The extremely limited set of distinctive features underlying a language, the restrictions on their actual combinations into bundles and sequences and, finally, a high amount of redundancy, lighten the load imposed upon the participants of the speech event.

In the hierarchy of the sound features the distinctive features are of paramount importance. However, the role of the redundancies must not be underestimated. Circumstances may even cause them to substitute for the distinctive features. In Russian the distinction between the palatalized and non-palatalized consonants plays a significant part in differentiating words. Palatalization produces a slight rise of the formants (see 2.423). The phoneme /i/ is implemented as a back vowel [ɨ] after non-palatalized consonants, and as a front vowel [i] in all other positions. These variants are redundant, and normally for Russian listeners it is the difference between the non-palatalized [s] and the palatalized [s̡] which serves as the means of discriminating between the syllables [sɨ] and [s̡i]. But when a mason telephoned an engineer saying that the walls [sɨr̡'ejut] "are getting damp" and the transmission distorted the high frequencies of the [s] so that it was difficult to comprehend whether the walls "were getting damp" or "turning gray" [s̡ir̡'ejut], then the worker repeated the word with particular emphasis on the [ɨ], and through this redundant feature the listener made the right choice. In S. S. Stevens' formulation:

> ".....the fact of redundancy increases the reliability of speech communication and makes it resistant to many types of distortion. By limiting the number of discriminations required of the listener and by assisting his choice through the redundant coding of information, we make talking to one another a reasonably satisfactory business" (6).

1.3 IDENTIFICATION OF DISTINCTIVE FEATURES

Any distinctive feature is normally recognized by the receiver if it belongs to the code common to him and to the sender, is accurately transmitted and has reached the receiver.

Suppose that both participants of the speech event use the same kind of standard English and that the listener has received the vocables gip, gib and gid, which are unfamiliar to him, as to many other English speakers. He does not know that gip means "to clean (fish)", gib, "castrated tom-cat", and gid, "an animal disease." Yet the information he obtains from these three samples is that they may be English words, since none of the features and feature combinations contained in them contradict the English code. Moreover, the three samples convey the information that, if they are words, then each of them has a different meaning, for there is a duple distinction between gip and gid and two different minimal distinctions separate gib from gip and gid. Were the English-speaking listener to hear the following highly improbable sentence: "The gib with the gid shall not gip it", he would know from his knowledge of the rules of the English code, that /gib/ ≠ /gip/ ≠ /gid/. Were the samples to

be transmitted in a German speech circuit, gib and gip would be identified as two optional variants of what is probably the same word, since in German the distinction of /b/ and /p/ is cancelled at the end of the word. The same identification would be made in a Finnish speech circuit, since in the Finnish code the difference between the sounds [b] and [p] has no distinctive value.

Information Theory uses a sequence of binary selections as the most reasonable basis for the analysis of the various communication processes (7). It is an operational device imposed by the investigator upon the subject matter for pragmatic reasons. In the special case of speech, however, such a set of binary selections is inherent in the communication process itself as a constraint imposed by the code on the participants in the speech event, who could be spoken of as the encoder and the decoder.

This follows from the fact that the sole information carried by the distinctive feature is its distinctiveness. The listener distinguishes the word /gib/ from /gid/ by one feature: the grave character of /b/ as opposed, ceteris paribus, to the acute character of /d/. The same word /gib/ is distinguished from /gip/ by a different feature: the weak character of /b/ as opposed to the strong character of /p/. In these two examples, pairs of words display one minimal distinction in corresponding segments, ceteris paribus. Other pairs of words can display a higher number of minimal distinctions either in one segment or in more than one segment. When we review these minimal distinctions used to discriminate between these pairs of words, we find only two possibilities: a) occurrences of the same opposition (gib:gid $\simeq$ fat:sat), and b) each of the two distinctions has a specific property of its own (gib:gid $\neq$ gib:gip).

To be sure, articulatorily, physically, and perceptually, there exists a continuous range of degrees from whisper to full voicing, but only two polar points - the presence and the absence of voice - are picked out as distinctive features. There is a continuous variation in the shape of the lips from a close rounding to spreading and in the corresponding acoustic effects; but the linguistic opposition flat vs. plain (e.g. German Küste "shore" - Kiste "box") is a linguistic assignment of distinctive value to two distant lip positions and to their contrastive acoustical effects (see 2.422). In general, no language possesses more than one minimal distinction based on the size of the lip orifice.

The dichotomous scale is the pivotal principle of the linguistic structure. The code imposes it upon the sound.

