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Sequences of Phonemic Approximations in Aphasia

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The trends of sequences of phonemic approximations to a single target were studied in three types of aphasia (Broca's, conduction, and Wernicke's), as gathered in five tasks (spontaneous speech, repetition of meaningful words, repetition of nonsense words, reading aloud, and automatized sequences). A phonemic *error ratio* was defined in order to quantify the distance between each approximation of a given sequence and its target. The results of a computer analysis based on this ratio were analyzed according to three parameters. A study of three *types of patients* revealed that conduction aphasics exhibited the most regular trend toward the target in sequences of phonemic approximations; the analysis of the various *tasks* indicated that sequences produced in repetition by conduction aphasics form an exception to the regularity of this trend, and an examination of the various *lengths of sequences* indicated that longer sequences showed a less decisive trend toward the target than shorter sequences. The discussion bears on some theoretical aspects of the phonological production mechanism and its control: *the initial strength* and *permanence of the internal representation of the target* emerge as important factors required for the good functioning of this mechanism.

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Among the signs of aphasia, phonemic paraphasias may be the most extensively studied. The great majority of these studies (e.g., Fry, 1959; Poncet, Degos, Deloche, & Lecours, 1972; Blumstein, 1973; Keller, 1978) endeavor a linguistic analysis of *each* phonemic paraphasia by comparing it to an assumed target which may be based on an external stimulus (reading or repetition), or which may be internal (spontaneous speech). Such deviations have thus been defined as the addition, deletion, displacement, or substitution of a phoneme. This "static" approach to the analysis of phonemic paraphasias may not capture all the information usually taken into account in the clinical observation of patients who show such paraphasias in their symptomatology (mostly conduction aphasics, but also to some degree Broca's and Wernicke's aphasics). Such observation suggests that phonemic paraphasias not only show nonrandom relations to assumed targets (Alajouanine, Ombredane, & Durand, 1939; Lecours & Lhermitte, 1969; Dubois, Hécaen, Angelergues, Maufras du Chatelier, & Marcie, 1964), but also that they demonstrate *regular tendencies* over the course of a whole sequence of *successive* attempts at a *single* target. Figure 1 shows such a sequence containing four attempts to pronounce the word "crayon" [krɛjɔ̃] 'pencil.' Each of the attempts at a correct verbalization of the word [krɛjɔ̃] is considered to be a phonemic *approximation* to the target, and the entire succession of approximations may be called a *sequence of phonemic approximations* (SPA), a term somewhat similar to the French term *"conduites d'approche phonémiques."*

A preliminary examination of the trend exhibited by the phonemic substitutions in the course of such sequences convinced us that this behavior was of interest to the study of aphasic patients' control over their own sound production. For instance, in the example of Fig. 1, the patient first produced three incorrect vowels [a], [ə], and [e] before he finally selected the target vowel [ɛ] of [krɛjɔ̃], thus probably showing a progressively more accurate succession of phonemic approximations to the target. This preliminary examination led us to the main question of this paper: is there usually a progression toward the target over the succession of phonemic approximations? If on the average there is no evident progression, that is, if phonemic approximations show *no particular* trend either toward or away from the target, one would not be able to

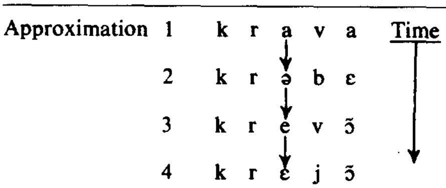

FIG. 1. A sequence of phonemic approximations to the word "crayon" [krɛjɔ̃] 'pencil.'

draw *specific* inferences concerning the functioning of an aphasic's control over his phonological output mechanism. On the other hand, if a general progression toward the target can be documented, one may infer that the patient can detect an error, and can induce the production of a closer approximation. This would also imply that the internal representation of the phonological target is adequately preserved to permit comparison with produced utterance elements.

METHOD

Patients and Corpus

The corpus of this study was gathered from the clinical recordings of the aphasia tests of 16 French-speaking aphasic patients. Each patient was given our aphasia battery[1] which tests the main aspects of the four modalities of language use (oral and written expression, as well as oral and written comprehension); for the purpose of this study, attention was focused on the following aspects of oral expression: spontaneous speech, repetition of meaningful words, repetition of nonsense words, naming, automatized sequences, and reading aloud.

