AUDITORY IMPERCEPTION IN CHILDREN: A STUDY OF SPELLING ERRORS

MARGARET GOLICK

1. INTRODUCTION

There are many children with normal intelligence, free from sensory defects or emotional disturbance, who have great difficulty learning to read and spell. Estimates of the incidence of 'learning disability' in the school age population range from 5 to 15 per cent (Orton, Monroe, Hallgren, Rabinovitch, Critchley). Psychologists, audiologists and other clinicians who investigate these children often refer to an 'auditory perceptual problem' underlying the late language acquisition, articulation errors, and bizarre or erratic spelling many of these children show (Wepman, Myklebust, de Hersch, Messing, Berry, Eisenson, Monroe, Chalfant). The notion of 'auditory inperception' is poorly defined and poorly understood.

In an effort to begin to clarify the nature of some of these perceptual problems a small pilot study was undertaken. The consonant spelling errors of children with learning disabilities were examined and an analysis was made of the acoustic characteristics of the consonants most frequently misperceived.

2. METHOD

Spectrograms were made of the fifteen words in a standardized diagnostic spelling test — the Phonic Spelling Test from the Durrell Analysis of Reading Difficulty (Durrell). The words had been recorded by a female speaker (the author). The words were all polysyllabic. The number of phonemes in each word ranged from six to nine. All are words ordinarily unfamiliar to school age children who are told to spell them 'just the way they sound'.

The acoustic characteristics of the sounds in these words were related to the spelling errors made on the test by eighteen children, between the ages of nine and thirteen years, referred to the McGill-Montreal Children's Hospital Learning Centre for evaluation of their learning difficulties.

All had at least average intelligence but had spelling scores at least one year below the level that would be expected on the basis of chronological age. Judging by their ability to spell familiar monosyllabic words all had learned our orthographic conventions for representing consonant sounds.

3. RESULTS

When frequency of errors, error types, and spectral character of misperceived sounds were calculated certain general findings emerged: there was no apparent relationship between overall difficulty of a word and either its total duration, or the number of phonemes it contained.

There was no class of phonemes that was inherently more difficult to perceive than any other. Perception depended on the acoustic characteristics of the particular segment. Thus a /t/ correctly decoded when it was the first segment in a word might be misperceived when it followed a consonant.

Speech perception and speech synthesis studies (Black, Fant) have indicated that cues to consonant perception are to be found in the frequency of the burst of a plosive consonant, the frequency of the fricative noise, formant transitions and duration of noise or silence. But not all cues are equally available in natural speech. Depending on its environment a voiced consonant may be devoiced, formant transition cues may be unavailable, the intensity of a fricative noise or consonant burst might be too low to be perceived, or a final consonant might be unreleased. Normal adults are able to make use of only a single cue if need be. These children seem to need a combination of cues. Where several were available the children were able to make use of them. Thus, few children misspelled intervocalic, initial or final consonants unless the intensity was very low or the duration very brief when compared with other instances of the same phoneme.

The most important acoustic determinant of misperceptions was duration of a segment. Consonants of less than 8 cs duration were most apt to be omitted. These very brief consonants were usually members of a consonant cluster and frequently in unstressed syllables.

Errors of sequencing, too, seemed to be provoked by brief duration of one of the adjacent segments. In ninety per cent of the instances where segments were reordered one of the segments was less than 8 cs in duration.

There appeared to be temporal factors in substitution errors too. In 85 per cent of all errors of substitution, the consonant substituted differed from the consonant presented by only one feature. (Miller and Nicely; Jakobson, Fant, Halle 1967). The three most common types of substitutions — in order of frequency — were those based on errors in judging voicing, errors in judging place, and errors in judging manner. There seems to be good evidence that where other cues are reduced, the discrimination of voicing and the discrimination of manner both depend on the ability to judge relative duration. Discrimination of place is based on formant transitions — which demands the ability to judge a change of frequency that takes place over an exceedingly brief period of time — usually shorter than the shortest segment.

Several additional observations seem relevant in trying to understand the abilities and disabilities of these children:

(1) additional consonants that were not in the original words were inserted by some children in their written versions. These epenthetic errors seemed to occur (a) in the records of children who may have failed to discriminate the individual sounds or their order, but accurately perceived the number of segments (blastment → pasterment), and (b) who perceived an infrequent sound sequence as a more common one (epithet → enpithet);

(2) even in these linguistically inefficient children there were no violations of phonotactic rules: there seems to be some evidence that decoding was facilitated by the knowledge of permissible sound sequences in English (e.g., the first segment of stimulus was never misspelled); and

(3) although consonant clusters seemed inherently difficult, the obstruent /ks/ cluster in 'explicate' was never misspelled; this suggests that frequency in the language has made this common initial prefix particularly easy to decode.

4. DISCUSSION

In most studies of auditory perception input signals are degraded in order to provoke errors that might reveal more about the perceptual process. In studying these children we have a natural source of errors. There seems to be merit in studying disordered perception for the light it can throw on normal perceptual processes.

