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This paper deals with the assessment of children's acquisition of phonological competence. Phonological competence refers to the idealized speaker/hearer's ability to understand the linguistic structure underlying phonetic input/output. Under the Jakobsonian assumption that the learning of phonological opposition follows a regular sequence, an index of phonological competence in the form of a speech sound discrimination test is proposed. Developmental articulation data are used to construct a model of emerging phoneme discrimination proficiency. The model is intended as a basis for the development of practical assessment procedures. (Author/PB)

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Under the Jakobsonian assumption that the learning of phonological opposition follows a regular sequence, an index of phonological competence in the form of a speech sound discrimination test is proposed. Developmental articulation data are used to construct a model of emerging phoneme discrimination proficiency. The model is intended as a basis for the development of practical assessment procedures.

A MODEL OF DEVELOPMENTAL PHONEME DIFFERENTIATION ABILITY

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This paper deals with the assessment of children's acquisition of phonological competence. Phonological competence refers to the idealized speaker/hearer's ability to understand the linguistic structure underlying phonetic input/output. Such competence can be formalized in sets of rules such as phonotactic rules, morphophonemic rules, and phoneme decision rules. A profile of phonological competence can be obtained by studying performance on tasks designed to reflect phonological rule acquisition. Measures of acquisition in this area have been confined to one or another aspect of phonological competence and have involved small numbers of experimental subjects. Sensitive instruments for assessing individual progress in phonological rule acquisition have not been developed.

The most basic skills prerequisite to phonological competence are encompassed in what we have termed phoneme decision rules. Phonemic decision processes relate to both perception and production and involve the learning of the set of phoneme oppositions characteristic of a language. The fundamental theoretical statements concerning the learning of phonemic contrasts were posited in a monograph by Jakobson (1941). Graham and House (1971) have written a concise summary of the Jakobsonian hypothesis:

> ...The universal first opposition for the child is stop consonant versus open vowel (for example, /p/ vs. /a/). Chronologically, this is followed by the use of a nasal consonant versus oral consonant opposition (for example, /p/ vs. /m/), and then by a labial versus dental consonant opposition (for example /p/ vs. /t/). with these two consonant oppositions forming the minimal consonant

> system for all languages. The remainder of the consonant system develops in accordance with the so-called laws of solidarity, which state that in a linguistic system a secondary value cannot exist without the corresponding primary value. The presence of fricatives, for example, implies the presence of stops and similarly, the development of a back consonant cannor occur in the absence of its corresponding front consonant. Thus, Jakobson hypothesized that the remainder of the English consonant system develops in the following order: palatovelars, fricatives, affricates, with the last distinction being between liquids. (p. 559.)

Subsequent treatments of phoneme opposition learning have relied heavily on the Jakobsonian model. The hypotheses contained in the model appear to be verified consistently in diary accounts of speech development (Leopold, 1939; Velten, 1943) as well as in speech production and perception data collected under experimental conditions. Ervin Tripp (1966) reports an examination of the literature from which were constructed "the generalizations which have the widest support." The first four generalizations are stated as follows (p. 68):

1. The vowel-consonant contrast is one of the earliest, if not the earliest, contrast for all children.

2. A stop-continuant contrast is quite early for all children; the continuant is either a fricative (e.g., /f/) or a nasal (e.g., /m/).

3. Stops precede fricatives.

4. When two consonants differing in place of articulation but identical in manner of articulation exist, the contrast is labial vs. dental (e.g., /p/ vs. /t/, /m/ vs. /n/).

Secondary evidence for the "front precedes back" and "stop precedes fricative" assertions comes from data on children's misarticulations. Analysis of such data shows a general tendency to substitute dental or alveolar consonants for back consonants and corresponding stops for fricatives (Snow, 1964).