The aphasic patients we distinguished in this study were of three types, defined here with reference to Lecours (1975).

Broca's aphasics. Patients with nonfluent oral expression, marked by the presence of arthric disturbances, but showing a reasonably preserved comprehension. These patients present phonemic as well as phonetic deviations (phonetic deviations are distortions which do not imply a change in the distinctive nature of the segment or phoneme involved).

Conduction aphasics. Patients with fluent oral expression, a marked deficit of repetition, but also showing a reasonably preserved comprehension. These patients show numerous phonemic paraphasias in their oral expression, but lack phonetic deviations.

Wernicke's aphasics. Patients with fluent oral expression, but with a considerable comprehension deficit. These patients may present deviations of all types, except for phonetic distortions. From this type of aphasia, only patients who showed a reasonably high incidence of sequences of phonemic approximations were included in the study.

Our patients' etiology showed a predominance of left-hemispheric cerebrovascular accidents (13 out of 16); one patient (a conduction aphasic) had a post-traumatic left subdural hematoma, one (a Broca's aphasic) had bihemispheric metastases of hepatic origin, and one (a conduction aphasic) had a left-hemispheric focalized infectious disease.

Figure 2 summarizes our corpus with respect to types of patients and tasks. We gathered a total of 800 sequences of phonemic approximations; the great majority of these (72%) was produced by eight conduction aphasics. Five Broca's and three Wernicke's aphasics each provided 14% of the remaining data. The greater part of these sequences (84.5%) was produced in the three tasks of spontaneous speech, repetition of meaningful words, and reading aloud. Since the patients contributed unequal numbers of sequences to each task, the numbers appearing in this figure are only descriptive, and thus do not permit comparisons between types of patients or tasks.

Transcription, Feature System, and Analysis

All sequences of phonemic approximations appearing in this study were gathered according to preestablished criteria which were as follows: first, the *target* had to be *clearly*

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	Broca's (*N* = 5)	Conduction (*N* = 8)	Wernicke's (*N* = 3)	Total
Spontaneous speech	16	140	24	180
Repetition of meaningful words	36	234	20	290
Repetition of nonsense words	15	51	6	72
Naming	2	3	21	26
Reading aloud	41	130	35	206
Automatized sequences	3	20	3	26
Total	113 (14%)	578 (72%)	109 (14%)	800

FIG. 2. Distribution of sequences gathered in this study.

identifiable to the interviewer or the transcriber; second, sequences had to consist of *two or more phonemic approximations to a single target*.

Each segment of speech containing such sequences, along with the sentence in which they were embedded, was transcribed by experienced listeners, using International Phonetic Alphabet (IPA) symbols. The sounds distinguished in this study included 17 consonants ([p, b, m, t, d, n, k, g, ɲ, s, z, ʃ, ʒ, r, l, f, v]), 16 vowels ([i, e, ɛ, a, y, ø, œ, u, o, ɔ, ɑ, ɛ̃, œ̃, ɔ̃, ɑ̃, ə]), and three semiconsonants ([j, w, ɥ]). The passages were noted in a broad, systematic phonetic transcription (Ladefoged, 1971), and were checked by the first author.

All transcriptions of sequences and corresponding targets were stored in computer memory (DEC-10), along with information on linguistic and nonlinguistic events occurring before, after, or between the approximations to a given sequence. Some of this further information is to be used in another study, and is thus not discussed here.