A much more rigorous study will be undertaken to follow up the suggestive leads of this pilot project. A more discriminating spelling test should be developed with enough different environments for each sound to determine more precisely the perceptual cues that are unusable by a given child. More attention will be paid to individual differences among children. If as preliminary study seems to suggest, there are differences among children in the kinds of errors they make, this may throw light on the specificity of perceptual abilities. The role of temporal factors is to be explored further by the use of stretched speech. Will speech reduced to half its normal rate by means of a Varivox be easier for those children to process? Will doubling the time per phoneme enable them to make use of perceptual cues that normally seem to go by them too quickly?

It has been suggested (Abbs and Sussman) that normal speech perception depends on "feature detectors" — organizational configurations of the sensory nervous system that are highly sensitive to certain parameters of complex stimuli. These children seemed unable to judge the number and order of phonemes in an unfamiliar word, particularly when one or more of the phonemes was less than 8 cs in duration; they seemed to have difficulty discriminating among consonants where judgments of relative duration must be made. The feature detector model of speech perception might account for these kinds of very specific perceptual deficits. Because of defective

physiological systems from birth, or systems that mature at an uneven rate, a child's feature detector system could be inefficient — and in processing speech he might show some of the same difficulties normal adults show in processing very rapid non-speech sounds (Warren and Warren).

Department of Linguistics
McGill University
Montreal, Canada

REFERENCES

Abbs, J.H. and H.M. Sussman
forthcoming "Neurophysiological Feature Detectors and Speech Perception: a Discussion of Theoretical Implications", *Journal of Speech and Hearing Research.*

Berry, M.F. and J. Eisenson
1956 *Speech Disorders: Principles and Practices of Therapy* (New York, Appleton Century Crofts).

Black, J.W. and S. Singh
1970 "The Psychological Basis of Phonetics", in *Manual of Phonetics*, Bertil Malmberg, ed. (Amsterdam, North-Holland Publishing Company).

Chalfant, C. James and M.A. Schefflin
1969 *Central Processing Dysfunction in Children* (Bethesda, Maryland, U.S. Department of Health, Education and Welfare).

Critchley, M.
1964 *Developmental Dyslexia* (London, William Heinnemann Medical Books).

de Hersch, K., J. Jansky, and W. Langford
1966 *Predicting Reading Failure* (New York, N.Y., Harper and Row).

Fant, G.
1970 "Analysis and Synthesis of Speech Processes", in *Manual of Phonetics*, Bertil Malmberg, ed. (Amsterdam, North-Holland Publishing Company).

Hallgren, B.
1950 "Specific Dyslexia", *A Clinical and Genetic Study* (= *Acta Psychiatrica Scandinavica Supplementum* 15).

Jakobson, R., G. Fant, and M. Halle
1967 *Preliminaries to Speech Analysis* (Cambridge, M.I.T. Press).

Johnson, D.J. and H.R. Myklebust
1967 *Learning Disabilities: Educational Principles and Practices* (New York, N.Y., Grune and Stratton).

Messing, E.S.
1968 "Auditory Perception: What Is It?", in *Selected Papers on Learning Disabilities*, John I. Arena ed. (Pittsburgh, Association for Children with Learning Disabilities) pp. 439-449.

Miller, G.A. and P.E. Nicely
1955 "An Analysis of Perceptual Confusions Among some English Consonants", *Journal of the Acoustic Society of America* 27:338-352.

Monroe, M.
1932 *Children Who Cannot Read* (Chicago, University of Chicago Press).

Myklebust, H.R.
1954 *Auditory Disorders in Children: A Manual for Differential Diagnosis*, New York, N.Y., Grune and Stratton.

Peterson, G. and H. Barney
1952 "Control Methods Used in a Study of the Vowels", *Journal of the Acoustic Society of America* 24:175.

Rabinovitch, R.D.
1962 "Reading and Learning Disabilities", in *American Handbook of Psychiatry*, S. Arieti, ed. (New York, Basic Books) pp. 857-869.
Warren, R.M. and R.P. Warren
1970 "Auditory Illusions and Confusions", *Scientific American* (December).

DISCUSSION

LEIDNER (Brookline, Mass.)
Your pronunciation of the second vowel in the word *tonometer* is schwa-like, which suggests that the spelling error in *tonermeter* may not be the result of an auditory perceptual problem, but rather the result of the not uncommon English rule *er* → [ə]/ — #. Perhaps the child, in hearing an unstressed schwa in the above word, assumes that it comes from an underlying *-er*. Thus this spelling error is qualitatively different from all the other errors on the list.

GOLICK
You are right of course. This was one of the reasons for excluding in the final tabulation errors in the spelling of vowels. The examples in the handout [presented to those present of the Section meeting] were all taken from records of misspellings of children with learning disabilities in order to demonstrate to this group, some of the kinds of errors they make. In this particular study *tonermeter* would not have been considered an error.