DEVELOPMENTAL ARTICULATION PROFICIENCY

Several attempts have been made to construct models of emerging control over phonemic oppositions (Crocker, 1969; Menyuk, 1968). Essentially, these have been attempts to verify Jakobson's proposed sequence in terms of children's acquisition of the phonological system of English. Menyuk analyzed children's articulation data to determine the percentage of times an expected consonantal feature was correctly produced. The resulting rank order of distinctive features is purported to represent the order in which phonemes characterized by the various features come under productive control as well as the relative perceptual strength inherent in the features themselves. Crocker's model offers an explanation of emerging articulatory competence in terms of learning to manipulate novel feature combinations. The important contribution of the developmental schemata constructed by these investigators is the idea that what is learned in the developing phonological system is a succession of distinctive feature oppositions.

Prior to the work of Menyuk and Crocker, investigators were content to map the sequence of phonemes as they appeared to come under productive control. Typical of this type of data analysis is Poole's (1934) charting of "phoneme mastery" by age. Table I is a summary of the Poole data presented by DeVito (1970). Other investigators have reported phoneme mastery data in a framework similar to Poole's and while at variance with one another in the case of some particular phonemes, are strikingly similar (Templin, 1957; Wellman, et al., 1936).

TABLE 1

Age at Which Various Sounds are Mastered*

Age	Sounds Mastered
3.5	b, p, m, w, h
4.5	d, t, n, g, k, ŋ, y
5.5	f
6.5	v, ð, ž, š, l
7.5	s, z, r, θ, hw

*From Poole (1934) as reported in DeVito (1970).

Attempts to systematize phonemic opposition mastery in terms of features reflects basic processes better than listing phoneme mastery by age, but it is only one step forward in accounting for the sequence of events reflected by the articulation data. Crocker (1969) added another dimension to the descriptive framework when he noted that analysis by feature combinations is more meaningful than analysis in terms of single features. This added dimension accounts for important developmental subtleties such as the [+ grave] vs. [- grave] distinction appearing early among the class of stops (viz., /p/ vs. /t/) but not appearing until late among the fricatives (viz., /f/ vs. /θ/).

A summary of the various descriptions of developmental articulation proficiency is presented schematically in Figure 1. The developmental model, expressed in terms of Jakobson, Fant, and Halle's (1952) distinctive

