

AN EXPERIMENTAL INVESTIGATION OF SPEECH PERCEPTION IN MOTOR APHASIA

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ABSTRACT

The perception of sentences with directional prepositions was studied in motor aphasia in two experimental conditions: in Experiment 1 aphasics had to identify prepositions in spoken sentences, while in Experiment 2 the sentence as a whole had to be understood and identified with a pictorial representation. The type of testing had a significant effect on the subjects' error number, suggesting that they chose different strategies. The types of perceptual confusions also depended on the testing procedure. The phonetic factor is of primary importance in preposition identification, whereas the semantic meaning of prepositions plays a major role in sentence identification.

I. INTRODUCTION

This report reviews a series of experiments investigating speech production and perception disturbances in motor aphasia. Our previous studies have shown that speech difficulties are caused by the inability or reduced ability to process and reproduce particular combinations of phonetic features in Russian (e.g. voicedness and softness in plosives) while at the same time retaining the correct use of other features (e.g. voicedness and softness in fricatives) /1, 2/. Motor aphasics seem to be quite sensitive to the phonetic realization rules, i.e. they produce and perceive those phonemes successfully which are "strong" from the point of view of production or perception and fail to pronounce and perceive "weak" phonemes which are characterized by a comparative complexity on either level. Another difficulty arises when individual phonemes have to be combined in speech utterances. As motor aphasics are unable to produce certain phoneme sequences they tend to simplify the sound chain of a

word to form a CVCV q sequence.

It is well known that a typical feature of motor aphasia on the syntactic level is so called motor agrammatism which is characterized by the omission of prepositions and other function words /3,4,5/. Prepositions are normally unstressed and therefore lack prominence compared to open class words. It is this peculiarity which, in the opinion of some researchers accounts for the exceptionally rare occurrence of prepositions in the free speech of patients with motor aphasia /6/. Observations made in the course of remedial speech work with motor aphasics have led us to suppose that the omission of prepositions is caused, among other factors, by their inability to realize certain phonemic sequences which may occur at the preposition-noun boundary, namely, consonant clusters. Similarly, one may suppose that the perception of phonetically strong or more prominent prepositions (with a CV or VC structure) will be quite different from phonetically weak ones (consisting of one consonant).

In the present study we tried to test experimentally the hypothesis of the phonetic nature of prepositional agrammatism and to find out whether aphasics' performance and perception was affected by test conditions. Another aim was to evaluate the ability of motor aphasics to make use of the semantic features of prepositions.

II. METHOD

In order to investigate motor aphasics' ability to comprehend sentences with prepositions as well as perceive these prepositions, a program was constructed which consisted of 5 series of sentences. Each series contained 6 sentences with the following directional prepositions: "k" (to, towards), "v" (in, into), "na" (onto), "ot" (from), "iz" (out of) and "s" (from). The sentences described simple spatial situations which could easily be realized in the form of line drawings, for example, "The bird is flying up to the cage", "The bird is flying

out of the cage", etc.

The prepositions in question could be divided into two groups according to semantic meaning: 1) prepositions denoting movement towards an object and 2) prepositions describing the reverse movement, i.e. away from the object.

Phonetically, these prepositions can be ascribed to two opposed classes: 1) syllabic and 2) non-syllabic. In the Russian language prepositions ending in a consonant (or consisting of one consonant only) have at least two variants due to the regressive assimilation of voicedness/voicelessness. Thus, the preposition "k" may be spoken as "k" or "g" depending on the quality of the initial consonant in the subsequent noun or adjective. Besides, when the following word begins with a "k" or a "g" the resulting cluster is pronounced as "kk" or "gg". In this experiment all nouns had a voiceless initial consonant so that all final consonants in prepositions were pronounced as voiceless, e.g. /k, f, at, is, s /.

The program consisting of 30 sentences was read aloud by a male speaker of Russian and recorded on magnetic tape. Each sentence was pronounced twice.

A special apparatus was devised and constructed by one of the researchers to conduct audio-visual matching experiments. A detailed description of the apparatus is given in /7/.

The subject was seated in front of a screen onto which either one or four pictures could be projected. The pictures represented schematically different spatial situations.

In Experiment 1 the subjects were shown a picture simultaneously with the auditory presentation of a corresponding sentence and asked to press one of the six panels on a special board which contained the preposition that matched the sentence and the line drawing. In other words, the subjects had to choose the right preposition out of the six given alternatives.

In Experiment 2 four pictures were projected on separate panels constituting the screen. One picture matched the orally presented sentence, a second required an opposite direction preposition, a third showed a closely related movement in the same direction but slightly different in its final stage, e.g. not "into" but "onto", and the last one was chosen randomly from the remaining situations. The subject had to press one of these panels which completely corresponded to the sentence.

In both experiments the time of non-verbal reaction was measured automatically.

There were 4 subjects with motor aphasia in the study. Two subjects with normal speech were also investigated. Two aphasics were tested twice in Experiment 1 and thus the total number of responses was 180. In Experiment 2 two subjects were tested twice and one subject three times, giving 240 responses in total.