A computer analysis was developed to study the proximity to the target of each phonemic substitution appearing in every approximation. This analysis was based on a feature system which attempted to capture, as much as possible, the *articulatory distinctions* made in French as spoken in Québec. The point of issue for our definitions of these distinctions was the feature systems of Ladefoged (1975) and Lecours and Lhermitte (1969), and to a lesser degree, of Chomsky and Halle (1968). We decided to slightly modify their feature systems, for two main reasons: on the one hand, since aphasia appears to affect phonological production much more than phonological perception (Blumstein, Baker, & Goodglass, 1977; Keller, Rothenberger, & Goepfert, in preparation), it seemed important to define features primarily in articulatory terms, while Ladefoged's definitions for prime features (1975, pp. 257–258) were for a good part defined in acoustic terms. Second, we were more conservative in using multivalued features than Ladefoged was, in that we broke the feature [Place] into four binary features instead of treating it as a single four-valued feature. This decision was due to a reluctance to count an error such as [p] → [k] as an error of distance three, while counting the error [p] → [t] as an error of distance one. Until such time as we have empirical data to assert that in the aphasic's phonological space [k] is indeed three times as "distant" from [p] as [t] is, using binary features seems to us to represent a safer course of action. But since it has been shown that with respect to vowels at least some aphasics do tend to show behavior that supports the notion of multivalued features (Keller, 1978), two multivalued vowel features [Height, four values] and [Back, three values] were included in our system. Our modified system thus incorporates recent research findings from aphasic phonology; at the same time, this pragmatic and provisional system is not meant to make any theoretical claims for phonology in general.

Based on this feature system, a computer analysis was devised to quantify the "phonemic distance" between each approximation in a sequence and its target; this analysis required the definition of a "*phonemic error ratio,*" involving two quantitative manipulations. The first manipulation derived a *sum* of absolute differences between target and error for each feature value of each segment in a given approximation. In the case of binary features, this was the sum of all gains and losses of its value; in the case of multivalued features, it was the absolute sum of substitution distances. Only substitutions were analyzed in this manner, and omissions and additions were left out.

As an example, the (made up) approximation [teri] for the target [pari] "Paris" contains two segmental errors [p] → [t] and [a] → [e]. The first segmental error would have been analyzed for all consonantal features, each of which is binary. Two feature changes would have been registered, [−Dento-alveolar] → [+Dento-alveolar] and [+Labial] → [−Labial]. The error [a]→[e] would have involved a feature change of distance two along the multivalued feature [Height], and would thus have been registered as two values added under the feature [Height]. Notice that since this analysis is based on fully specified feature matrices, errors involving redundant features as well as those involving nonredundant features were registered in this manner (cf. discussion by Lecours & Caplan, 1975).

The second manipulation involved a *standardization* of the values obtained from the first manipulation in order to render approximations from different tasks, patients, types of aphasia, and place within a sequence comparable to each other. Thus substitution totals obtained from the first manipulation, occurring in a particular place within a sequence, were divided by the total number of vowels or consonants, whether correct or erroneous, occurring in the same place in the approximation. Ratios were derived for individual patients on individual tasks, separately for vowels and consonants, and for each feature individually. The summary ratios to be reported below were computed on the basis of these ratios.

RESULTS

There were on the average 4.7 approximations per sequence of approximations for a single target (range 2–20). Mean error ratios were computed by taking the last approximation of each sequence as point of reference; in this way, mean error ratios were calculated for substitutions occurring in the last, the second last, third last, etc., approximation of a given group of sequences.

Groups of sequences were gathered for calculation of mean error ratio according to three different parameters: type of aphasia, task, and number of approximations per sequence. The three parameters will be discussed separately.

(1) Types of Aphasia

The first part of this study involved grouping the 800 sequences of phonemic approximations of our corpus according to the three types of aphasia defined above. As reported in Fig. 2, our five Broca's aphasics produced 113 sequences, eight conduction aphasics gave us 578 sequences, and the remaining 109 sequences were produced by three Wernicke's aphasics. Mean error ratios were calculated for the last four approximations, separately for each aphasic group (Fig. 3).

On the whole, conduction aphasics show a continuous progression toward the target, both for vowels and for consonants; they end on the average on a low error ratio (i.e., near the target) in the *last* approximation in the sequence (position 1, Fig. 3). Broca's aphasics show the same