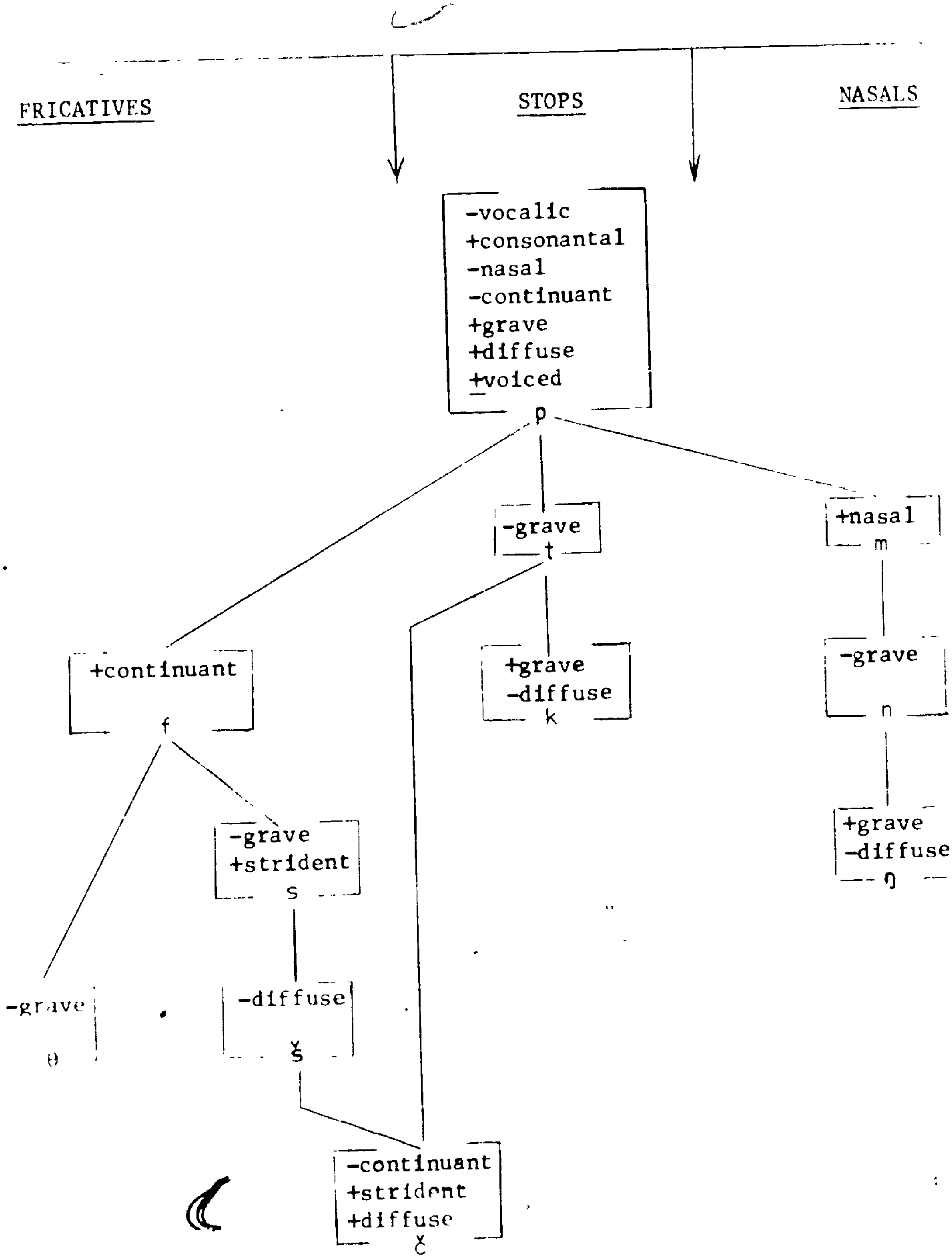

FIG. 1 SUMMARY: Schema of developmental articulatory control in terms of distinctive feature combinations.

feature system, is similar to that presented by Crocker (1969) except that he specifies /f/ as [+ strident]. That /f/ should be specified [- strident] was demonstrated by Woolley (1968). Other minor differences exist but will not be discussed. In the model three major classes of consonants by manner of articulations are distinguished. As lines of feature combinations develop, only feature specifications that represent a change from prior specifications are indicated in the brackets. The secondary features [± grave] and [± diffuse], which account for place of articulation differences, are established in the stop class before novel combinations of these features with primary features are established. Primary features are those that establish classes of consonants differentiated by manner of articulation, [+ nasal] and [+ continuant]. Each consonant in the schema (except nasals) represents a phoneme <u>type</u> which eventually splits into voiced and voiceless tokens. The split into voiced and voiceless cognates occurs later than the establishment of phoneme type. Developmental patterns of particular significance which are implicit in the model can be explicated as follows:

1. The class of stop consonant types is established before any other class.

2. The class of nasal consonants is established before the class of fricatives.

3. Among the fricative phoneme types, where two strident types (/s/ and /š/) oppose two non-strident types (/f/ and /θ/), a strident/non-strident split occurs prior to any split within these types.

4. Within consonant classes, front consonant types are established prior to back consonant types.

DEVELOPMENTAL PHONEMIC DISCRIMINATION PROFICIENCY

A proficiency profile of emerging phoneme decision processes can be obtained by employing a carefully constructed test of auditory discrimination. Such tests require the child to differentiate two stimulus syllables that manifest a phonemic contrast (e.g., /me/ vs. /sə/). The potential of the auditory discrimination test as an index of developmental proficiency has not been investigated. While literally hundreds of experimental studies have focused on auditory discrimination abilities, less than ten such studies involve any analysis of error patterns. Using the model of developmental articulation proficiency as a starting point, it should be possible to construct a model of developmental phonemic discrimination behavior. First, the oppositions that need to be resolved in order to master the phonological system of English will be described. Then a model of sequential events in the mastery of these oppositions will be hypothesized.