Only one phonemic relation presents a somewhat different aspect. This is the relation between vowels with a compact and those with a diffuse spectrum (open and close, in articulatory terms). In a language such as Turkish, the vowels are grouped into compact and diffuse pairs, other things being equal: /kes/ "cut!" is to /kis/ "tumor" as /kol/ "arm" is to /kul/ "slave". But a language such as Hungarian distinguishes, ceteris paribus, three degrees of compactness. Cf. /tår/ "bald" with an open rounded back vowel - /tor/ "feast" with the corresponding mid vowel - /tur/ "rakes up" with the close vowel, and, similarly, in the unrounded front series, /næ/ "take it!" - /ne/ "don't!" -

/ni/ "look!"*. The minimal distinction remains the same as in Turkish: /o/ and /e/ are opposed to /u/ and /i/ as relatively compact to relatively diffuse. In Hungarian, however, the same opposition (relatively compact vs. relatively diffuse) reappears in such pairs as /tår/ - /tor/ and /næ/ - /ne/; that is to say that /a/ : /o/≃/o/ : /u/. In this "phonemic proportion" /o/ (or /e/) functions as the "mean proportional." It carries two opposite features - compactness vs. the diffuse /u/ (or /i/) and diffuseness vs. the compact /a/ (or /æ/). (On ways of dealing with such bi-polar phonemes in analytical procedures see 2.414).

No other inherent phonemic oppositions exhibit such bi-polar complexes. There are, however, conjugate distinctions prone to merge, e.g., the pairs continuant - interrupted, and strident - mellow. When two conjugate oppositions merge the resulting opposition is maximally clearcut, optimal. Thus the optimal continuant consonants are strident; the optimal interrupted, mellow. A similar relation links the oppositions grave vs. acute and flat vs. plain. The optimal grave vowels are flat; the optimal acute are plain (concerning the reverse combinations of such features as interrupted strident, continuant mellow, flat acute or plain grave and ways of treating them in the analytical procedures see 2.324 and 2.4236).

It is the dichotomous scale of the distinctive features, in particular, and the whole patterning of the linguistic code, in general, that to a large extent determines our perception of the speech sounds. We perceive them not as mere sounds but specifically as speech components. More than this, the way we perceive them is determined by the phonemic pattern most familiar to us. Therefore, a monolingual Slovak identifies the rounded front vowel /ø/ of the French word jeu as /e/, since the only distinctive opposition in his mother tongue is acute (front) vs. grave (back) and not flat (rounded) vs. plain (unrounded). A monolingual Russian, on the contrary, perceives the same French vowel as /o/ because his native tongue possesses only the one of the two oppositions in question, namely, flat vs. plain. Even as expert a linguist as the Frenchman Meillet perceived the Russian sharpened /t̡/ as a sequence of /t/ and non-syllabic /i̯/ and not as a consonant with simultaneous, superposed sharpening (palatalization), for Meillet's judgment was based on his native French, which lacks the sharpening feature but possesses the non-syllabic /i̯/. Hence it is only to be expected that when nonsense syllables are used in intelligibility tests (traditionally called "articulation tests") the results depend upon whether or not these sequences are patterned in accordance with the rules of combination of the given linguistic code.

Interference by the language pattern affects even our responses to non-speech sounds. Knocks produced at even intervals, with every third louder, are per-

*The examples, which we have from John Lotz, belong to a colloquial variety of Standard Hungarian.

ceived as groups of three separated by a pause. The pause is usually claimed by a Czech to fall before the louder knock, by a Frenchman to fall after the louder; while a Pole hears the pause one knock after the louder. The different perceptions correspond exactly to the position of the word stress in the languages involved: in Czech the stress is on the initial syllable, in French, on the final and in Polish, on the penult. When the knocks are produced with equal loudness but with a longer interval after every third, the Czech attributes greater loudness to the first knock, the Pole, to the second, and the Frenchman, to the third.

If on the aural level too, speech analysis were to be conducted in terms of the binary phonemic oppositions, the task would be substantially facilitated and could perhaps supply the most instructive correlates of the distinctive features.

As to the acoustic investigation of the speech sounds, its whole development has been toward an ever more selective portrayal of the sound stimuli. Both the instruments used and the interpretation of the data recorded by them are progressively more oriented toward the extraction of the pertinent items. Investigators have come to see that the wave traces contain too much information and that means must be provided for selecting the essential information(8). As soon as it is realized that the proper criterion of selection is the linguistic relevance (expressed in binary terms), the acoustic problems of the speech sounds find a far more determinate solution. Correspondingly the articulatory stage of speech must be defined in terms of the means utilized to obtain any pair of contrastive effects. For example, as far as language uses an autonomous distinctive opposition of gravity and acuteness, we examine the acoustical correlates of the linguistic values in question and the articulatory prerequisites of these stimuli.

In short, for the study of speech sounds on any level whatsoever their linguistic function is decisive.

The interesting attempt, suggested by B. Bloch to decipher the phonemic pattern of a language from a mere examination of a sufficient number of recorded utterances (9) is onerous but feasible. It implies, however, two strictly linguistic assumptions. The first was formulated by Wiener (3): "In the problem of decoding, the most important information which we can possess is the knowledge that the message we are reading is not gibberish." This corresponds to the knowledge obtained by any listener upon reaching the so-called threshold of perceptibility, when the sounds heard begin to be perceived as speech sounds (10). Since it is speech, the second assumption follows as a corollary of the first: in its sound shape any language operates with discrete and polar distinctive features, and this polarity enables us to detect any feature functioning ceteris paribus.

