

Sequence Learning in Aphasic and Deaf Children

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Investigators in the area of language and language disability have usually emphasized the aspect of language associated with meaning, grammatical structure, and word frequency. The purely perceptual or discriminatory aspect peculiar to language has, however, been generally neglected. Yet it stands to reason that from a developmental viewpoint, mastery of language presupposes the ability to discriminate one sound pattern from another. These sound sequences have temporal and combinative characteristics. They occur within time in temporal succession and they are made up of a limited number of discriminable elements (phonemes), presented in various sequential combinations or rather permutations. For instance, the following three words: "pæt," "tæp," "æpt," are all composed of the three phonemes [æ], [p], [t], yet in each word these same three phonemes are heard in a different sequence. It should be obvious that it is easier perceptually to distinguish two patterns made up of elements that have nothing in common like "LOD" and "ZIM," in contrast to two patterns

composed of different sequences of identical elements, e.g. "MIZ" and "ZIM." Note that the quoted examples have nothing to do with symbolic relation or conceptual meaning. Language learning thus presupposes at least an implicit mastery of distinguishing sound sequences on a perceptual or auditory level, a mastery which is made difficult by the great number of permutations of identical elements. This characteristic which is referred to here as "combinative," as well as the temporal characteristic may be unique to auditory as compared with visual perception and suggested to writers like Lashley (1951, pp. 112-136) and Broadbent (1958, p. 46) a rather unusual hypothesis with respect to man's capacity for language. This hypothesis states that animals fail to acquire language mainly because they cannot organize and master sequences of combinative information and not because of an intrinsic connection between language and conceptualization.

This theoretical framework supports a new approach to investigation of language deficiency. Although the term *aphasia* was first coined in connection with loss of language behavior due to brain injury in a person who pre-morbidly knew language, it is now common to diagnose children as aphasic even though they never developed verbal behavior. The primary cause for the

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language deficiency of such children is not attributed to lack of intelligence, of emotional adjustment, or of hearing (Monsees, 1957; West, 1962, pp. 16-35). A definite diagnosis of aphasia is a matter of considerable concern and differing opinions, since hearing loss may be associated with aphasia. At this stage of knowledge a clinician's or teacher's judgment of the child's total language behavior over a prolonged period is often the basis for distinguishing an aphasic from a deaf child. Goldstein *et al.* (1960, pp. 756-758), found in a carefully controlled study that no single medical or psychological test reliably differentiated aphasic from deaf children.

To investigate sequence learning in connection with early language deficiency would thus seem to be of great theoretical and practical consequence. Without speculating on the organic cause of aphasia, Monsees (1957, 1961) has stated the theoretical proposition that language deficiency in aphasic children may be correlated with a deficiency in the receptive learning of sequences. Following this lead, the present study compared visual learning of sequences in aphasic children with that of deaf and hearing controls.

The visual mode of presentation was here chosen as one more easily grasped by aphasic and deaf subjects. Moreover, Hirsh's research (1961) has established that the threshold for perception of a sequence is of remarkably similar duration regardless of sensory modality. If the organization of incoming sequential information is apparently little affected by the sense modality of input it may take place at a more central neurological level than any one specific sense system.

A paired-associate procedure was employed which consists in training a subject, by repeated trials and corrections, to make specific responses to two or more stimuli presented to him. By observing correct responses for a certain number of times the experimenter can infer that the subject has successfully associated a specific stimulus with a specific response and that he has learned to distinguish one stimulus from another. A paired-associate procedure was judged to simulate more closely the kind of learning that may take place in language learning than an immediate memory procedure in which the subject merely has to give back the stimulus presented to him. A typical immediate memory task is the familiar Digit Span Test.