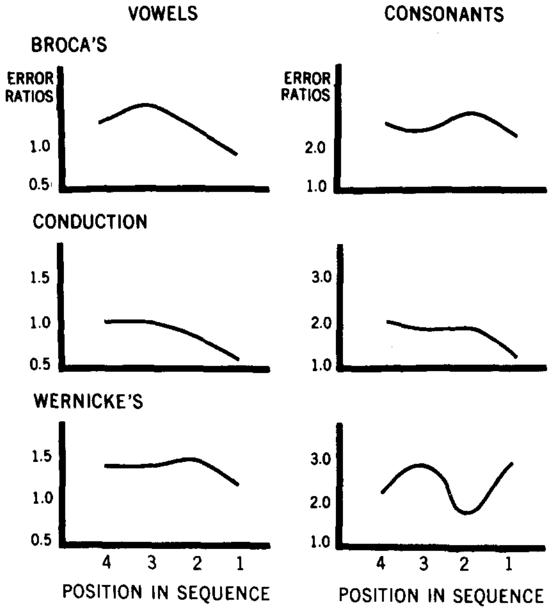

FIG. 3. Trends of mean error ratios for sequences of phonemic approximations of all lengths and from all tasks, separated according to type of aphasia. *Position 1* is the last position in the sequence. It is to be noted that absolute values of mean error ratios for vowels and consonants are not comparable (cf. also Figs. 4 and 5), since the number of features on which ratios are established differs from vowels to consonants. On the other hand, the *trends* of mean error ratios from the two types of sounds *are* comparable. The curves are based on the following average numbers of phonemes: Broca's, vowels: 155, consonants: 206; conduction, vowels: 839, consonants: 1143; Wernicke's, vowels: 157, consonants: 236.

progression for vowels, but at a greater distance from the target; on the other hand, their averaged sequences for consonants do not give the impression of a continuous progression toward the target. And in Wernicke's aphasia, neither consonant nor vowel ratios show a continuous progression toward the target; on the contrary, the consonants may even show a *negative* progression, i.e., a progression *away* from the target.

A *curve-fitting* analysis (Hewlett–Packard, 1976) appears to support these first impressions. This analysis tests the hypothesis that the trend of the mean error values fits a linear regression line over the course of a sequence, represented by the expression $y = a + bx$. Results indicate that trends of conduction aphasics for both vowel and consonant sequences fit a linear regression line at $p < .01$; this indicates that on the whole, ratios do seem to get closer to the target from one approximation to another. Broca's aphasics show this type of line only for vowels ($p < .05$); the consonant line does not significantly correlate with a linear regression. As for Wernicke's aphasics, curve fitting did not produce any significant results. However, nonsignificant correlations with linear regression were lower for consonants ($r = .14$) than for vowels ($r = .53$).

These results are not really surprising if some additional information is taken into consideration. First, we recall that Broca's and conduction aphasics evidence relatively good comprehension; this suggests that these patients maintain a relatively intact auditory feedback for their own production. Wernicke's aphasics, on the other hand, show a notable comprehension deficit which may in some manner interfere with the feedback mechanism.

The second piece of information relates to patients' persistence in engaging in self-correcting behavior. Clinically, the patients who show the most persistent self-correction behavior for phonemic errors are conduction aphasics, and to some degree Broca's aphasics; it is not infrequent to see such patients attempting a target 10 or more times. Wernicke's aphasics on the other hand do not show very persistent self-correction behavior, even though quite often a Wernicke's aphasia will evolve toward a conduction aphasia. This suggests that conduction aphasics and in all likelihood Broca's aphasics know what the correct phonemic form of the target ought to be, otherwise they would not be so persistent in making self-corrections. Wernicke's aphasics on the other hand may either not have as firm a phonemic target available to them as conduction and Broca's aphasics do, or their knowledge of what the phonemic target ought to be may decay over time.

The third piece of information relates to the results reported above. We noted that sequences for conduction aphasics and the vowels in the sequences of Broca's aphasics show a general progression toward the target. This means that in those conditions, the available target is sufficiently identifiable to permit a considerable reduction of the error distance over the course of phonemic approximations. This trend is not as clearly observable in the sequences of Wernicke's aphasics and in the consonants of the sequences of Broca's aphasics.

All of this suggests that conduction aphasics, and maybe Broca's aphasics, adequately feed back their own phonological productions, compare them to the original targets, and then induce, on the average, an improved approximation to the target. Furthermore, they suggest that the targets are adequately represented to permit these operations. Wernicke's aphasics, on the other hand, seem less able to perform this sequence of operations; one or more operations may thus be impaired, or the targets themselves may be so weak or degraded that these operations are no longer possible.