Ultimately, only minimal sound contrasts are of interest in assessing phonemic discrimination. Non-minimal contrasts do not afford an opportunity to interpret the role of individual features in cuing oppositions. Furthermore, because non-minimal contrasts are easy to discriminate, even for very young children, they offer limited information about developmental patterns. In the consonantal system of English, i.e., those phonemes marked [+consonantal] and [-vocalic], there are three kinds of minimal contrasts: contrasts in manner of articulation, contrasts in place of articulation, and contrasts in voicing. In Table 2 an exhaustive list of minimal consonant contrasts is presented. Inability to discriminate any of these contrast pairs represents a

TABLE 2

Exhaustive List of Minimal Consonant Contrasts in English

PLACE CONSTRASTS

- pt, pk, tk — voiceless stops
- bd, bg, dg — voiced stops
- fθ, fs, fš, θs, θš, sš — voiceless fricatives
- vð, vz, vž, ðz, ðž, zž — voiced fricatives
- mn, mŋ, nŋ — nasals

MANNER CONTRASTS

- bm, dn, gŋ — stop-nasal
- pf, bv, ts, dz, tθ, dð — stop-fricative
- tč, dǰ — stop-affricate
- čš, ǰž — fricative-affricate
- mv, zn — nasal-fricative

VOICING CONTRASTS

- pb, td, kg — stop
- fv, θð, sz, šž — fricative
- čǰ — affricate

hypothetical starting point for developmental phonemic discrimination proficiency, while the ability to discriminate all pairs perfectly represents a hypothetical end point (adult competence).

DEVELOPMENTAL ARTICULATION VARIABLES

Hypotheses about response patterns in the initial phase of consonant discrimination behavior are based on inferences from developmental articulation data. Given that clear-cut inferences are possible, their validity rests on the assumption that speech sound production behavior and phoneme differentiation behavior are aspects of the same mechanism and therefore a function of the same underlying factors. Predictions will be expressed in terms of the relative ease or difficulty of making discriminations within or between classes of consonants.

Hypothesis 1. Since stop consonants are the first class of consonants to come under articulatory control at all points of articulation, stop place contrasts will be discriminated earlier than place contrasts among fricatives and nasals.

Hypothesis 2. Since the class of nasal consonants comes under articulatory control at all points of articulation before the class of fricatives, place contrasts among the nasals will be discriminated earlier than place contrasts among the fricatives.

Hypothesis 3. Since the class of stop consonants comes under articulatory control before the fricative and affricate classes, stop voicing contrasts will be discriminated earlier than voicing contrasts among fricatives and affricates.

Hypothesis 4. Since, in emerging articulatory control, the split between strident and non-strident fricatives occurs before splits within these categories, fricative place contrasts opposed in stridency will be discriminated earlier than those not opposed in stridency will (e.g., /f/ vs. /s/ will be easier to discriminate than /f/ vs. /θ/).

Hypothesis 5. Since stop and nasal consonant classes come under articulatory control in advance of the class of fricatives, homorganic stop-nasal contrasts will be discriminated earlier than homorganic stop-fricative contrasts.

Hypothesis 6. Since the affricate consonant class does not come under articulatory control until after homorganic stops and fricatives are established, homorgainc stop-fricative contrasts will be made earlier than homorganic stop-affricate and homorganic fricative-affricate contrasts.

The factors that influence the developmental articulatory schedule are only known in general. There are those who claim that a progression from the most discriminable to the least discriminable phones explains the sequence (Olmstead, 1966). And there are those who describe the developmental sequence as a series of dichotomous splits that systematically fill the gap between the proto-consonant /p/ and the proto-vowel /ɑ/ along several acoustic dimensions (Jakobson and Halle, 1956). In any case, the data available allow descriptive statements about the sequence.