In connection with sequence learning each "stimulus" of the paired-associates test would be a particular sequence, composed of at least two elements, in contrast to an ordinary or discrete paired-associate task where the stimulus to be responded to is distinct and not combined. The following is a paradigm of paired-associate learning of four associations to four stimuli where the letters stand for stimulus elements, the numbers stand for responses, and the arrows for associations to be learned. First a discrete paired-associate task; $A \rightarrow 1, B \rightarrow 2, C \rightarrow 3, D \rightarrow 4$; secondly, a sequence paired-associate task; $AC \rightarrow 1, BD \rightarrow 2, AD \rightarrow 3, BC \rightarrow 4$.

It should be noted that the sequence task was designed so as to assure that the correct response was to the sequence *per se* and not to one possible discrete aspect of the stimulus situation. If the letters A and B stand for discrete stimulus elements, a differential response to the sequence AB in contrast

to the sequence BA would not suffice to infer sequence learning. The peculiar confusing aspect of a sequence due to permutations of the same units would be missing and the response could simply be to the first element of the two sequences.

Two kinds of sequence tasks were employed, one in which the sequence of stimuli was presented successively, another in which the stimuli making up a specific sequence were shown simultaneously in a specific spatial position. Performance on a discrete paired-associate task provided the basis of equating groups on a simple, non-sequence type of visual memory. It was expected that this study would shed light on the following questions: (1) Is childhood aphasia associated with deficiency in sequence learning such that it becomes manifest in the visual modality? (2) Does this deficiency appear equally on successive and simultaneous sequence? (3) Does sequence learning differentiate deaf from aphasic children?

Method

General Methodology. As the number of available experimental subjects was limited and spread over an age range from 5-6 to 13-7, it seemed advisable first to collect normative information on sequence learning. Sixty-four boys and girls—of two age groups, (seven and ten), and of two intelligence levels, (60-85 and 15-40 percentile of the Lorge-Thorndike Verbal Scale), from a public grade school in Prince Georges County, Maryland—provided control data on performance on the sequence tasks as related to age, intelligence, sex, order effect, and a discrete

paired-associates task. Inspection of these data showed that intelligence at the ten-year-level only was a discriminating variable while sex and order had no significant effect. The lack of difference between the high- and low-intelligence groups at age seven seemed to be due to the fact that the task in general was too difficult for this age group. Hence, it was decided to concentrate on the older group, select the older subjects from the available aphasic children and match them with control subjects on the basis of performance on discrete paired associates.

Subjects. The aphasic group consisted of ten children enrolled at the Hearing and Speech School of the Children's Hospital of the District of Columbia. There were six boys and four girls ranging in age from 9-1 to 13-7, with a mean age of 10-6. All subjects were diagnosed as sensory aphasic by competent audiologists and all suffered from severe language deficiency.

The criteria for diagnosis are outlined in greater detail by Monsees (1957 and 1961). No child had learned to comprehend language before coming to school or was seriously emotionally disturbed. Data on possible hearing loss were quite inconsistent and even where a moderate loss in sensitivity appeared rather certain, the reaction of the child to a hearing aid and to the teaching process was atypical and indicative of some language difficulty over and above the loss in sensitivity.

It should be of interest to sketch the pattern of their performance on the five performance subtests of the Wechsler Intelligence Scale for Children. With one exception, the lowest score for each aphasic child was on Picture Arrangement, a task which in-

volves meaningful understanding of a temporal sequence. They also scored relatively low on the speed-test of Coding. On Block Design, however, a test commonly called sensitive to perceptual deficiency, their mean score was above average. On the remaining two subtests their mean score was average. The mean performance IQ for the total group was 100.7. Such findings seem to discredit the notion that aphasic children suffer from a general deficiency in areas of perception and learning as a concomitant of some cerebral dysfunction.

From the pool of 32 hearing children aged ten to ten and-a-half years and tested for normative purposes, ten were selected as hearing controls on the basis of sex, IQ, and score on the discrete paired-associates task.

Finally, to obtain a deaf control group, the three learning tasks were given to all deaf children aged ten, enrolled at the Virginia School for the Deaf and Blind. From this group of 17, ten children were selected on the basis of their scores on the discrete paired-associates task.