The dissociation between consonantal and vocalic trends that have been reported here are in agreement with documented evidence showing vowels to be better preserved than consonants in most types of aphasia (Trost & Canter, 1974; Shankweiler & Harris, 1966).

(2) Tasks

In the second part of this study, we focused our attention on the differences between the various tasks, as evident in the trends of averaged sequences. Specifically, we wondered whether the general progression toward the target observed in conduction aphasia could be documented in all tasks. In this section, we shall concentrate on data from conduction aphasia, since the corpus for Broca's and Wernicke's aphasia was insufficient to permit comparisons between the various tasks.

Mean error ratios were computed for the sequences of all lengths in the following five tasks.

Spontaneous speech, collected during the patient's initial interview and during his telling of a story (all eight patients contributed to this task).

Repetition of meaningful words, where the patient had to repeat simple and complex words as well as short and long sentences (seven patients).

Repetition of nonsense words, where the patient had to repeat three-syllabic nonsense words (six patients).

Reading aloud, where the patient had to read aloud isolated words, sentences, and a short text (six patients).

Automatized sequences, where the patient had to tell the days of the week, the months of the year, numbers from 1 to 10, and if appropriate, a short well-known prayer (three patients).

Figure 4 presents, for each task, mean error ratios for the last four approximations of all lengths in conduction aphasia. In *spontaneous speech,* sequences for both vowels and consonants exhibit a strong general progression toward the target; this is confirmed by a curve-fitting analysis which at $p < .05$ for vowels and $p < .01$ for consonants indicates a good correlation with a linear regression line.

The *repetition of meaningful words* shows similar progression toward the target (at $p < .05$ for both vowels and consonants), but ending in an error distance farther from the target than in spontaneous speech. The *repetition of nonsense words* does not show such a tendency. The correlation with a linear regression line is not significant for vowels at $p < .05$, and consonants even show a significant correlation with a linear regression line moving *away* from the target. *Reading aloud* shows a continuous trend toward the target somewhat similar to the one observed for spontaneous speech; there is a significant correlation with a linear regression line at the $p < .05$ level for vowels as well as for consonants. Finally, *automatized sequences* show a very strong progression toward the target ending in a very small distance between the last approximation and the target; a correlation with a linear regression line on the last three approximations shows high correlation ($p < .01$) for both vowels and consonants. (An analysis of the last four approximations results in a significant correlation with an exponential curve.)