Obviously such a task of deciphering becomes more difficult in the frequent cases called "switching code" by communication engineers (11) or "coexistent phonemic systems" by linguists (12). The Russian aristocracy of the last

century with its bi-lingual speech - switching continually from Russian to French and vice versa even within a single sentence - provides a striking illustration. Another example is set by some Mohammedan cultural languages with their Arabic interpolations. Two styles of the same language may have divergent codes and be deliberately interlinked within one utterance or even one sentence. For instance, urban colloquial Czech is a whimsical oscillation between the literary language and vulgar Czech, each of them displaying its own phonemic pattern.

The dichotomous scale is superimposed by language upon the sound matter much in the same way as the diatonic scale is superimposed upon the sound matter by the musical pattern (13). But just as a musical scale cannot be grasped without reference to the sound matter, so in the analysis of the distinctive features such a reference is inevitable. Knut Togeby eloquently demonstrated this by a consistent assumption of the contrary (14). A distinctive feature cannot be identified without recourse to its specific property.

Such an investigation is supplemented but not supplanted by an inquiry into the distribution of these features in the speech sequences. M. Joos has observed, that since the diphthong /au/ (spelled ou as in council) is never followed within a simple English word by [p b f v m], this distributional feature defines the labial class of English consonants (15). Such a statement, however, presupposes the identification of each of the consonants in its various occurrences. We must know that /t/ in rout is identical with /t/ in rite which is opposed to /p/ in ripe as grave vs. acute, ceteris paribus. Otherwise, we would not know that in rout the diphthong /au/ is followed by /t/ and not by /p/, and we could not prove the above statement.

Thus for the identification of /p/, and of every other phoneme, a reference to the specific property of each of its distinctive features is imperative. But to which of the consecutive stages of the sound transmission shall we refer? In decoding the message received (A), the listener operates with the perceptual data (B) which are obtained from the ear responses (C) to the acoustical stimuli (D) produced by the articulatory organs of the speaker (E). The closer we are in our investigation to the destination of the message (i.e. its perception by the receiver), the more accurately can we gage the information conveyed by its sound shape. This determines the operational hierarchy of levels of decreasing pertinence: perceptual, aural, acoustical and articulatory (the latter carrying no direct information to the receiver). The systematic exploration of the first two of these levels belongs to the future and is an urgent duty.

Each of the consecutive stages, from articulation to perception, may be predicted from the preceding stage. Since with each subsequent stage the selectivity increases, this predictability is irreversible and some variables of any antecedent stage are irrelevant for the subsequent stage. The exact measurement of the vocal tract permits the calculation of the sound wave (16), but the same acoustical phenomenon may be obtained by altogether different means. Similarly, any given attribute of the auditory sensation may be the result of

different physical variables (17) so that there is no one-to-one relation between the dimensions of the acoustical stimulus and the auditory attribute. The former cannot be predicted from the latter, but the totality of the dimensions of the stimulus renders the attribute predictable.

To sum up, the specification of the phonemic oppositions may be made in respect to any stage of the speech event from articulation to perception and decoding, on the sole condition that the variables of any antecedent stage be selected and correlated in terms of the subsequent stages, given the evident fact that we speak to be heard in order to be understood.

1.4 INHERENT AND PROSODIC DISTINCTIVE FEATURES

The distinctive features are divided into two classes: 1. inherent and 2. prosodic. The latter are superposed upon the former and are lumped together with them into phonemes. The opposition grave vs. acute, compact vs. diffuse, or voiced vs. unvoiced, and any other opposition of inherent distinctive features appears within a definite sequence of phonemes but is, nevertheless, definable without any reference to the sequence. No comparison of two points in a time series is involved. Prosodic features, on the other hand, can be defined only with reference to a time series. A few examples may clarify this statement.

A syllabic phoneme is opposed to the non-syllabic phonemes of the same syllable by a relative prominence. For the most part syllabicity is an exclusive function of the vowels. Cases when some vowels or liquids, ceteris paribus, carry the distinctive opposition syllabic vs. non-syllabic are particularly rare. For instance, the Old Czech sequence b r d u changes meaning depending upon the syllabic or non-syllabic character of the /r/ (see 2.226).

It is obvious that whether or not /r/ constitutes a maximum in loudness can only be determined by comparison with the loudness of the other phonemes of the same sequence.

In a sequence of syllables a relative prominence opposes one syllabic phoneme to the others of the same sequence as stressed vs. unstressed. In a number of languages words have, ceteris paribus, a different place of stress, for instance, English billow /b'ilou/ - below /bil'ou/. The greater and lesser prominence of syllabics is a relative notion which can be determined only by a comparison of all syllabics pertaining to the same sequence. The same holds when the distinctive role is played by the relation not of the loudness levels but of the pitch levels of the voice. In K. L. Pike's formulation, "the important feature is the relative height of a syllable in relation to the preceding or following syllables" (18).

When in place of or beside the level, the modulation plays a distinctive role, we identify the pitch or loudness contour of a phoneme by comparing two points in the time series. For instance, the Lithuanian falling pitch, which is opposed to the rising pitch and is due to a lowering of frequency, habitually accompanied