Material. To minimize difference in language experience, stimuli of the three paired-associate tasks were nonsense figures drawn with black ink on 3" x 4" white cards. The figures were copied from Vanderplas and Garvin (1959) and are identified by figure and number as listed in procedure. Figure 1 illustrates the kind of figure presented during the tasks.

Procedure. Three paired-associate tasks were given to each subject on an individual basis: Discrete Paired Associates (DPA), Simultaneous Sequence (SIM), and Successive Sequence

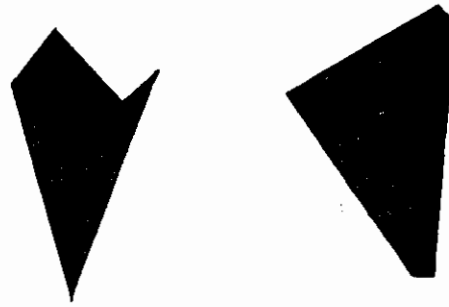


Figure 1. Sample of nonsense figures presented in paired associate tasks.

(SUC). Testing was done in a private room, free from unnecessary distraction. The child sat across the table from experimenter who presented the stimuli manually, one at a time. Verbalization was kept to a minimum.

For DPA a board 15" x 3" on which were painted six circles one and one-half inches in diameter was placed on the table before the child. The circles from left to right were colored red, yellow, grey, blue, orange, green. The experimenter showed the child the first nonsense figure (figures 2-5) and said or gestured that "this (pointing to the figure) goes with this (pointing to the first circle)." Subsequently he showed five more figures (figures 4-30, 4-28, 4-27, 3-30, 3-29), each time pointing out the connection between one specific figure and one color. After the initial presentation each subject had 36 trials of observing one figure and pointing to the colored circle initially associated with it. A right response met with approval and a wrong response was corrected by the experimenter. Each figure was shown six times, preceded and followed by figures different from a previous presentation.

The sequence task in this experiment consisted of four figures designated as

A, B, C, and D, corresponding to Vanderplas' figures 3-25, 4-23, 3-10, 4-6 for SIM and figures 3-17, 4-14, 3-12, 4-4 for SUC. Response consisted in pointing to one of four cards with the numbers 1, 2, 3, or 4 written on them. The paradigm for the sequence task was AC → 1, BD → 2, AD → 3, BC → 4. For SIM, four stimulus cards 6" x 4" were used on which were drawn two stimulus elements, e.g., for AC figure 3-25 was to the left of figure 3-10 (illustrated in Figure 1). The card was held before the subject until he responded. The four stimulus cards of SUC showed each one different figures and were presented in pairs of two. For example, for the sequence AC, figures 3-25 and 3-10 were shown consecutively for two seconds each with a one-second interval between. Thus SIM differed from SUC in that the two stimulus elements making up the sequence were simultaneously present in left-right position for SIM and were successively shown in before-after sequence for SUC.

After an introductory presentation of the four sequences each subject had a maximum of 100 corrected trials on the sequence task. For those subjects who made nine correct responses within ten consecutive trials, the task was discontinued. The order of sequences is

illustrated by the first ten trials: AD, BD, AC, BC, BD, AD, AC, BC, AD, AC. The performance on the three learning tasks was evaluated in terms of total errors within a maximum of 100 trials.

Results

Mean total errors on the three tasks separately and the two sequence tasks combined are summarized in Table 1. Scores on DPA were quite similar in the three groups as they formed the basis of selecting the controls. The difference in mean performance between SIM and SUC was evaluated for each group separately by means of *t*-tests for correlated means. The three *ts* were found to be less than one, showing that mean errors on the two sequence tasks were not reliably different for any of the groups.

In order to compare the three groups' mean sequence errors, nine *t* tests of mean differences between paired subjects were made. While deaf and hearing controls did not differ significantly from each other in any of the three comparisons, differences between the control and aphasic groups yielded *ts* of 2.16 and 1.84 for SIM and both sequences respectively. Such findings are significant only beyond the .10 level

TABLE 1. Mean and range of errors on paired associate.