ACOUSTIC VARIABLES

In predicting consonant discrimination response patterns in the early stages of development, we have relied entirely on what is known about developmental articulation ability. Later in the developmental period, it is possible to stipulate some of the variables that play important roles in determining discrimination response patterns. From reports on various aspects of discrimination testing it is known th the list of influencing variables includes the phonetic context of contrasting segments (Rudegeair, 1970); the relative cue strength of the distinctive feature opposition involved in the contrast (Miller & Nicely, 1955; Rudegeair, 1970); the syllable position of the contrasting segments (Rudegeair & Kamil, 1969; Templin, 1957); and task difficulty factors which are extraneous to discrimination ability per se and are a function of alternative tasks used to collect discrimination data (Blank, 1968; Briere, 1967; Rudegeair & Kamil, 1969; Vellutino, et al., 1972). Predicting response patterns at later stages of developing ability depends upon understanding which variables assume the most importance. Of the four categories of variables mentioned, the first two are of particular relevance to the present discussion.

Phonetic Context Factors

The role of phonetic context on consonant discrimination behavior is exemplified in the results of a study by Rudegeair (1970). In that study 18 syllable pairs representing initial consonant contrasts were presented to six-year-old children for discrimination according to a forced-choice, matching-to sample procedure. Each S was presented each pair 16 times and error percentages were computed and compared. One of the predictions tested in the study was that expressed in Hypothesis 3 presented earlier (viz., discrimination of /p/ vs. /b/, /t/ vs. /d/, /k/ vs. /g/ is easier than /f/ vs. /v/, /θ/ vs. /ð/, /s/ vs. /z/). This prediction was borne out by the data in the 1970 experiment. However, analysis of the eff of phonetic context on discriminating these pairs showed that in the context consonant plus /ə/ there were three errors in response to the stop contrasts for every two errors in response to the fricative group. When ratios over all vowel contexts are collapsed, the predictions based on articulatory development were substantiated, but contextual conditions can alter the pattern drastically.

<u>Relative Cue Strength of Distinctive Features</u>

As the complete phonemic system emerges, acoustic parameters come to play the primary role in determing consonant confusability. If it is found, for example, that contrasts based on [± voice] are always easier than contrasts based on [± nasal], then it may be said that the voicing feature is stronger as a perceptual cue than the nasality feature. An example of how relative cue strength of different features affects response patterns can be seen in the results of the often-cited Miller and Nicely (1955) study. In that experiment consonant plus /a/ nonsense syllables were presented to adults under various conditions of noise and filtering. Ss were instructed to repeat what they heard and the resulting confusion matrices were presented in the report. Considering just the voiceless fricatives /f/, /θ/, /s/, the relative strength of the features [± grave] vs. [± stident] can be assessed. /f/ differs from /θ/ only in that /f/ is [+ grave] and /θ/ is [- grave]. /θ/ differs from /s/ only in that /θ/ is [- strident] while /s/ is [+ strident]. In those conditions which most approximate normal listening /f/ was heard as /θ/ about one-sixth of the time and /θ/ was heard as /f/ half of the time. Contrastively, /θ/ was reported as /s/ three times in 500 observations and /s/ was reported as /θ/ seven times in 500 observations. Obviously gravity is not nearly as resiliant to confusion as stridency. It can be inferred from these data that two sounds differing in stridency are much more likely to be discriminated correctly than two sounds distinguished by gravity.

This assertion is a contradiction of the first hypothesis made earlier on the basis of developmental articulation data, since there it it is implied that /p/ [+ grave] vs. /t/ [- grave] will be easier to discriminate that /f/ vs. /s/ or /θ/ vs. /s/. The hypothesis may stand, however, since it can be assumed that developmental articulation abilities are a function of other variables equal in impact to acoustic confusability factors. As long as a child finds it easier to discriminate /p/ from /t/ than to discriminate /s/ from /θ/ or /f/, he can be identified as being in an early rather than a late phase of speech sound learning. This serves as one example of how the discrimination learning sequence can be used as an index of sound learning progress. Appropriate analyses to determine the perceptual cue strength of various features and feature combinations as well as additional information about positional and contextual variables will allow more sensitive measures of the developing system.