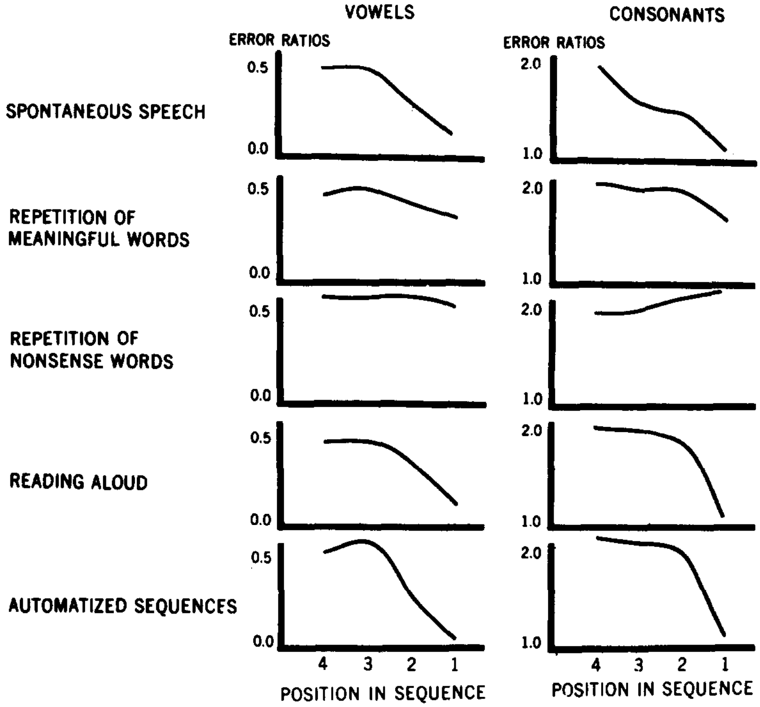

FIG 4. Trends of mean error ratios of conduction aphasics, separated according to task. The curves are based on the following average numbers of phonemes: spontaneous speech, vowels: 201, consonants: 278; repetition of meaningful words, vowels: 378, consonants: 496; repetition of nonsense words, vowels: 63, consonants: 93; reading aloud, vowels: 196, consonants: 281; automatized sequences, vowels: 20, consonants: 30.

In summary, the continuous progression toward the target is strongest in spontaneous speech, reading aloud, and in automatized sequences; the repetition of meaningful and nonsense words, by contrast, does not show such a strong progression toward the target, and even shows an absence or inversion of this tendency. It is interesting to note that the particular behavior of these patients on the repetition tasks corresponds to the classical deficit of repetition in conduction aphasia (Dubois et al., 1964, p. 10; Goodglass & Kaplan, 1972, p. 68).

In the previous section, we left open the possibility that the differential results for type of aphasia could be interpreted either in terms of the functioning of the feedback mechanism or in terms of a weakness or decay of the target available to the production mechanism. It appears that the results of the present section can be well accounted for if *differential strength* for the internal representation of targets is assumed.

In both spontaneous speech and automatized sequences, stimuli are nonspecific. In the former, the patient can choose targets which are most easily available to him and which under this hypothesis would presumably have a stronger internal representation; he is also free to avoid less available items which would supposedly be less strongly represented. As for automatized sequences, their production is based on rote memory and one may thus assume that their underlying internal targets are strongly represented. On the other hand, stimuli of all three other tasks are specific and imposed. In reading aloud, stimuli are presented through the visual pathway, and are thus permanently available and capable of constantly reinforcing the target representation. In repetition by contrast, stimuli are transitory and mediated through the acoustic pathway; moreover, the repetition of nonsense words involves a production based on new learning. Therefore, the targets internal representations may be weaker in repetition, especially when stimuli are nonsense words.

Even though strength of the internal representation of the phonological target may be a somewhat abstract concept, it seems that all our data are coherently explained by a strength hypothesis: the greater the supposed strength of the internal representation, the stronger the progression toward the target. As stated previously, our data did not permit us to examine individual tasks in Broca's and Wernicke's aphasia; nonetheless, preliminary examination suggests that data from these tasks in those two types of aphasia are in accord with this hypothesis.

(3) Differential Length of Sequences of Phonemic Approximations

In the last analysis, we examined differential length as a possible cause of changes in the trends of sequences of phonemic approximations. Mean error ratios were computed for sequences gathered in all tasks in conduction aphasia, but for different numbers of approximations per sequence, again by taking the last approximation as a common point of reference. Only sequences from conduction aphasia were used here, because data from Broca's and Wernicke's aphasia were insufficient for this analysis.

Figure 5 presents the trends of mean error ratios for groups of sequences of four different lengths: *length 3,* containing all sequences with three approximations (152 sequences), *length 4,* all sequences with four approximations (115 sequences), *length 5, grouping* sequences of five *and* six approximations (129 sequences), and *length 7,* for all sequences seven or more (up to 15) sequences long (93 sequences). Data were grouped so as to render the various groups comparable to one another. The trends exhibited by the sequences of these four lengths were superimposed on a single graph, but separated for vowels and consonants.

Sequences of all lengths evidence a general progression toward the target. However, two points seem to differentiate particularly long sequences from shorter ones. The first point is that long sequences, mainly those seven or more approximations long, show final approximations whose mean error ratios are higher, i.e., phonemically more distant from

