. MG was dropped from the symbol communication program for lack of progress and because he appeared willing to make attempts at vocal imitation. He has since acquired single-word labels for four nouns and four verbs. His accuracy for the use of these labels for drawings is 90% and his accuracy of sound production is poor. He has acquired the manual signs for a dozen words. He does not spontaneously produce the signs or words. The dysarthric child, FH, completed the symbol communication program and spontaneously began using the symbols to communicate with the trainer. He went on to acquire a printing and reading vocabulary which he also used to initiate requests.

## DISCUSSION

These experiments were designed as an inquiry into the communication disorders of nonverbal mentally retarded adolescents. Because hearing sensitivity in all of our subjects was known to have been adequate for normal development of language, we concentrated on investigating higher-order auditory capacities. The first two experiments required the subject to ignore gross differences between sounds and instead respond to the sounds on the basis of the properties they had in common—in this case, properties of the sound source—rather than the physical properties of the sound itself. The tests required the children to respond differently to "dog" and "human" sounds. That is, the child was required to "categorize" the sound *sources* into two classes (regardless of the overall intensity or spectra of the actual sounds). This task requires auditory capacities beyond sensory analysis. While the dysarthric subject was able to perform this task with ease, the nonverbal subjects performed poorly. This result from the first two tests suggests that retarded children who fail to develop language may do so due, at least in part, to an underlying agnosia affecting one or more sensory systems.

Results of the third test indicate that the nonverbal children were eventually able to respond correctly to all of the examples of sounds in the two classes. They thereby demonstrated that they could hear the sounds and discriminate between them. Thus, partial hearing loss, although present in some of the subjects, could not be considered as the primary reason for failure in the tests of auditory categorization. This test also ruled out motivational and sound reproduction factors as the cause of poor performance.

On the other hand, when the sources of the two sound classes were individuals who had daily interactions with the children, the two nonverbal children tested improved in their ability to respond correctly even to novel examples of the two sound categories. This result demonstrated that the children were able to categorize some sounds. It is possible that these subjects are unable to classify sounds on the basis of their source alone when that source is a *group* of similar individuals. They were successful finally when the source was a *single* familiar individual. These results suggest difficulty graded on degree of complexity of the source. When the source was a group of similar individuals the performances were worst. When the source itself was specific (a single individual), performances improved.

Some retarded nonverbal children, therefore, show symptoms that would be expected in persons born with agnosia affecting at least the auditory system. This is in contrast to the results of the dysarthric child who had no difficulty with the sound classification task. From these results it has been concluded that, in this group of nonverbal retarded children, the communication deficit is not restricted to language but also involves other kinds of auditory function as well. More important, the symptoms of agnosia were evident in the visual functioning of the two children tested in that modality, demonstrating that the deficit for these children was not limited to the auditory system. Thus, this group of nonverbal retarded children seems to be suffering from a *general agnosia* or a general inability to respond to stimuli on the basis of their meaning. The disorder appears to be at a level common to at least two sensory modalities in two of the children.

At this point, a word should be said concerning the inclusion of mentally retarded subjects in a study involving failure to develop language in childhood. In the past, most studies of nonverbal or aphasic children have carefully ruled out mental subnormality as a cause for failure to speak or develop language (e.g., Benton, 1964; Eisenson, 1968; Landau, Goldstein, & Kleffner, 1960; Stein & Curry, 1968); however, a few authors do consider the mentally retarded on the same continuum as normal children (e.g., Wortis, 1962). When viewed as neurologic cases, it appears possible that many retarded children may fail to develop language for the same reasons as do otherwise normal children who are called developmentally aphasic. That is, they suffer early brain damage or congenital neurologic defect. The normal children whose only disabilities are linguistic have suffered brain damage that is more likely restricted. The mentally retarded children have apparently suffered insults that have disrupted more basic functions that underlie many abilities, only one of which is language. The results of the present work support this approach by suggesting that the picture of auditory agnosia in a group of nonverbal retardates is substantially similar to that seen in adult stroke patients, but that the agnosia is not necessarily limited to the auditory modality. Indeed, some cases seem to show a general agnosia or inability to attribute meaning to stimuli while retaining the ability to respond to specific stimuli in a specific way.

For training purposes, it would be expected that nonauditory training routes for language would be more successful if the language deficit were restricted to the auditory modality. Indeed, such appeared to be the case when these subjects were followed in their communication training programs. CB was more successful in visual recognition than MG and has gained more language skills while in the same training program with the same therapist. Perhaps much earlier training using manual signs would have been more successful for some of the children whose ability to recognize meaning is greater for visual stimuli.

The results of these experiments suggest that, in order to tell the therapist exactly what abilities remain as a basis for building language, an evaluation of nonverbal retarded children should include some inquiry into their ability to respond to the *meaning* of stimuli as well as their ability to respond to the *physical presence* of stimuli. Such testing should first be carried out in the auditory modality. If auditory abilities seem limited, alternative sensory modalities that might be candidates for language training should also be assessed for their capacity to perform language-like functions before using them as a foundation for language training. In addition, the results of these tests suggest that children with a limited ability to respond to meaning will be more successful if training is kept on a concrete level. The children are better equipped for responding to specifics than to generalities and training will be less frustrating for the patient if he is introduced to abstractions after he has mastered a large number of specifics.

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