SUMMARY

An attempt has been made to construct a model to describe emerging phoneme differentiation behavior. Progress is gauged not by comparing performance to any absolute scale, but by comparing individual ability to differentiate specified types of contrasts among specified classes of consonants. It is assumed that as the child learns the role of novel

feature combinations his ability to consistently make discriminations in the new class is not as sure as it is in a class learned earlier, *ceteris paribus*. Eventually, consistency within various classes is equal, as in the adult model. Future research should be geared toward exploiting the process of learning to resolve phonemic oppositions as a means to understanding phonological acquisition and as an index of developing competence.

REFERENCES

Blank, M. Cognitive processes in auditory discrimination in normal and retarded readers. *Child Development*, 1968, 39, 1901-1101.

Briere, E. J. Phonological testing reconsidered. *Language Learning*, 1967, 17(3 & 4), 163-171.

Crocker, J. R. A phonological model of children's articulation competence. *Journal of Speech and Hearing Disorders*, 1969, 34, 203-213.

DeVito, J. *The psychology of speech and language; an introduction to psycholinguistics*. New YorK: Random House, 1971.

Ervin-Tripp, S. Language development. In L. W. Hoffman & M. L. Hoffman (Eds.), *Review of Child Development Research*. New York: Russell Sage Foundation, 1966.

Graham, L. W., & House, A. S. Phonological oppositions in children: a perceptual study. *The Journal of the Acoustical Society of America*, 1971, 49(2 part 2), 559-566.

Jakobson, R. *Kindersprache, aphasia und allgemeine lautgesetze*. The Netherlands: The Hague Mouton & Co., 1941, 1968.

Jakobson, R., Fant, C. G. M., & Halle, M. *Preliminaries to speech analysis: the distinctive features and their correlates*. Cambridge, Mass.: The M.I.T. Press, 1952.

Jakobson, R., & Halle, M. *Fundamentals of language*. Paris: The Hauge Mouton, 1971.

Leopold, W. F. *Speech development of a bilingual child: a linguist's record*. (Northwestern University Studies in Humanities.) Evanston, Ill.: Northwestern University Press, 1939-1949.

Menyuk, P. The role of distinctive features in children's acquisition of phonology. *Journal of Speech and Hearing Research*, 1968, 11, 138-146.

Miller, G. A., & Nicely, P. E. An analysis of perceptual confusions among some English consonants. *Journal of the Acoustic Society of America*, 1955, 27, 301-315.

Olmsted, D. L. A theory of the child's learning of phonology. *Language*, 1966, 42(2), 531-535.

Poole, I. Genetic development of articulation of consonant sounds in speech. *Elementary English Review*, 1934, 11, 159-161.

Rudegeair, R. E. The effects of contextual influence on children's discrimination of initial consonants. Technical Report No. 146, 1970, Wisconsin Research and Development Center for Cognitive Learning, Madison, Wisconsin.

Rudegeair, R. E., & Kamil, M. L. Assessment of phonological discrimination in children. Technical Report No. 118, 1970, Wisconsin Research and Development Center for Cognitive Learning, University of Wisconsin, Madison, Wisconsin.

Snow, K. A comparative study of sound substitutions used by "normal" first grade children. *Speech Monographs*, 1964, 135-141.

Templin, M. C. *Certain language skills in children: their development and interrelationships*. Minnesota: The University of Minnesota Press, 1957.

Vellutino, F. R., DeSetto, L., & Steger, J. A. Categorical judgment and the Wepman test of auditory discrimination. *Journal of Speech and Hearing Disorders*, 1972, 37(2), 252-257.

Velten, H. V. The growth of phonemic and lexical patterns in infant language. *Language*, 1943, 19, 281-292.

Wellman, B. L., Case, I. M., Mengert, I. G., & Bradbury, D. E. Speech sounds of young children. University of Iowa Studies in Child Welfare, 1936, 5:No. 2.

Woolley, D. E. Some observations on Stridency in English. Paper presented at the Forth Regional Meeting of the Chicago Linguistic Society, April, 1968.