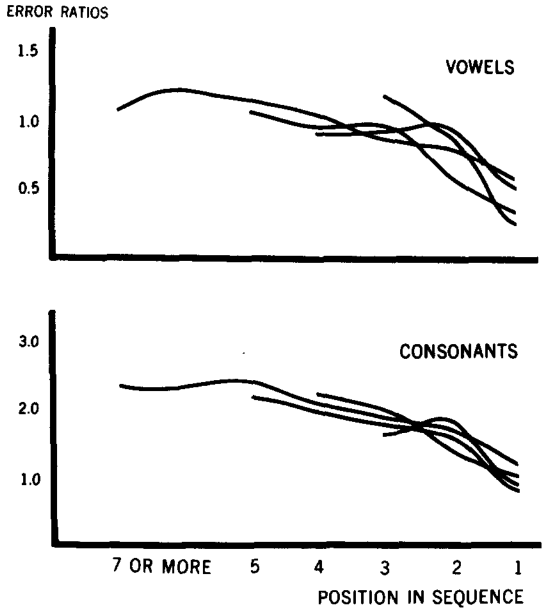

FIG. 5. Trends of mean error ratios for different lengths of sequences in conduction aphasia. The curves are based on the following average numbers of phonemes: length 3, vowels: 272, consonants: 398; length 4, vowels: 175, consonants: 235; length 5, vowels: 217, consonants: 302; length 7, vowels: 129, consonants: 186.

their targets, than the ratios of shorter sequences. The second point emerges from a curve-fitting analysis of the type described above; longer sequences appear to fit a linear regression line better than do shorter sequences: *length 7* is correlated with a linear regression line at $p < .01$ for both vowels and consonants, and *length 5* is correlated at $p < .01$ for vowels and at $p < .01$ for consonants. Yet at *length 4,* only consonants are significantly correlated ($p < .01$), and at *length 3,* only vowel values are significant ($p < .001$). The remaining values for the short sequences are not significantly correlated with linear regression lines.

In view of the elevated error ratios of the initial approximations of longer sequences, it may be assumed that their underlying targets were probably harder to approximate than those of shorter ones; this situation may have resulted in a greater number of attempts needed to approximate the target, as well as the steadier and slower progression toward the target which emerged from the curve-fitting analysis. Under the strength-of-representation hypothesis, this would mean that longer sequences have a weaker initial representation than do shorter sequences. As a result, a greater proportion of the longer attempts may actually have shown decay over the course of their sequences, thus contributing to the elevated mean error ratios of their final approximations. Another factor contributing to this final elevation may have been fatigue; patients may have given up during lengthy, but evidently not totally successful, attempts at producing a single item.

DISCUSSION

Two hypotheses concerning the functioning of the phonological production mechanism have emerged from the previous discussion.

The first hypothesis suggests that speakers have some awareness of how a planned utterance is to be executed, in other words, an *internal phonological representation*. It has been suggested that, in aphasia, this representation can be differentially impaired by task and by type of aphasia.

The second hypothesis relates to the functioning of a presumed *internal monitor* for speech (cf. Lee, 1950; Laver, 1969). The possibility has been suggested that in aphasia, one or more of the operations of this mechanism (feeding back, comparing, and inducing corrections) can be impaired differentially by type of aphasia.

Intactness of both of these aspects is necessary for nonpathological speech. Speakers must evidently feed back and compare their utterances to what they had planned to say in order to be able to make corrections, as they frequently do (Laver, 1969). If it is the phonological form of their utterances that causes them to make the correction, we must suppose that they have some internal phonological representation which they can refer to during the monitoring process.

In the aphasiological literature, it is generally supposed that phonemic paraphasias are due to some impairment of the planning and/or execution of the phonological aspect of an utterance (cf. Alajouanine, Lhermitte, Ledoux, Renaud, & Vignolo, 1964, p. 10; Luria, 1970, p. 213; Blumstein, 1973, p. 71). There is little doubt that these operations are indeed affected, given the prevalence of such phenomena as the anticipation and perseveration of phonological elements. Yet it is possible that aphasia can in addition affect the internal phonological representation[2] of a planned utterance, and/or the monitoring system used to detect errors in execution. An impairment of the phonological monitoring system might prevent the adequate detection of phonological errors, or impede an improvement when a correction is made. Similarly, the target itself may be impaired: its initial representation might not be strong enough to permit correct outputting and comparison, or even if it is initially adequate, it might decay over time. Moreover, both types of impairment might coexist within the same patient.