III. DISCUSSION OF THE EXPERIMENTAL DATA

First of all, it should be mentioned that the average error number was much higher in Experiment 1 (23%) than that in Experiment 2 (16%). This indicates that it is much more difficult for aphasics to detect (in the spoken utterance) a particular segment (a preposition) and recognize it from a number of alternatives than to identify this utterance with one of the given visual stimuli (line drawings). Normal subjects made no mistakes in either experiment.

Figure 1 gives the matrices of preposition substitutions in Experiment 1 and 2 (in per cent).

		(A) prepositions perceived						
		k	s	v	na	ot	iz	
e x p e r i m e n t 1	k	57	13	13	7	3		
	s		73		3	3	21	
	v	7	10	70	7	3	3	
	na				3	77	17	3
	ot	7	3	7		73	10	
	iz	3	7	3	3		84	
		(B)						
		k	s	v	na	ot	iz	
e x p e r i m e n t 2	k	95		5				
	s	2	68		7		23	
	v	8		85	2		5	
	na				2	95	3	
	ot	2				95	3	
	iz		15	4		13	68	

Fig. 1 Confusion matrices of prepositions in Experiment 1 (A) and Experiment 2 (B). Each line of the matrix shows

the distribution of prepositions (in per cent) the aphasics perceived in sentences presented as indicated in the left margin. Cells forming the diagonal are correct perceptions. Prepositions are transliterated (the prepositions "v" and "iz" were actually pronounced as "r" and "is", the transliteration of the other consonants in the prepositions coincides with the transcription).

For most prepositions (4 out of 6) the number of correct responses was higher in Experiment 2 than in Experiment 1. There are two exceptions, i.e. prepositions "s" (from) and "iz" (out of). Both prepositions belong to the "away from the object" group. It seems to be worth mentioning that the preposition which was the easiest to identify ("iz") is phonetically the longest, while the preposition which turned out to involve the largest number of errors was the one with shortest duration ("k"). It was quite natural to expect that the phonetic structure of a preposition was crucial for its correct identification. To test this hypothesis, we calculated the percentage of correct identifications of one-phoneme versus two-phoneme prepositions. The data obtained confirmed this hypothesis. One-phoneme prepositions were identified correctly in 67% of cases whereas two-phoneme (syllabic) prepositions were correctly identified in 70 per cent of cases.

At the same time, it seemed sensible to suppose that the phonetic structure of prepositions would affect the comprehension task in Experiment 2 to a lesser degree than in Experiment 1. This hypothesis proved to be true. The total count of correct responses in Experiment 2 to one-phoneme prepositions was approximately the same as to two-phoneme prepositions (83% and 80%, respectively).

In order to investigate further the role of the phonetic and semantic factors in speech perception and comprehension, we analyzed the types of most frequently encountered mistakes from considering the length and semantic meaning of prepositions. The experimental data have shown that there is a "universal substitutor", namely, the preposition "iz" (out of) which replaces other prepositions in most cases in both experiments. As mentioned above, this preposition ranked first in the list of identification accuracy in Experiment 1.

It was rather tempting to look for a phonetic tendency in the perceptual confusion pattern.

In Experiment 1 one-phoneme prepositions revealed a slight tendency to be percei-

ved as two-phoneme prepositions. In the case of two-phoneme prepositions, the mistakes were determined by chance.

In Experiment 2 the aphasics tended to perceive one-phoneme prepositions as two-phoneme ones much more frequently than vice versa (71% and 23%, respectively). The two-phoneme prepositions, however, were randomly confused with prepositions of either class.

Our next task was to test the semantic hypothesis of prepositional agrammatism according to which the perceptual impairments in aphasics reflect the complexity of semantic features associated with a certain preposition.

Experiment 1 was designed to evaluate the ability of motor aphasics to process the speech flow and identify its segments. As expected, the semantic factor is not of primary importance for the aphasic listener and, consequently, the percentage of correct responses to prepositions denoting movement towards an object was roughly equal to that of prepositions having the opposite meaning (74% and 77%).

Conversely, in Experiment 2 the role of the semantic factor increases: the prepositions that denote movement towards an object are 1.2 times more frequently perceived correctly than those which describe movement away from it. The total number of correct answers is 92% and 77%, respectively.

An analysis of the mistakes has shown that motor aphasics understand the directional meaning of a preposition and are able to ascribe it to one of the two basic groups but fail to recognize the more subtle features. Thus, in Experiment 2 the "towards an object" prepositions are confused with each other in 75% of the cases of erroneous responses and the "away from the object" prepositions undergo substitutions within the group in 75% of all cases. There was no uniformity in the subjects' performance in respect of this semantic feature in Experiment 1.

The reaction time during the two perceptual experiments was found to be much longer in motor aphasics than in normal subjects and to vary significantly from stimulus to stimulus. There seems to be no relationship between the type of preposition and the latency period. The latter appears to be a function of the severity of motor aphasia.

IX. CONCLUSIONS

Our data support the hypothesis that disturbances in production and perception of prepositions so often encountered in motor aphasia are related to the phonetic structure of these function words.

The relative importance of the phonetic factor in the perception of prepositions depends on the type of the perceptual task. Thus, it seems to be of primary importance in tasks involving the phonemic analysis of speech flow (as in Experiment 1) and is replaced by other factors, e.g. semantic, when experimental conditions provoke the subject to listen to an utterance not merely for its segment analysis but for its comprehension as a whole (as in Experiment 2).

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