Seven psychological models of word recognition are considered in the light of experimental results concerning the concept of the primary perceptual unit and findings from first language acquisition research. On the basis of these considerations a model for the phonetic mental representation of words is proposed which assumes simultaneous representation of differently sized units in the form of prototypes. The implications of this model for models of word recognition are discussed.

INTRODUCTION

Hardly any of the leading word recognition models contain explicit information on the phonetic mental representation of words. This may be seen as a serious drawback of these models considering that (phonetic) mental representation may not only be regarded as a result of the perception process, but that it functions as a monitor for further processing units to which - at least implicitly - the status of mental representation is ascribed.

Klatt /1/ assumes in his LAPS (lexical-access-from-spectra) model that the listener is able to distinguish words directly by spectral analysis of the speech signal without having to segment it into smaller units. However, he also assumes that words have an internal structure which can best be described by units of diphone size. An important part of the word recognition process according to Klatt's model is the recognition of the internal diphone structure of a word by a listener. In this model words must thus be mentally represented as diphone sequences in the listener.

In describing his 'logogen model' Morton /2/ gives the impression that he does not regard any segmentation within word boundaries necessary for the recognition process. Words are held to be represented as holistic entities.

In the 'chunker model' /3/ it is assumed that words are represented as sequences of discrete units in the listener. The size of these units equals approximately single sounds, although statements on the linguistic status of the units and thus on their degree of abstractness (phoneme, allomphone or phone) are avoided.

Forster /4/ was the first to include specific statements on the phonetic mental representation of words in his 'search model'. This model is based on the assumption that words in the lexicon are represented as sequences of phonological segments (phonemes). Pisoni, Nusbaum, Luce and Slowiaczek /5/ also make explicit statements on the mental representation of words in their 'phonetic refinement' theory. They believe that words are represented in the mental lexicon as sequences of discrete phonetic segments equaling single sounds which are defined in a multi-dimensional space /6/.

Elman and McClelland /7/ assume that there are processing units of different sizes on different levels. These processing units are acoustic phonetic features, phonemes (allophones) and words. Even though Elman and McClelland assume interactions between these different units during the word recognition process, on closer examination of their 'trace model' these units appear to be hierarchically organized. Thus the question remains, whether the different units are simultaneously present in the sense of a mental representation or whether they have to be deduced one from another in a given sequence.

- Grosjean and Lee /8/ distinguish between units of processing and units of representation, but only make specific statements in the former. In their view, units of processing are the stressed syllable and the phonological word consisting of a stressed syllable and a number of unstressed syllables linked with the stressed syllable. Unfortunately, Grosjean and Lee do not specify how these units are related to potential units of mental representation. Considering the importance of the auditory features as a basis for prosodic features in the word recognition process, it seems feasible to deduce that they do not tend to assume that words are phonetically represented in form of sequences of discrete single sounds.

PRIMAR Y PERCEPTUAL UNITS

As mentioned above, the problem of phonetic mental representation of words is closely linked with the question of the basic units of speech perception. When, in the early fifties, experimental phonetics and psychologists started to investigate the relation between the linguistic unit and its processing by the human listener, they were guided by the concept of minimal pairs and the ensuing distinctive feature theory developed by phonologists. The assumption that the smallest isolated units - presented in pairs of synthesized signals to listeners in the laboratory who were asked to identify and discriminate them. Notwithstanding the valuable results obtained by such studies, one should be aware of the fact that the experiments were based on artificial acoustic phenomena which were as far distant as possible from their natural manifestations.

In criticism of the assumption of distinctive features as being psychologically real, in the beginning of the seventies, models of word recognition were developed which assume that words are phonetically presented as sequences of discrete phonetic segments equaling single sounds which are defined in a multi-dimensional space /6/.