[2] The terms "internal representation" and "target" here refer to elements of an utterance which are *planned*, but not yet *executed* (cf. Laver, 1969; Clark & Clark, 1977; Keller, 1980).

The results of this study suggest that the strength and the permanence of the internal representation of the target are indeed factors affecting the trends of sequences of phonemic approximations in aphasia. In a task where an external reinforcement of the target was constantly available (reading aloud), and in tasks where the elements produced are either highly habituated or of the patient's own choosing (automatized sequences and spontaneous speech), conduction aphasics were on the average more effective in producing an improvement than on tasks where the stimulus was not constantly available or not of the patient's own choosing (repetition of meaningful and nonsense items). One may suggest that the stronger the internal target, the more effective was the correction.

In addition, there is some evidence that the internal representation of targets may actually decay over time. In the repetition of nonsense words, patients initially were closer to the target than they were when they ceased their attempts at correcting themselves. This is the only task showing such a negative trend, and it was the only task in which no previously stored item could be called upon during the attempts at producing the item. It is thus likely that the patients show forgetting of the item over time.

It was suggested that an impairment of the monitor system could exist in Wernicke's aphasics; in general these patients show very little self-correction behavior, which could represent part of their anosognosia. This may be due to either an impairment of the phonological representation itself, or it may be the result of an interference with the operations of the monitor system, which may in some manner be associated with these patients' pronounced comprehension deficit. Our study could not dissociate the two factors in the case of these patients.

In conclusion, phonemic errors can seemingly be caused not only by a malfunctioning of the phonological production mechanism itself, but also by an impairment of the input to this mechanism, i.e., of the internal representation of the phonological target. A probable impairment of an internal representation, as against an operational deficit, has previously been documented for aphasia by Zurif, Caramazza, Myerson, and Galvin (1974) who showed that posterior aphasic patients tend to group words in an unconventional manner when asked to group them on the basis of similarity of meaning. For instance, while normals tend to put all humans ("wife," "partner," "knight," etc.) into one group and all animals ("shark," "crocodile," "dog," etc.) into another, posterior aphasics mingled them all together. This suggests that these patients had a deficit in their semantic representation of such lexical items, a result that appears to form a consistent counterpart to the deficit in the phonological representation that has been postulated here.

Given that our study has dealt in major part with the phonemic deviations of conduction aphasics, it is of interest to consider our results in the framework of the main physiopathological interpretations that have been proposed in relation to conduction aphasia. From Wernicke (1874) and Lichtheim (1885) to Geschwind (1965, 1971), the *associationists* have attributed conduction aphasia to a left hemisphere lesion sparing the third frontal and first temporal convolutions, but destroying the association fibers interconnecting these two cortical areas (hence the label). Wernicke (1874) for instance first thought that conduction aphasia may be the result of an insular lesion, while later, he suggested that it may be the result of a lesion of the arcuate fasciculus (cf. Geschwind, 1965, p. 628), a view now shared and taught by most associationists. The *globalists,* on the other hand, have suggested that the anomalies observed in the speech of conduction aphasics are more likely to result from cortical impairment, rather than from the interruption of an axonal pathway. Goldstein (1948), for instance, is very explicit in this respect: "If we want to bring the disturbance of repetition into relation with some anatomic defect, we cannot assume a defect of a simple fiber connection but dysfunction of a cortical apparatus. This is still more valid concerning the other symptoms which occur in these cases" (pp. 239–240). Stated in this manner, our observations and results support Goldstein's view, since the perturbations characteristic of conduction aphasia in repetition or spontaneous speech are not an absence of production (as one would expect of an interruption of an exclusive pathway), but an admixture of normal and deviant productions which reflects the interaction of a number of factors (such as the length, phonological complexity, and syntactic nature of the stimuli), and which suggests the existence of different strengths and the temporal decay of the internal representation of phonological targets. But if one were to suggest that the associationist interpretation is not confined to an interruption of the left arcuate fasciculus, but also implies the use of alternate and initially untrained pathways (such as perhaps the right arcuate fasciculus, as suggested by Lhermitte, Lecours, Ducarne, & Escourolle, 1973, pp. 446–447), the described behavior of conduction aphasics could also be satisfactorily accounted for within the associationist framework.

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