TRUTENAU (Legon, Ghana)
One should have liked the examples given in the illustrative handout [presented to those present at the section meeting] much more rigorously classified. In some cases spellings were offered which may be quite perceptive attempts at an untutored phonetic transcription of some American pronunciations of the items involved.

Again there were cases involving the substitution of a wrong final morpheme (like 'disonment' for 'dissonant', 'blasthood' for 'blastment'). These belong to quite a different order of 'mistake' than other examples given.

One last point: though we were assured that no phonotactic rules had been broken, examples like *ebptt*, *tnbr*, *assrlb*, *xpcake* make this assertion a little hard to believe.

GOLICK
In every case where a spelling could be construed as a possible spelling for the sound in question it was credited as correct. Thus for *polarize*, correct spellings could include 'polerise', 'pollerize', 'polareyes', 'polarise', etc. It was only when there was no conceivably correct representation of one of the consonants that an error was counted, e.g., *bolelig*.

Even when an entire final morpheme was substituted we had to go on the assumption that one or more of the sounds had been misperceived.

Examples like *ebptt*, *tnbr*, etc. were taken from the records of youngsters who generally omitted vowels because they did not know how to spell them. So in venturing the observation that phonotactic rules were not broken, I did not refer to these bizarre juxtapositions of consonants, but to other data. For example, though there were frequent examples of one fricative substituted for another, this never occurred when a phonotactic rule would be broken, e.g., the initial consonant in *stimulus* was never misspelled.

ALLEN (Chapel Hill, N.C.)
Tests which attempt to assess phonological ability from spelling ability should control carefully for the existence of words which contain the NAMES OF LETTERS, as, for example, the word 'explicate' contains the phonological name of the letter "x". Charles Read has shown (*Harvard Educational Review*, 1970) that pre-school children use letter names in their spelling rules, and such information would offer a form of redundancy to the perceptually disadvantaged child.

GOLICK
I chose this test because there was so much data available for a pilot study of errors. You are right. For a rigorous test enough words should be chosen that offer no easy solutions. Of course, we also need words that allow us to find out if they can, in fact, make use of redundancies.

GUPTA (Jodhpur, India)
In your learned paper you have given certain causes of committing spelling errors. The 'feature detector' theory is a possible explanation. But the practical aspect of this study is the removal of these errors so committed. Can you, please, point out the easiest device for overcoming this difficulty? This may be a little beyond your paper but the answer will be of practical utility.

GOLICK
It is hard at this point to think of a simple way of overcoming this difficulty. We are hoping that studies of this kind might give us more information about what these children cannot do, so that we can design appropriate remedial measures. For instance, if too brief duration of a phoneme makes it impossible to process, perhaps speech that is slowed up will help children learn to make use of cues that go by them too quickly. Meanwhile teachers, psychologists, speech therapists approach the problem by trying to make auditory perception more efficient — learning to hear sounds to judge their sequence, to exploit the phonotactic rules, and of course to choose the right symbol for a given phoneme.

NOOTEBOOM (Eindhoven)
Your paper was very interesting. Too little work is done of this kind. One could

think, however, of doing this kind of experiments in a more rigorous manner in using nonsense words. Then, one could e.g., also more easily circumvent the difficulties George Allen mentioned.

GOLICK
Nonsense words might be a good idea. At any rate, we need a set of words that allow us to see each sound in a number of different environments.

NOOTEBOOM
We know that speech is largely interpreted in terms of the language system the hearer possesses. Do you know whether the phonemic system of the children was the same as that of grown-up? I ask this because a similar technique is used by my colleague Eggermont to investigate the phonemic system of very young children.

GOLICK
No phonemic analysis was made of the language of these children. They were not very young — between nine and thirteen years — and when judged superficially their English seemed adequate. However, children with 'auditory perceptual problems' tend to be linguistically inefficient. Perhaps this difficulty lies in an incomplete phonemic system.

SCHNORRENBERG
Es ist erstaunlich für mich, dass — auch bei Kontextlosen, ungewöhnlichen Wortstimuli — Kinder mit sinnlosen Antworten in diesem Ausmass reagieren, da vielmehr zu erwarten ist, dass sie mit lautlich assoziierbaren sinnvollen Wörtem antworten, was nach Altersphasen zu differenzieren wäre, was einige Beispiele ja auch Zeigen.

GOLICK
In the examples given, there do seem to be occasional responses that suggest the child was attempting to spell a more familiar word. But on the whole, I think the children respond to the instructions: 'Here are some words you have probably never heard before. Just spell them the way they sound', and simply try to decode the sequence of sounds, without expecting them to be a familiar word.

VON RAFFLER ENGEL (Nashville, Tenn.)
In support of the last two speakers, I would like to mention an example which comes to mind of several I have collected in that particular area: One very good speller wrote instead of *an only child, a lonely child.*

GOLICK
The problem of misspellings and misperceptions of words in context must be different at least in part from the problem of misspelling and misperceiving unfamiliar words

given in isolation. Context cues, redundancy, and perhaps even emotional factors (an only child may be a lonely child) will affect auditory perception differently in the former case than in the latter.