Another possibility of gaining insight into the phonetic mental representation of words is given in looking at the earliest stages of a child's language acquisition process. In first language acquisition research it has become quite an unquestioned fact that the child learns a word as bearing meaning corresponding to a certain object or class of objects. In other words, the child learns the word 'ball', for example, as a phonetic unit and not as a combination of the single sounds /b/+/a:/+/l/ or even as a matrix of 39 distinctive features. Empirical research supports this view: For example, Bruce /14/ found in investigations with 5- to 7 1/2-year-old children that the younger children in developing holistic processing of words changes to more analytic processing. Liberman, Shankweiler, Fischer and Cowan /9/ and Grosjean and Gee /8/ found that children could segment words with multiple syllables better than into single sounds. In using rhyme tests Magnuson, Nusbaum and Soderstrom /10/ found that preschool children were not able to give a meaning of words to the sounds they heard. School children, however, were able to do this, which may be accounted for by the fact that they can and do use the language that they hear. Schoolchildren, however, were able to do this, which may be accounted for by the fact that they can and do use the language that they hear. Schoolchildren, however, were able to do this, which may be accounted for by the fact that they can and do use the language that they hear.
at the disposal of the listener/speaker once he has established them. From which kind of representation the listener primarily takes the relevant information for solving a perception task is determined, for example, by the type of task, the context of perception, the speed and/or the complexity of the incoming stimuli etc. Besides, it seems to make sense to assume that the perceptual activities of a listener vary not only with various tasks, but that he may also interchangeably focus on different kinds of representation while solving one particular task. Thus a listener can switch to single sounds or even phonetic features when discriminating difficult words such as proper names or words of a foreign language, and then he can switch back to words later. Such a type of model in which a simultaneous representation of stimuli within different systems of similarity and context is postulated, is successfully being used in other psycholinguistic fields. As far as criteria of such representation on problems solving; it has already been shown that the flexibility in problem solving is based on the ability to change perspective (17). Since different listeners make different experiences in their perceptual surroundings, the degree of their ability to discriminate, i.e. the number of types of representation of a given word they have at their disposal, may differ from one individual to another. This is why the kind of representation on which listeners rely, is a successful recognition process, that is influenced according to properties of the listeners themselves. For example, the knowledge of a given language increases with learning (such as is acquired when learning to read and write an alphabetical writing system) may lead to a more differentiated organization of the mental representation of words. Morais, Cary, Alepria and Bertelson (18) could even show that adult illiterates had much more difficulties in solving certain linguistic tasks than literates, and that phoneme analyses that adult literate adults. What Morais et al. showed for speakers of Portuguese, Sanders (19) could confirm also for native speakers of German. Within the scope of the introduced model these results may be explained by the fact that adult illiterates have no concept of the single sound the word literates have, which, should not lead to the misinterpretation that the one group could listen better than the other. As a matter of fact, illiterates are just as able as literates to distinguish minimal acoustic differences in discrimination tasks when they show higher scores on short term retention of the previously focussed type of representation in the process of word recognition. Closely related to the question in which sense the phonetic conceptual units are represented is the problem of how these representations are present. Here a number of 'local types' (20) or Rousch's related concept of 'prototypes' (21) seem to be adequate alternatives to abstract feature matrices. The representation in form of prototypes is postulated for the representation of the phonetic level in the model. It seems plausible to assume that a listener generates a prototype from all the incoming sounds of a word, which listeners rely in a successful recognition. i.e. the number of strategies in speech perception. However, is doing so the following facts should not be ignored: - word stress patterns are normally used in word retrieval; words seem to be organized in the lexicon according to stress contours (23, 24, 25). - Linguistic analyses show that listeners with different languages to develop different perceptual strategies in speech perception. - Configurational (prosodic) features of words hinder the listener from focussing on single sounds in recognizing words (26). - Unstressed function words usually are recognized some time after their off-set, in most cases only after taking into account the following stressed syllable. - The size of the phonetic units used by listeners varies with the complexity of the words in similar languages (27). - The size of the primary perceptual unit varies with the kind of task. (28) - Word recognition models which assume only one kind of 'local type' - phonetic unit of primary perceptual unit - phonetic unit of single words of syllables or words are confronted with a number of problems when trying to explain findings that show listeners have a clear control over the process of auditory word recognition and that they focus at will on any kind of word representation that seems useful for successful word recognition.

REFERENCES

16/ D.O. Bruce, "The analysis of word sounds by young children", Journal of Educational Psychology 24, 1974, 104-158.