Group	Discrete P.A. ¹	Sim. Sequ. ²	Succ. Sequ. ²	Both Sequ. ³
Aphasic	18.1 (5-25)	31.0 (10-67)	25.5 (2-65)	56.5 (17-132)
Deaf Control	21.7 (14-28)	23.7 (5-69)	17.6 (5-24)	41.3 (15-99)
Hearing Control	17.8 (4-24)	15.8 (1-51)	18.7 (1-38)	34.5 (2-77)

¹36 trials, 6 responses, chance error = 30.

²100 trials, 4 responses, chance error = 75.

³200 trials, 4 responses, chance error = 150.

of confidence. Differences between the aphasic and control groups on SUC as well as the three differences on mean sequence errors between the aphasic and deaf group yielded *ts* well below acceptable criteria of significance.

Discussion

Because it is difficult to obtain large homogeneous groups of aphasic children and the need for empirical research in this area is particularly great (West, 1962, pp. 70-80) it seemed justifiable to report these findings as a preliminary attempt at correlating a specific psychological performance with receptive language deficiency. The results are presented more as an example of a possibly fruitful psychological investigation than as a definitive answer to the three questions in the introduction. Although the average scores of the three groups differed in the expected direction there was much overlap among the groups. On the basis of these findings one cannot state that sequence deficiency has been demonstrated in aphasic children or that sequence performance differentiated aphasic and deaf children.

One clear result which emerged rather surprisingly in all three groups was the fact that successive sequence learning differed only little from simultaneous learning. One would have thought that the memory load would make the successive task more difficult than an analogous simultaneous task. For the aphasic group in particular a relatively poorer performance on SUC than on SIM would have provided evidence concerning the temporal factor in verbal behavior. If further results on successive and simultaneous

presentation in groups varying in age and ability are consistent with the present findings, they may give a clue to the process of temporal integration as outlined by Lashley (1951, pp. 112-136). As related to difficulty of sequence learning such a result would emphasize the combinative aspect of language learning over the temporal factor.

It should also be pointed out that the aphasic children were all in attendance at a school for a number of years which gives them special training in successive sequence learning according to the Association Method of teaching aphasic children (McGinnis, 1956). It may be that at an earlier age or in the absence of such training more striking differences between aphasic and control groups would be forthcoming. Moreover, the length of the sequences in this task was a minimum of two elements. If the sequences were lengthened (e.g., to four elements: ABAA, AABA, etc.) or the successive presentation was accelerated, differences, contrary to present findings, between successive and simultaneous presentation may emerge and affect the various groups differentially.

Summary

In order to investigate a hypothesized association between language and sequence learning, ten sensory aphasic children were paired with ten hearing and ten deaf controls on age, sex, IQ, and performance on a nonsequential visual memory task. Results, while in the expected direction, were not conclusive and more research is suggested to explore the hypothesis further.

Similar scores on the successive and simultaneous sequence tasks indicated that the hypothesized difficulty of language learning is related to the combi-native rather than the temporal aspect involved in perceptual sequence learning.

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COMING SOON

Lloyd Price and Oliver Wever will describe a "Modified Instrument for Pure-Tone Delayed Auditory Feedback." In this paper "A simplified procedure for instrumentation of pure-tone DAF with key tapping is described. This system incorporates two monostable multi-vibrators and a regulated power supply, the plans of which are presented and discussed. The advantages of such a system are simplicity and cost; a possible disadvantage is that information related to tapping pressure is lost."

Joanne Subtelny, Jorge Mestre, and J. Daniel Subtelny will present a "Comparative Study of Normal and Defective Articulation of /s/ as Related to Malocclusion and Deglutition." The purpose of the study, according to these authors, was "to define variation in articulation of /s/ occurring as a function of differences in skeleto-dental morphology. Articulatory relationships defined by cephalometric roentgenography, were studied in normal speakers with normal occlusion and in normal and defective speakers with severe malocclusions. . . ."